IIT Institute of Design

FUTURE LIVING

Blending Human Aspirations with Environmental Realities

A Framework for Mid-century Housing

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PREFACE

This report describes the 109th project conducted in the Systems and Systematic Design course at the IIT Institute of Design.

The course teaches the use of Structured Planning, an information handling process that works in tandem with other planning and design methods to construct well-formed planning concepts. The best way to learn the process is to employ it in a project that takes on a complex, relevant system problem. The Systems and Systematic Design Workshop provides that opportunity. It is both teaching vehicle and the laboratory in which Structured Planning has been developed over the 45-year evolution of the process.

Many projects have been undertaken with Structured Planning, and each has furthered its development. Among the early published projects was one for Chicago's transit authority (CTA): Getting Around: Making the City Accessible to Its Residents (1971). In 1983, the House of the Future project won the Grand Prize in the Japan Design Foundation's First International Design Competition. In 1985, the design of a habitation module for Space Station was undertaken for NASA. In 1987, the Aquatecture project won the Grand Prize again in the Japan Design Foundation's Third International Design Competition. In 1991, Project Phoenix (on global warming) was honored as Environmental Category Grand Winner in Popular Science magazine's "100 Greatest Achievements in Science and Technology" for the year. In 1993, two award winning projects, NanoPlastics and Aerotecture, were widely publicized in Europe and Japan; in 1995, the National Parks project developed plans for the future of the U.S. National Park Service. In 2001, Access to Justice, a project sponsored by the National Center for State Courts, was implemented for use in state courts in Chicago and across the United States, and in 2005, four projects on Home, Play, Work and Health were finalists in four of the five competition categories for Denmark's INDEX Awards, the world's richest design prizes. Most recently, the 2006 project on Massive Change studied adaptation strategies for global warming in Chicago and similar cities, the 2007 project outlined design planning concepts to complement policy planning for national health care, and the 2008 project took the opportunity of the Burnham Plan centennial in Chicago to look ahead to planning possibilities for the next 100 years. Many of these projects, including this one, may be viewed at the Institute of Design web site: www.id.iit.edu/141/. As the process has evolved, it has become an increasingly useful planning tool for business, institutions and government.

THE COURSE

The semester-long Systems and Systematic Design course is a design workshop in which teams of graduate students, deliberately of mixed international origins and different academic backgrounds, apply the computer-supported Structured Planning process to complex design planning problems. The goal for each project is to develop information thoroughly, propose innovative solutions that take maximum advantage of the information, and integrate those ideas into system concepts that can both be evaluated in their own right and (in a real situation) be a comprehensive project specifications for a follow-on, detailed development project.

Course Goals

Three major learning goals set the direction of the course:

- ***Systems.*** What is the nature of "systems concepts" where policies, products, processes, activities, events, services and communications act together to achieve multiple goals? What can be done to ensure that a system as devised is as complete as possible, covering all required functions and attaining a high degree of "wholeness" and organic reliability?
- ***Systematic Methods.*** What is Structured Planning and how can its tool-kit of systematic methods be used to collect, structure and synthesize information in projects of greater complexity than can be comfortably dealt with intuitively? How can such methods be used by a team to extend the effectiveness of all?
- ***Teams.*** How do individuals with different cultural origins and different academic backgrounds work together successfully on teams?
- What roles are there to be played and what difficulties must be overcome? What behavioral characteristics are important and what principles of group action need to be put into practice?

THE PLANNING PROCESS

As the process for finding, structuring, using and communicating the information necessary for planning, Structured Planning seeks to create well-formed concepts. A well-formed concept answers the question "what?" that should be asked before the "how?" questions of development are addressed. "What should be developed?" is a question too often answered inadequately or even unasked—with all the attendant consequences. The product of Structured Planning is the problem statement for the design and development to follow.

A diagram of the process (***Fig.1.1.*** and ***Fig.1.2.***), sets out the activities that make up Structured Planning, along with the working documents and final products produced along the way. The general description below follows the diagram. The process and its products are discussed here in the abstract; specific examples created for this project may be seen in the appendices that accompany the report.

I. Project Definition

The Structured Planning process begins with Project Initiation and the acceptance of a Charter. This is a "brief" that serves as an initial communication vehicle between client and planners. It contains background, context, basic goals, a project statement that cuts to the heart of the planning task, resources to be used, a schedule and an initial set of issues to be investigated.

Defining Statements are mini "white papers" produced in the Framework Development portion of Project Definition. They focus the project within the direction of the Charter, concentrating on the issues and arguing specific directions that the project should follow with regard to them. Together with the Charter, they frame the project.

II. Action Analysis

Any system can be viewed as a complex entity working with its users in different ways appropriate to its modes of operation. To plan effectively, a planning team must recognize these Modes, identify Activities that occur within them, and

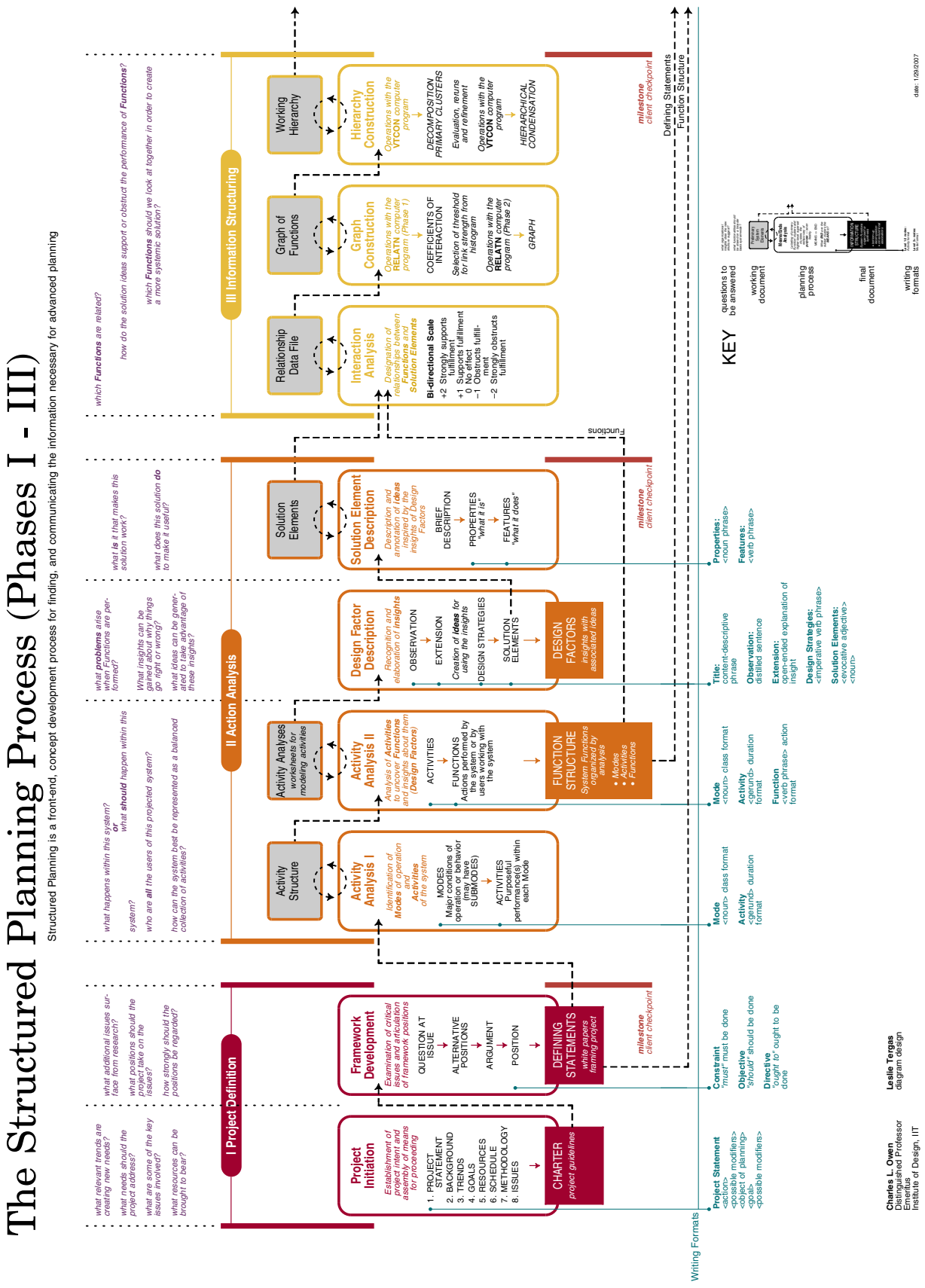

Fig.1.1. The Structured Planning process: phases I through III.

isolate the Functions that the users and system perform or are intended to perform within each Activity. The result of the Activity Analyses is a Function Structure.

Half of the purpose of Action Analysis is the enumeration of Functions. The other half is the development of information about them that reveals insight about what happens as they are performed. During Action Analysis, insights are sought about why things go wrong in performing some Functions, and how other Functions manage to be performed well. These insights are uncovered in the Design Factor Description procedure and developed in documents that become part of a qualitative knowledge base. Activity Analyses record information at the Activity level; Design Factors document insights and ideas associated with Functions.

To capture as fully as possible the ideas suggested on Design Factor documents, solution ideas are written up in the Solution Element Description portion of Action Analysis. This is done on simple one-page forms designed to capture enough detail about ideas to give them substance when they are needed later. They have three important sections: "Description"—a short explanation, "Properties"—what the idea is, and Features—what it does.

The product of Action Analysis is three sets of critical information: a set of Functions (the Function Structure), a set of insights (Design Factors) and a set of preliminary ideas (Solution Elements).

III. Information Structuring

Paradoxically, as useful as the Function Structure is for establishing coverage, it is not the best form of organization for developing concepts. Reorganizing information for use in concept development is the job of two computer programs, RELATN and VTCON.

The controlling factor for whether two Functions are associated from the planning standpoint is not whether they are categorically "related" in some manner, but whether a significant number of their potential solutions are of concern to both. Which Solution Elements are of concern to each Function is established in an Interaction Analysis procedure. The RELATN program uses this information in a Graph Construction process to establish links between Functions.

Another program, VTCON, completes the information structuring process. In the Hierarchy Construction activity, VTCON finds clusters of highly interlinked Functions and organizes them into an Information Structure, a visually understandable, very general form of hierarchy most appropriate for planning.

IV. Synthesis

In its form from the VTCON program, the Information Structure is simply a hierarchical reorganization of Functions. Nodal points above the Function level do not have names. The task of Means/Ends Analysis is to create labels for all nodes in the hierarchy. Moving bottom-up from the known Functions in the bottom level clusters, names are found to label nodes as "ends" for which lower-level nodes are "means". The process continues to a completely labeled Information Structure.

The process is then reversed as a top-down, structured brainstorming procedure: Ends/Means Synthesis. In this process, the planning team asks of high level nodes, "what means do we need to meet this end?" As means are established, they are treated in turn as new ends for which means must be found, until the means become concrete enough to be described as final elements of the system (System Elements). Existing Solution Elements are reviewed as potentially usable directly; others are modified or combined to make them usable, and new ideas are added to fill unmet needs newly recognized.

System Element Interaction compares System Element with System Element in a search for additional synergies that can contribute to systemic qualities. More than simply recognizing relationships, the planning team proactively seeks out inventive new ways for System Elements to work together—the invention and design of relationships. Changes and additions are incorporated in the properties and features of the individual System Elements.

The last Synthesis task, System Element Description, completes the specification of System Elements, including a succinct description, all relevant—now essential—properties and features, and extensive Discussion and Scenario sections that contain detailed expositions of the ideas in both conceptual and operational terms.

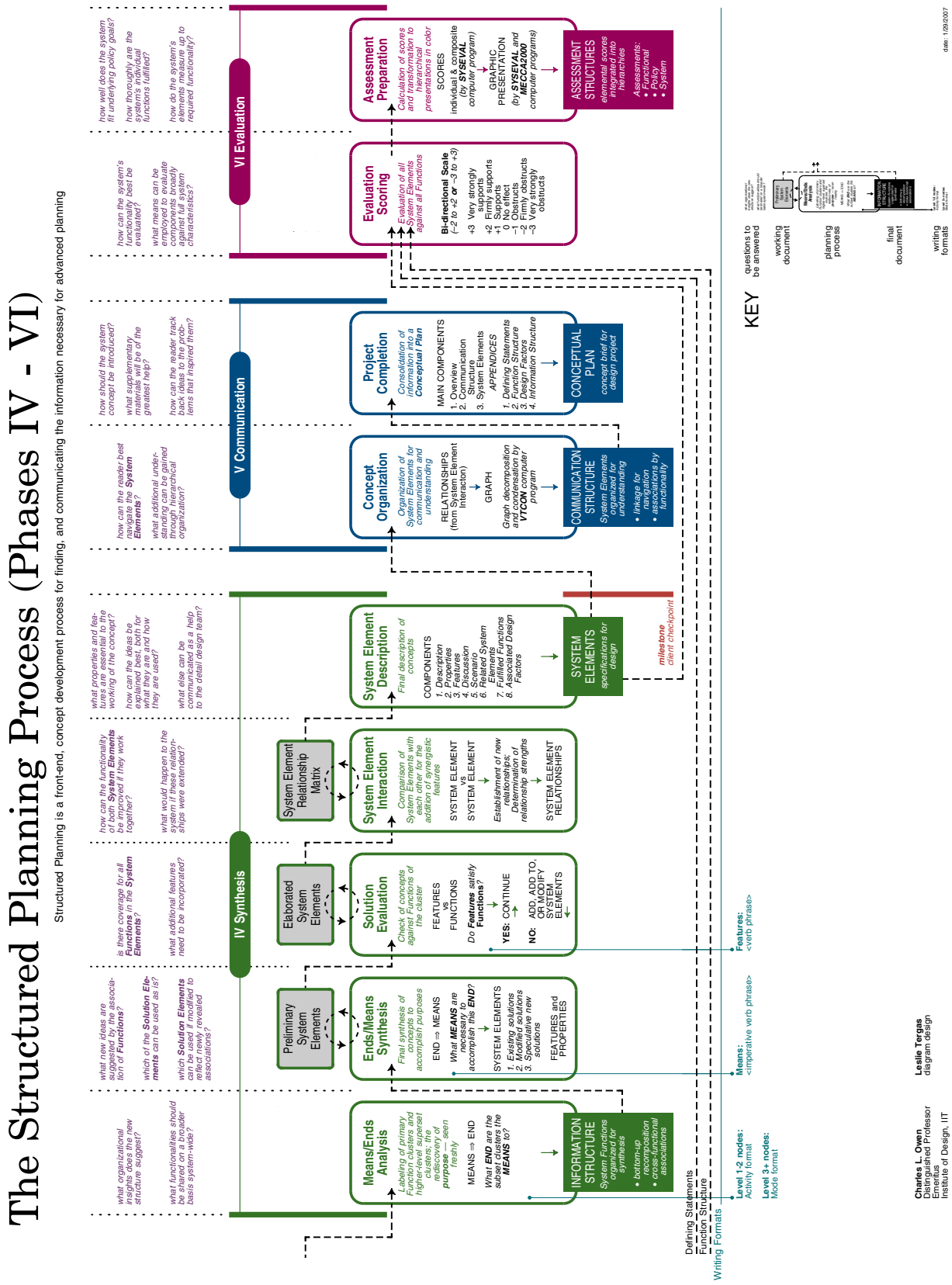

Fig.1.2. The Structured Planning process: phases IV through VI.

V. Communication

Because the result of the Structured Planning process is a complex system, usually with a number of System Elements, a Communication Structure is frequently included as an aid to understanding. This is created during Concept Organization by the VTCON program from an assessment of how important the System Elements are to each other's operation. Using this structure, the reader can understand the system more easily and navigate its concepts with efficiency.

The product of the Structured Planning process, assembled in the Project Completion section, is a Conceptual Plan, made up of an Overview that provides background and introduces the system, the System Elements that describe the ideas and their relationships, and Appendices that contain all relevant support information, including the Defining Statements, Design Factors, Function Structure and Information Structure.

VI. Evaluation

Structured Planning incorporates evaluation among the steps of the process, most notably during Synthesis. It also offers an optional full-system evaluation technique that can be employed to evaluate final results against policy-level and/or function-level criteria. Used for this, it provides merit values hierarchically for the system, its component parts and individual system elements. It can also create similar hierarchical evaluations for the assessment of functional performance and policy performance. Used to compare systems, it can provide system, functional and policy assessments for multiple competitive candidates measured against common function and system structure frameworks.

THE PROJECT TEAM

Twenty-five graduate students from the USA and abroad were organized in teams to study possibilities for future living. Besides the USA, their home countries included Canada, Mexico, South Korea, Republic of China (Taiwan), People's Republic of China, Singapore, India and South Africa. Previous undergraduate and graduate degrees included degrees in product design, industrial design, interaction design, graphic design, communication design, textile design, architecture, interior architecture, art history, studio arts, biology, computer science, human factors engineering, liberal arts, mathematics, economics, English, French, and communication.

Organization

To optimize the participation of 25 team members in a single project, the project was divided into two parts: an 8-week, 3-phase first part for research and analysis, and an 8-week, 2-phase second part for synthesis.

In the first part, five teams of five worked on separate aspects of home living, establishing the Functions a future home system should perform (see the methodology above) and gaining insight about them with ideas for how to fulfill their requirements.

For the second part, after the Functions had been organized into an Information Structure, the five teams were reformed to include one representative each from all five original teams, enabling each new synthesis team to have knowledge of the entire project to date. The newly constituted synthesis teams devoted the project's fourth phase to developing component solutions for the sections of the Information Structure assigned to them.

In the fifth, final phase, a team of five members with architectural experience was drawn from the five synthesis teams. This team took the developing System Element concepts from the five synthesis teams and visualized them in demonstration houses showing, in as great a range as possible, the worldwide geographic, cultural, climatic and demographic diversity the system can accommodate. The five four-member synthesis teams completed descriptions of System Elements, and all six teams finished the project with a presentation and this report.

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INTRODUCTION

In the next few decades, population growth, climate change and resource depletion—conditions we created—will be directly confronted by emerging hypertechnologies we are now creating, among them: nanotechnology, robotics and information technology. The confrontation will change our living habits.

The systems for living we take for granted will be reinvented whether we like it or not. And the extent of the revision will be worldwide, affecting developed and developing societies alike. How we will fare will depend significantly on the insightfulness of design thinking.

Sustainability is now a watchword everywhere. But sustainability only means managing resources so that they won't be depleted or irretrievably damaged. A forest is sustainable as a resource if it is not clear-cut but instead is subject to controlled, limited logging; and new trees are planted to replace those removed. The system does not have to be self-sustaining, only one in which rates of use do not exceed rates of recovery. Inputs and outputs are expected, but are expected to be balanced.

Our world, however, is one of increasing demand. Population, now over 6 billion, will increase to over 9 billion by mid-century. In a world with half again as many people as are now alive, all of whom with greater expectations, we will have to find ways to use less. Future living, as a consequence, will be better served by self-sufficiency. As a higher level goal than sustainability, self-sufficiency, wherever it can be achieved, can truly support global sustainability by reducing demand on resources.

Domestic living places a substantial demand on the essential resources of energy, water and food. In the U.S., residential energy use is about 20% of total energy consumed. Water use for public supply accounts for almost 20% of the water withdrawn from waterways and aquifers, and water used for irrigation to produce food for household consumption adds considerably to that. In almost any imaginable future, the availability of energy, water and food will depend on wise management of supply.

Vision and thoughtful planning, however, may turn apparent loss into actual gain. Less may become demonstrably more. Deployed with vision, the hypertechnologies may allow us to actually improve quality of life while reducing demand—even contributing to resource supply.

Quality of life inevitably is embodied in our dwellings. The 2009 Systems project looks once more at housing systems and what they can be to support human values, societal health and environmental well-being at a potentially difficult time in human history.

RELEVANT TRENDS

Trends initiated by emerging technologies, changing environmental conditions, and evolving social change will have real impact on future living. Among trends becoming evident today are:

Water Resources

Already in many parts of the world, water supplies are reaching levels of insufficiency. Complicated by agricultural needs for irrigation and the needs of urban centers becoming megacities, the fresh water resources of our lakes, rivers and subsurface aquifers are subsiding. In 2008, nearly 6,000 people, most of them children, were dying daily from insufficient or contaminated water supplies. One-third of the world's population, by some experts' analysis, live in water-stressed countries now, with two-thirds of the world to share their dilemma by 2050.

Food Resources

Until quite recently, world food supplies were not expected to be a problem—or at least not a significant problem. Current thinking now places food resources among those requiring serious attention. The green revolution of the 1950's lulled planners into a false belief that similar agricultural science advances could be expected to keep food supplies reliably ahead of the demand of growing populations. Now the combination of population growth and the unexpected intrusion of climate change is projected to force famine conditions on many parts of the world. Complicating the picture, drought and intense, unpredictable precipitation events will affect many of the major areas now acting as the world's breadbaskets.

Mineral Resources

Mineral resources are approaching finite limits, exhausted in some locations, more difficult to extract in others. While supplies of some minerals are in no immediate danger, others are under severe pressure. Oil, a resource of vital concern, is likely to reach peak production in the next few decades with annual reductions thereafter. Not only will oil have to be replaced as a major energy source, additional energy sources will have to be found to keep pace with the population increase.

Climate Change

Climate and weather patterns are changing. Some regions are simply getting drier or wetter, but the great damage will come from sustained, severe droughts and abrupt, intense weather events. The problem is change: eco-systems confronted with (1) wetter or drier conditions for periods far longer than the environment or its inhabitants are prepared, and (2) sudden, short-term, intense weather events such as violent super tornadoes and hurricanes, cloud-bursts, blizzards and heat waves. Climate zones will change; by the end of the century Chicago, as an example, will have summers similar to those now experienced in Mobile, Alabama and winters like those of today's northern Arkansas. Cities and rural areas worldwide will experience differing, but equally radical change.

Population Movement

In an interesting paradox, the countryside is becoming less—not more—inhabited as we add to the population. People are moving from the country to the cities. As of 2005, the world was more urban than rural for the first time in history. Over the next decade, 300 million rural Chinese are expected to move to the cities. In 1950, only two cities in the world, Tokyo and New York City, were over 10 million in size. By 1975 there were 4 such megacities, and by 2003, there were 20. By 2015 there will be at least 22, more likely, 33. In China alone there are between 100 and 160 cities with over 1 million inhabitants (America has 9, and Eastern and Western Europe together have 36). Cities are complex, sophisticated systems, but their managers will need all the skill they can command to deal with the great urban migration. The major changes will take place in the developing countries, but cities of the developed world will feel the effects through immigration as well as local relocations, and more and better housing will be mandatory.

Increasing Expectations

The growing availability and capabilities of communications through hand-held devices, satellite transmissions, and the Internet are providing people everywhere with daily knowledge of living conditions, problems, products, threats and opportunities locally and globally. The media have become avenues for broad and fast communication informing the populace about how the rest of the world lives and creating

expectations that both fuel demand and create readiness for change.

Internet Penetration

Computer use and Internet access grow exponentially every year. Information of encyclopedic detail can be obtained more and more easily, and complex, sophisticated processes can be used remotely. Access to high-quality communications and sophisticated computer tools are increasingly available to individuals and groups anywhere. Internet penetration in 2009 reached 74% in North America, 24% worldwide.

Emerging Technologies

The pace of technological change continues to accelerate, bringing new science to commercial, institutional and industrial uses at an ever quickening pace. Most notable among many fields, major technological innovations can be expected in the new disciplines of molecular nanotechnology, robotics and the biosciences. Computing capacities continue to grow at the exponential pace predicted by Moore's Law, doubling computer power roughly every two years. The effect is to radically increase capabilities while decreasing size and cost—and dramatically increasing the usefulness of digital electronics in almost every aspect of commercial, institutional, social and personal life.

THE FOCUS OF FUTURE LIVING

Projects on "houses of the future" and the way we will live almost always approach the subject from a viewpoint of labor-saving benefits to be introduced through the application of new technologies. Goals are material with almost no regard for the real needs of family, community or society and little concern for the environment. Typical projects promote leading edge products of industry or attempt to stir the buying interests of those desirous of the latest and most technologically advanced products.

In this project, the focus is directed by the real need to respond to developing global changes that by mid-century will have universal impact on our lives. Five major focal points are:

Self-sufficiency

Vast amounts of energy, water, agricultural resources and mineral resources are required for the dwellings of the 6.7 billion people now alive. By 2050, world population will have swelled to 9.2 billion. Almost any improvement in dwelling self-sufficiency can have major impact on the expenditure of resources. How can new technologies be employed to reduce demand on resources-- even create new sources of supply?

Space Optimization

Trends in the last century have been to larger and larger homes. As wealth has reached the middle classes, house size and number of possessions have increased in blind response to a value system of "more is more". How can the new technologies reduce the need for space and space-filling possessions without diminishing the gains they provide? How can we have our cake and eat it too? How can less be more?

Accessibility

All is possible for the healthy and wealthy. But for maximal benefit of self-sufficiency as a dwelling strategy, housing must be accessible to all or nearly all. How can housing be designed to be readily usable by those with disabilities and the growing, potentially very large, elderly segment of the population—as well as the healthy? How can those in the bottom income percentiles participate along with those with greater wealth?

Adaptivity

Families and individuals vary almost infinitely in patterns of social behavior, interests, age, capabilities and just about any means of discrimination that can be applied. And people change. For any real hope of self-sufficiency, housing systems, physical and non-physical, must be able to continue to be useful under change. How can a housing system conform to the special needs of any dweller? Families should not have to shed their homes like hermit crabs do when housing no longer meets needs. How can a house be made to change with its inhabitants' changing needs and interests?

Value Support

A house should be more than shelter. To achieve their potential, individuals need support from environment, immediate family and community that takes different forms over a lifetime. A very important setting for this support is the home. How can systems in the home work to contribute to education, communication, social development and intellectual, emotional, physical and social growth?

PROJECT GOALS

The overall goal of this project is not housing that can be built today, or even tomorrow, but housing that will evolve to take advantage of technologies now just in stages of early development. Enlightened response to fast-changing environmental conditions and the new Technologies that can deal with them is the goal and the challenge. What will be needed is a new approach to home and housing that integrates support for human aspirations with means for achieving self-sufficiency wherever possible. This project should point the way by projecting the capabilities beginning to emerge from the new technologies in a design for a housing system that could be built in the not-too-distant future.

The full range of functions that should be addressed includes provisions for:

a. ***Food Production***—growing and preserving food,
b. ***Water Conservation***—collecting and recycling water,
c. ***Energy Production***—producing electrical energy,
d. ***Reconfiguration***—changing the purposes of spaces and changing the capabilities of the dwelling,
e. ***Vertical Transport***—moving people and goods to higher or lower floors without stairs,
f. ***Assembly and Disassembly***—adding, removing and transporting dwelling components as needs change,
g. ***Environmental Adaptation***—fitting the dwelling to different climatic and weather conditions,
h. ***Cultural Adaptation***—fitting the dwelling to different cultural norms,
i. ***Disaster Proofing***—protecting the dwelling, inhabitants and goods from likely natural disasters,

READING THE REPORT

This report covers the description of the Future Living system and the process that produced it. It is a modified version of the conceptual plan that, in a working situation, would be prepared as the brief for a follow-on detail design team. Because it is directed to a more general readership, overly specialized information that would be needed by developers has been avoided. What remains is a main body of system description and a set of appendices that contains a full accounting of essential information and examples of working documents.

Main Body

The main body consists primarily of three major sections containing the project concepts in the form of units called System Elements, and an architectural demonstration section showing a sample dwelling that could accommodate them. As the end product of the planning process, the System Elements are the elements of the system. For this report, an apt metaphor for them would be chapters and sections of chapters.

Each System Element usually has two main parts, a Discussion and a Scenario. The Discussion lays out components of the idea, describes them in detail, and explains how they work together. The Scenario describes how the idea might actually be employed in a real situation presented in a “you are there” format. The Discussion explains what the idea is; the Scenario explains what it does. Three other parts of the narrative are brief introductory summations. The Description describes the idea in a sentence or two. Properties list what component characteristics must be. Features list what the System Element must do. Essentially, Properties and Features are the specifications for the System Element as a concept to be developed.

The System Elements are organized by how they relate to each other and their purpose within the overall mission required of the system. Those near each other in the progression through the report are placed together because they should be read together in understanding the part of the system in which they play their role. These associations are captured in a Communication Structure.

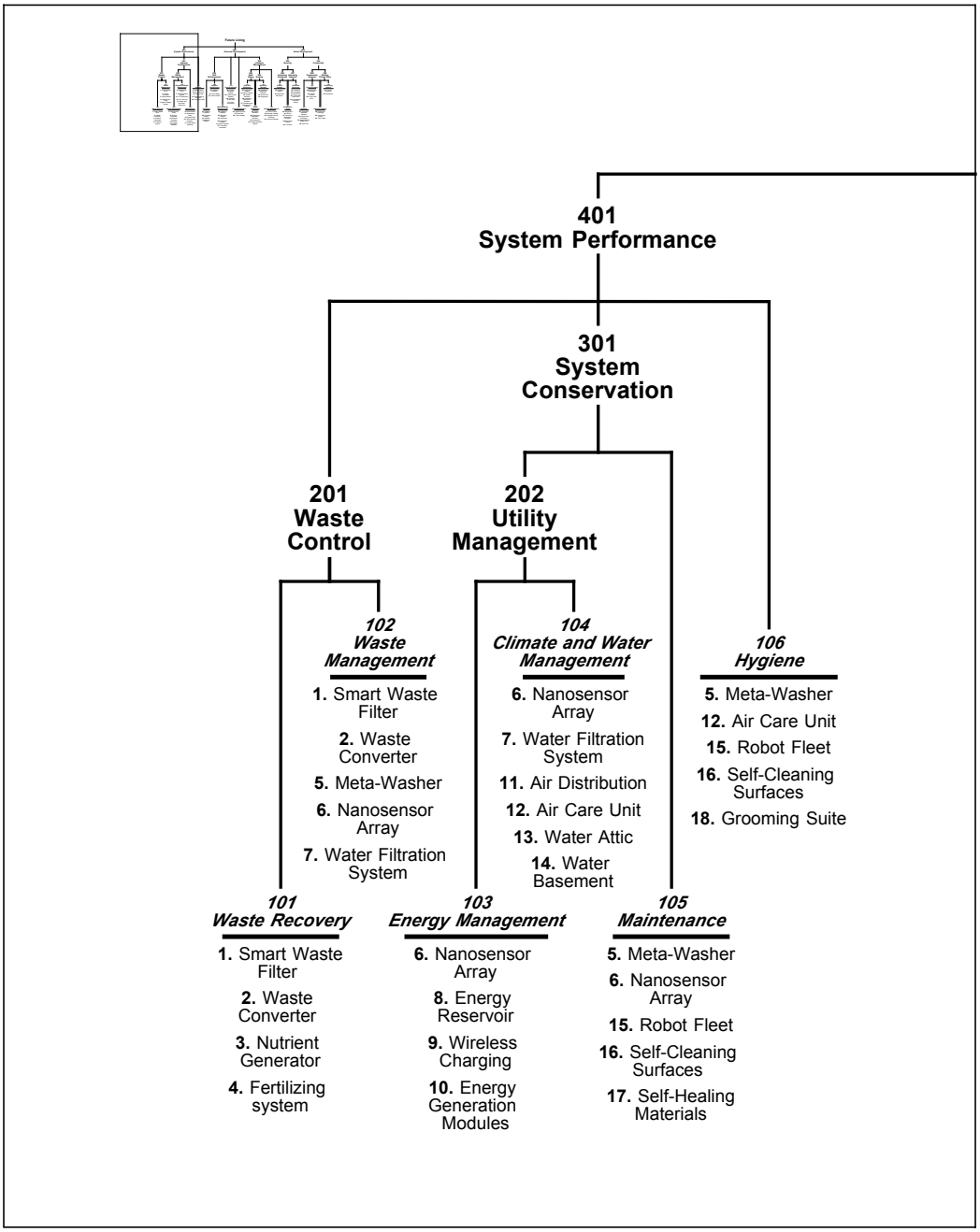


Fig.1. **Left-most section of the Communication Structure**

Communication Structure

Sixty-one System Elements are covered. They can be read in any order, but, ideally, should be read with those with which they are most closely associated. A hierarchical Communication Structure reveals these relationships visually. Figure 1 shows the left-most section of the structure (separated for readability). This section contains System Elements concerned with System Performance, subcategorized to three levels. The System Elements themselves are listed by name and number in their lowest-level, primary categories, or clusters.

The three main sections of the main body are System Performance, Personal Development and Social Development. Each section is shown in a separate figure enlarged from the

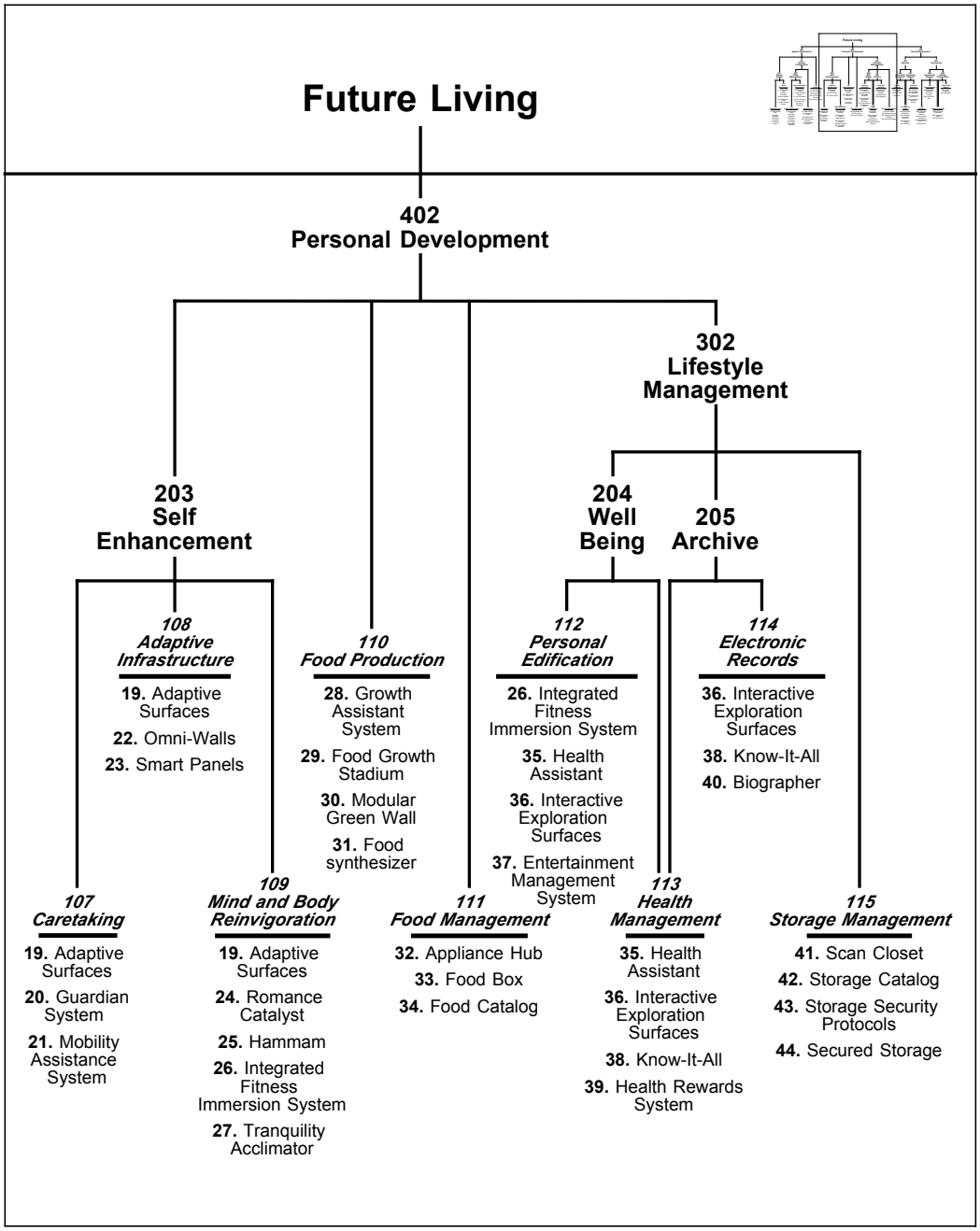


Fig.2. **Middle section of the Communication Structure**

overall structure, similarly to the way System Performance was shown in Figure 1. In some cases, System Elements appear in more than one primary categorical cluster, and some categories belong to more than one higher category. This is a feature of the Communication Structure. It is a hierarchical "inclusion" structure in which each node includes all the elements Of the nodes below it. Additionally, this form, unlike a "tree", allows multiple membership of nodal clusters in clusters at higher levels of generality. As a mathematical entity, it is called a semi-lattice; it is a structure well-suited to organizational problems in the man-made world.

Appendices

The Appendices for the report are extensive. They are divided into two classes.

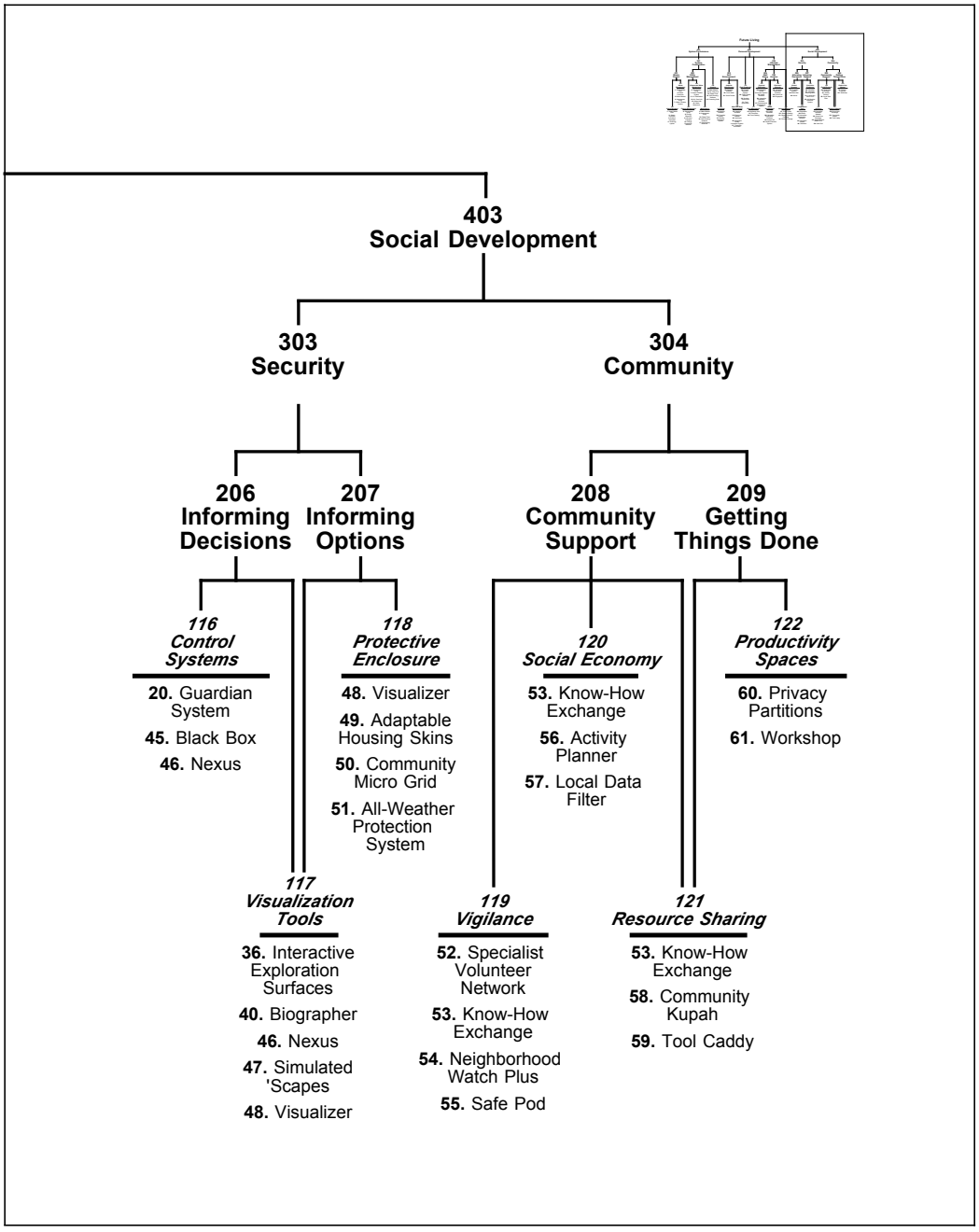


Fig.3 **Right-most section of the Communication Structure**

The first class makes up the bulk of the material. It is extensive primarily because it contains research and analysis that has value important to those interested in deeper understanding of particular System Elements and their genesis. This group consists of (1) Defining Statements that establish policy positions for issues of concern to the project; (2) the Function Structure that records the process of determining what a system for future living must do; (3) Design Factors that uncover insights about how and why Functions can be performed well or poorly—and ideas for how to use that information; and (4) an Information Structure that reorganizes the Functions in a "road map" well suited to the process of creative synthesis.

The second class contains examples of the many Structured Planning working forms used over the course of the project.

This group of appendices exists primarily to demonstrate how information in the project is transformed progressively as concepts emerge from insights and are synthesized over the course of the project into System Elements. With examples from the first class, it is possible to reconstruct the path that an area of interest took in moving from issue to insight to idea, and its development through modification, elaboration and association into a finished element of the system. Appendices in this class include forms for Activity Analysis, Solution Elements, Means/Ends Analysis, Ends/Means synthesis, System Element Interaction, and final System Elements as they are prepared for a Plan.

SYSTEM PERFORMANCE

OVERVIEW

System performance is made up of the environmental systems of the home, working in concert to provide the basics of living. Energy, hygiene, maintenance, water, climate, waste, and nutrients systems are strongly interralted, providing inputs and outputs to each other. This synergy between system processes, when expressed in the home of 2050, takes on a thoughtful organic nature, similar to the systems of the human body: water and energy are like the circulatory system; nutrients and waste like the digestive system; hygiene and maintenance like the immune system; climate is like the respiratory system; and finally, the response network is like the nervous system, which senses, considers what it sees, hears, feels, and reacts upon that input. All of the systems feed into this network, and allows them to work in an interrelated way.

The energy management system collects energy from multiple sources, distributes it inside the home and distributes leftover energy back to the microgrid. Energy Generation Modules are used to collect energy by every means possible given the region and availability, while an Energy Reservoir is used to store energy in an array of batteries, reserving a week's worth of energy and protecting the home from severe outages. Finally, a Wireless Charging system allows for energy distribution through either inductive charging or magnetic resonance technologies outfitted throughout the house.

The maintenance system keeps the home in good working order, while the hygiene system prevents bodily contamination. The system elements for these systems are tightly interrelated, and are primarily overseen by the Nanosensor-Array, an array of microscopic, wirelessly networked nanotech devices that use multiple sensing technologies, including acoustic, optic, chemical, magnetic, and thermal. The Grooming Suite, a cluster of technologies for body cleaning and grooming, works in concert with other house systems. It leverages the Meta-Washer, an integrated multi-function appliance for cleaning and waste disposal, and Self-Cleaning surfaces, a nanotechnology that allows surfaces to be self-cleaning and sanitizing, to provide a hygienic and healthy environment. The suite includes an Omni-Shower, a shower with configurable fixtures, biometric data collection, and health evaluation, as well.

The water management system collects, purifies and distributes water throughout the system. It takes water from

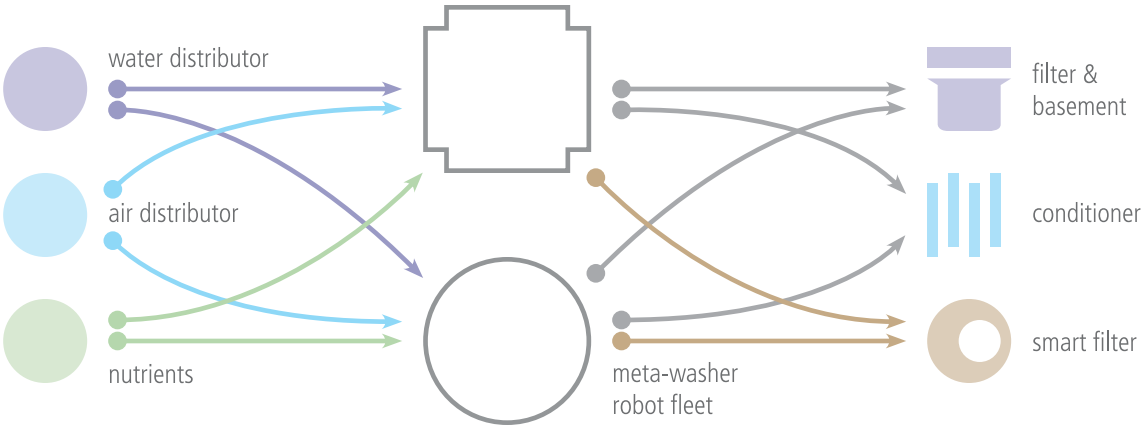
the environment primarily and the grid secondarily. Water is filtered internally and then distributed through the home. A Water Basement is used to keep large amounts of water on hand, and is constantly being filtered by a Water Filter, which uses a combination of simple and biological filtration technologies to ensure that any water that enters the system is of potable quality. Alternatively, the climate system manages the heating and cooling of the home through air. It pulls in air from the outside, adjusts the baseline temperature and humidity and uses local and remote air care units to treat the air, allowing climate regulation throughout specific areas within the home.

The waste management system thoughtfully processes the home's waste to recover as much as possible. It also input to the Nutrient Recovery system. Once something has entered the waste system, the first stop is a macro-separation by the Smart Waste Filter. If the filter can't make the separation, the material goes on to the Waste Converter for breakdown. The nutrient system, on the other hand, repurposes waste products into fertilizer for growing food, and nutrients for humans. Its inputs come from the waste system and the water system. The Nutrient Generator combines or synthesizes nutrients for human supplement, while the Fertilizing System combines nitrogen, phosphorus, and potassium with composed waste, adjusting chemical levels according to the growing region, time of year, and crop to be grown.

The system performance systems leverage technological advances and inventiveness to foster a healthy environment for its inhabitants and facilitate the tasks that will allow them to care for themselves, as well as for their home.

SYSTEM ELEMENTS

SYSTEM PERFORMANCE



HYGIENE

ROBOT FLEET

The Robot Fleet is a combination of microscopic, small and medium-sized robots to handle maintenance and hygiene tasks of various complexity, dexterity, and hazard. As part of the overlapped areas of hygiene and maintenance, the Micro-Fleet and Adaptable Multibot actively maintains, repairs and cleans the future home.

Discussion

While **Self-Cleaning and Self-Healing Surfaces** promise to dramatically cut down on contamination and maintenance activity, a second, active strategy is necessary. This strategy should be capable of handling the unexpected in a highly automated way. The **Robot Fleet** is a complete system of robots designed for actively dealing with messes.

The eyes and ears of the **Robot Fleet** are an array of sensors capable of detecting contamination, visual location and mapping hardware and software, and specialized commands given by the inhabitant. It is capable of providing preventative maintenance as well as on-the-spot intervention.

Once a problem has been identified, one or more **Adaptable Multibots** are sent out to survey the site. If specialized facility is necessary, the **Adaptable Multibot** can go back to its docking station and self-equip with the appropriate tool. During the repair or cleanup process, the **Adaptable Multibots** can summon more robots if necessary.

The **Robot Fleet** also consists of tiny nano-bots, in this case, named the **Micro**

PROPERTIES

- A bay station or series of bay stations for robots
- A supply of hundreds of micro and nanorobots, designed specifically for cleaning, cheap and easily replenished through a mail-order supply, treated to discourage ingestion by pets and children
- Two larger, unspecialized robots, capable of reconfiguring to different heights and incorporating specialized appendages, given the task at hand.
- A series of specialized appendages for maintenance tasks, including tools for maintenance
- A software interface for communicating low inventories, robot malfunction and repair needs, and connecting to other house systems
- Areas for disposing of waste

FEATURES

- Decides when human intervention necessary
- Coordinates unobtrusively with patterns of house activity
- Repairs and cleans round-the-clock, so as to cut down on true emergencies
- Combines into larger fleets for certain tasks
- Accesses a sensor array monitoring for hygiene and maintenance

Fleet. The **Micro Fleet** repairs or cleans when the chore is too fine to be handled by the Adaptable Multibots or if the chore can be handled more efficiently with robots working in parallel. These nanobots can combine into cleaning sheets or work individually, like ants. The **Micro Fleet** is composed of cheap, disposable pieces, given the likelihood of breakage. When the work is over, they are collected by the Adaptable Multibots and returned to the docking station.

Scenario

As Joe finishes the last bite of his breakfast, he hears a crash from the other room. He finds that his German retriever, Bosco, has upset two of his prized orchids. Both orchids fell five feet from the mantle - now all that's left are two piles of dirt, broken stems, petals and the pot, smashed into powder and hand-sized shards. Bosco is also covered in dirt.

After scolding Bosco, Joe begins the task of cleaning the mess up. Since Joe lives alone and has recently undergone back surgery, he can't bend over to clean up the mess, nor can he call on someone else. Thankfully, Joe had his home outfitted with a **Robot Fleet** six months ago. The **Robot Fleet**, as part of the hygiene and maintenance systems of the home, is designed to clean up and sanitizes areas of the home where **Self-Cleaning** and **Self-Healing Surfaces** would be overwhelmed.

Joe asks the home's central monitoring system to pay attention as he circumscribes the mess with his foot and describes what needs cleaning up. The system maps Joe's movements to a room and surface location and then dispatches a single **Adaptable Multibot** to size up the situation. The **Adaptable Multibot** has been informed that the mess is dry, so before being dispatched, it has armed itself with a dry vacuum component and a clearing arm, capable of corralling pieces of debris.

When the **Adaptable Multibot** arrives, it begins to clear away large pieces of the broken pot, sweep up chunks of dirt, and broken flower parts. After collecting large pieces and vacuuming up dirt, it decides that a second pass of cleaning is necessary -- as some of the mess might prove lethal to Bosco if he licks the area later. It sends a message back to the central maintenance and hygiene unit. The unit deploys 50 nanobots from its **Micro Fleet** component.

The nanobots begin their work of collecting microscopic particles from the site of the broken plant. The nanobots work individually and in clumps, picking up particles and depositing them with the Adaptable Multibot. Several bots find their way to Bosco and nibble pot and dirt bits off of him. Bosco gets curious and tries to eat one of the bots, but its foul taste makes him think twice.

After thirty minutes of activity, the floor looks good as new. The Adaptable Multibot does a final pass, picking up and accounting for the nanobots. The unit returns back to the utility closet and puts its collected waste into the waste system.

GROOMING SUITE

The Grooming Suite is a cluster of technologies, loosely coupled to the bathroom, which handle body cleaning and grooming in concert with other house systems and uses technology in a smarter way. It relies on the Meta-Washer and Self-Cleaning Surfaces to provide a hygienic experience.

Discussion

The **Grooming Suite** addresses broad issues with grooming and cleanliness, and leaves many grooming details up to the open market. It does not require the next nose hair trimmer, nail clipper, toothbrush, razor, or automated face washer, and so forth.

The disabled and frail will undoubtedly receive assistance with oral hygiene, body hair and nails, and skin health by a robotic home assistant. However, all facilities in the **Grooming Suite** can be adjusted to appropriate heights, given the physical human factors in mind and conform to basic safety guidelines. The **Grooming Suite** can identify each inhabitant and adjust the fixtures in place to make it convenient for children and the frail to use the bathroom with confidence.

Bathroom use is a golden opportunity to collect biometric information. If the **Health Profiler** for the **Grooming Suite** is turned on, data gleaned from saliva, urine and skin scanning will be sent back to the health units of the home.

The **Omni-Shower** is an enhanced shower. Its input derives from the meta washer, and its output feeds back into the meta washer. It has a built in dryer, making towels obsolete, and has the capacity to scan human skin, using skin texture recognition.

Scenario

Brandon has returned home after a grueling afternoon of football practice. In several hours, he'll be attending a black tie dinner at his father's workplace. Not only does he need to take a shower, but he also needs to shave, cut his nails, and trim his monobrow.

As soon as he walks into the bathroom, the bathroom recognizes that it's him and adjusts the toilet and sink to his levels, appropriate to his 6-foot-2 height. This self-adjusting fixture component knows the physical human factors of each house member and can adapt the bathroom to each specific need.

In Brandon's profile, the **Health Profiler** has been turned on. Diabetes and skin cancer run in his family, and so he's decided that the **Grooming Suite** can take

PROPERTIES

- A shower/bath tub suite tied into the same inputs and outputs as the **Meta-Washer**.
- A set of sensors capable of taking biometric measurements inside the mouth, outside on the skin's surface, or evaluating chemical makeup of urine and feces.
- A software suite that manages and transmits biometric data, recognizes occupants, and reconfigures fixtures if necessary.
- Slip-proofed equipment

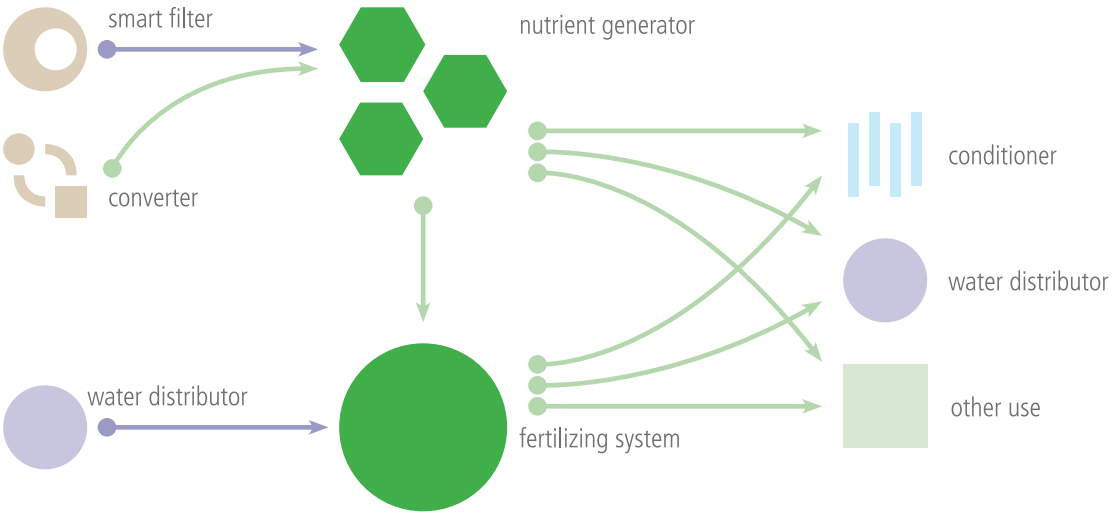
FEATURES

- Raises or lowers fixtures in accordance with ADA guidelines once the inhabitant is identified
- Measures health data where possible (e.g. teeth brushing, elimination, before/after taking a shower.
- Communicates with other systems to conserve water and energy
- Arranges for own weekly cleaning

and report his vital signs back to the central health center. When he uses the toilet, the toilet measures the glucose levels in his urine. When he brushes his teeth, the sensor on his toothbrush reports back to the bathroom other markers for diabetes in his saliva and the degree to which he's kept up good oral hygiene habits. It's clear he hasn't been flossing, so he'll receive an email reminding him to do so.

Brandon's shower in the **Omni-Shower** lasts 15 minutes, as the house's energy meter is restricting water usage. When he finishes up, rather than using a towel to dry off, he's blown dry by the shower's built in dryer. Before he gets out of the shower stall, the shower scans his body for any tell-tale changes in moles or the appearance of lesions.

All checks out, and Brandon proceeds to shave and trim his nails. The **Grooming Suite** is self cleaning, and after Brandon leaves the bathroom to get dressed, all the stray hairs are vacuumed out. Once a week, a the **Micro Fleet** crawls the bathroom, picking up hairs and debris that is hard to reach.



NUTRIENTS

NUTRIENT GENERATOR

The Nutrient Generator is a machine that generates ready-to-use nutrients from useful components reclaimed from system outputs. It takes deconstructed organic output from Smart Waste Filter, Waste Converter, and water from the Water Basement and reconstitutes, consolidates, and recombines them into consumable products. Various nutritional supplements, such as vitamins, minerals, fiber, fatty acids or amino acids are provided to residents based on their health needs. The produced nutrients can be administered directly into the home's air via the Air Care Unit into water supply at specific use areas, or made available to be consumed as multivitamins or food additives.

PROPERTIES

- Nutrient generating machine capable of producing ready-to-consume nutrients
- Database of nutrition recipes
- Direct connection to the home's waste system

Discussion

Between the **Smart Waste Filter** and **Waste Converter**, the vast majority of discarded waste is deconstructed into basic materials, some at the molecular level. Of these basic materials, some are valuable as nutrients or components of nutrients. However, these nutrients must be administered in specific amounts or proportions, or molecular components may require certain combination or chemical synthesis before arriving at a usable state. By reconstructing nutrients after extraction from discarded waste, the **Nutrient Generator** helps minimize both waste and dependence on external sources of nutrition.

FEATURES

- Sources from organic output of **Smart Waste Filter** and **Waste Converter**
- Generates pills, tablets, liquid or air supplements that offer fundamental nutritional values
- Adjusts based on shared information from other health-regulating systems
- Fulfills nutritional needs based on diet, special conditions, climate or periodic trends
- Adapts to different delivery types (solid, gas, liquid)

Vitamins have a strong role in both general health and the prevention of disease. As such, the **Nutrient Generator** works in close tandem with the **Health Assistant** in the formulation and administration of dietary supplements. Nutrient formulation within the **Nutrient Generator** is customized based on a composite of the households nutritional needs, taking into account factors such as lifestyle, diet, or seasonal risks. Nutrients can be administered in a variety of forms, depending on the biochemical requirements of the nutrient and user preference.

The **Nutrient Generator** also packages nutrients such that their intake will be the least disruptive to everyday life. Nutrients whose intake quantities are flexible can be atomized into the air or added to the water supply. Nutrients with more specifically prescribed intake quantities can be programmed for release at specific times or specific events. In order not to change the smell of the air, taste of the food, or color of the water, nutrients can be encapsulated or compressed and coated with neutral, selectively permeable outer shells, or bonded to innocuous carrier molecules.

Scenario

Jill keeps looking out the window as she prepares dinner. Winter came suddenly, and the few people she can see in the streets are clutching their coats tight to their chests, fighting through the bitter cold and heavy snow. She's worried about her young son, William, who will be coming back from school shortly: he hasn't had any of his seasonal flu shots, and Jill just saw a news report that a flu virus has been creeping into preschools across the state.

As soon as William gets home, Jill checks the **Health Assistant** for a report on his biometrics. After a urine analysis, it is confirmed that he has a particular string of influenza, although it's still early enough that he's not exhibiting major symptoms. The **Health Assistant** displays some information on possible medication, as well as dietary supplements the **Nutrient Generator** can provide. Some vitamin C, and other nutrients, should make for a great supplement to the medicine he'll be taking. To prevent an overdose, the **Health Assistant** recommends spraying nutrients on his dinner, rather than atomizing and releasing them into the air.

The next morning, Jill sends out a copy of his nutrient prescription to the school's cafeteria so that they can accommodate an appropriate lunch for William. The **Nutrient Generator** has also provided her with a nutrient pack that she can dissolve in his water bottle. With this regimen, the **Health Assistant** assures her, William should be find by dinner time.

FERTILIZING SYSTEM

The Fertilizing System takes basic components from the waste system, specifically recovered nitrogen, phosphorus and potassium, and recombines them with composted waste to create ideal fertilizer for the home's food production facilities. The Fertilizing System can tailor its output to the specific foods being grown, the season and the regional soil needs, especially if food is being grown outside.

Discussion

Plant growth is facilitated by the combination of essential nutrients, water, and sunlight. These essential nutrients are nitrogen (N), phosphorous (P), and potassium (K), and plants get them from their soil and use them to yield macro-nutrients for human consumption. Potassium, for instance, allows plants to provide carbohydrates, while nitrogen is the key nutrient for the production of proteins. Exhausted nutrients from the soil have prompted several techniques to replenish them. One of them is crop rotation, where dissimilar crop types with specific nutrient requirements are complemented by changing the crops in any given soil to promote its fertility. Another is the use of fertilizer, which replenishes the nutrients directly.

The **Fertilizing System** aims to retrieve as many nutrients as possible from the waste and water systems in order to produce a fertilizer that's rich in the nutrients that are required by any particular crop, as well as the required amount of fertilizer to meet the demands of crop configurations in a particular home. A mature tree, for instance, requires 10 pounds of fertilizer per 1000 square feet of land, compared with merely 2 pounds required per 100 feet for vegetable crops. Given limited land and fertilizer, it would make more sense to grow vegetables. Fertilizer requirements depend on seasonal changes: perennial plants require twice as much fertilizer in the early spring than they would if planted in June.

Scenario

Julia wants to increase her family's vegetable intake this year. She accesses the **Fertilizing System** interface and begins to plan her soil needs. After she enters the types of vegetables she'd like to grow and when she'd like them to be available, the system gives her some feedback. The **Fertilizing System** has almost no nitrogen stores. It normally derives nitrogen from the family's urine, but because all four of her children have moved out, the supply has been much lower than usual. This means she can either buy commercially available nitrogen rich fertilizer, or recalibrate her vegetable goals.

Julia would prefer to keep all of her fertilizer production based in the home. The **Fertilizing System**, in concert with the health monitoring systems of the home, prescribes a portfolio of leafy greens instead. Julia is delighted by the idea of

PROPERTIES

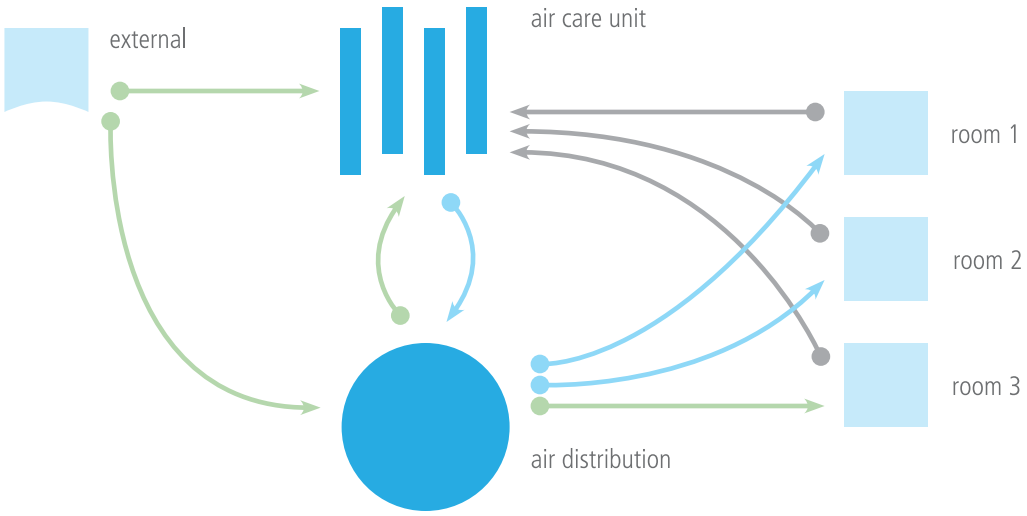
- Machine capable of recombining compost and nutrients
- Supply of nitrogen, potassium and phosphorus provided by the waste system
- Computer interface and software for designing fertilizer

FEATURES

- Adapts easily to crop change
- Responds to crops that require different nutritional needs by differentiating the nutrient mix
- Composes building blocks of fertilizer
- Regulates the output of fertilizer

eating more leafy greens than usual this year, but her husband, who takes blood-thinning medication, has to watch his intake of these types of vegetables. She decides that she'll supplement her leafy-green vegetable supply this year with community sourced vegetables.

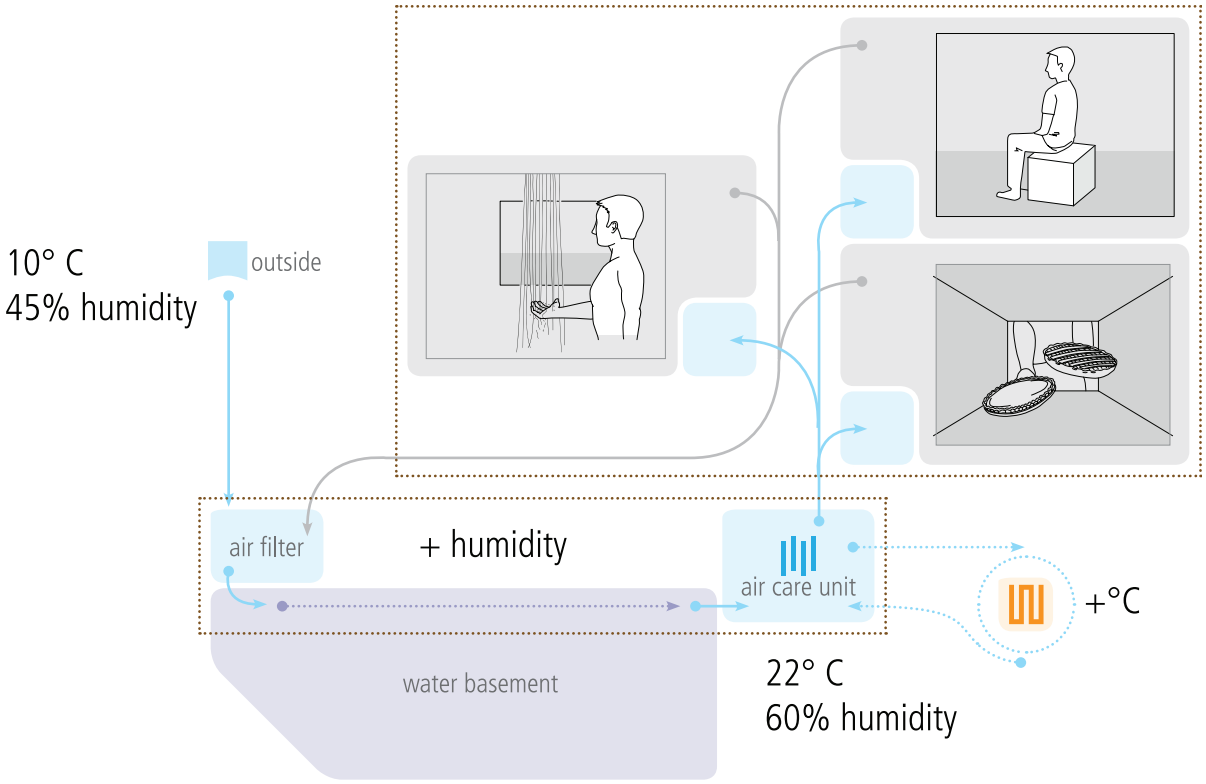
Two weeks later, the **Fertilizing System** alerts her that her first batch of fertilized soil is ready for pick up. She goes down into her basement, scoops out ten pounds, and proceeds to use it on her roof top garden.



CLIMATE

AIR CARE UNIT

The Air Care Unit is responsible for the air quality in the building. It has two parts, a Central Air Care Unit and a Local Air Care Unit. The first stop for the home's air is the Central Air Care Unit, where large-scale corrections are made to air that has been humidified, cooled or heated from the water in the Water Basement. Right before the corrected air is funneled into a room, the Local Air Care Unit makes room specific corrections. Such corrections include air temperature, humidity, scents and speed per individual room profiles.



Discussion

The **Air Care Unit** is part of a system designed to handle basic temperature and humidity issues, based on best practices in terms of passive climate control principles. However, it is also designed to accommodate second-order climate concerns, such as scents, speed or ionization. After air has been drawn in by the **Air Distribution** system, the **Air Care Unit** decides the most efficient means to fulfill the climate profile set by the inhabitants.

For instance, if all the inhabitant profiles prescribe rooms of similar temperatures and humidity, the Central **Air Care Unit** adjusts air above and beyond the corrections made by the **Water Basement**. If the rooms need to vary wildly in terms of climate, the adjustments will be handled by Local **Air Care Unit**s on a per-room basis. In either case, any water from the de-humidifying process is fed back into the **Water Basement**.

The **Air Care Unit** will tweak the temperature (adjusting it by passing it over a heated coil / refrigerated gas), mood (adding scent or negative ions) and speed (if one feels a need for a stronger wind).

PROPERTIES

- Sensors measuring environment (thermometer, humidity, pollutants)
- Nano air filter, electronic hygrometer and humidifying unit
- Interface to system for setting home climate conditions and per-person conditions

FEATURES

- Filters outside air and removes any pollutants
- Measures and adjusts humidity levels
- Tweaks air quality before entering each zone (e.g. adding negative ions, scents)

Scenario

Orlando recently received feedback on the energy use trends in his home. He was surprised at how his family's heating, cooling and energy needs outstripped the amount of energy collected by the solar panels on his rooftop. In addition to setting up automatic energy usage limits, he's programmed his **Air Care Unit** to keep the home's temperature and humidity as close as comfortably possible to the **Water Basement**'s corrections.

The Central **Air Care Unit** will make such corrections (within a comfortable range) and distribute the air to all the other rooms of the house. The Local **Air Care unit**s will not be used as part of this strategy. A few months later, it's clear that the adjusted profile has paid off. Orlando's home no longer draws energy from the grid, except for the occasional cloudy day.

This Thanksgiving, Orlando's parents are visiting. They are very sensitive to the cold, and complain when the temperature dips below 75. But they also complain when the temperature exceeds 82. Since Orlando plans to do a lot of cooking for Thanksgiving, he's worried about roasting his parents in the process!

To remedy the situation, he asks the **Air Care Unit** to rapidly adjust the temperature and humidity of any room occupied by Grandma and Grandpa to their comfort zone. If the room is occupied by other family members, the air profiles are averaged in the favor of the grandparents. After three days, everyone has managed to stay comfortable and happy, despite the intense cooking in the kitchen and the near-zero temperatures outside. Next month, when Orlando notices slightly higher climate energy consumption, he knows it's been worth it.

AIR DISTRIBUTION

PROPERTIES

- Air temperature control channel
- Lightweight channels throughout the home
- Automatic fan units used to draw air in from the outside, vents throughout the home

The Air Distribution system is comprised of a number of channels that run in the walls and/or floors of the building. It is responsible first for drawing air into the home over the Water Basement so that the air-temperature is adjusted to about 20°C. It then distributes air after after it has been prepared in the central Air Care Unit, terminating at each local Air Care Unit. If the target room does not have a window for releasing built-up air, the Air Distribution system can evacuate air as well.

Discussion

The **Air Distribution** system is the respiratory system for the house. It is responsible for pulling air into the system, sending it where it needs to go and releasing it back out if necessary. It monitors the environment and responds by structurally changing the parameters of the home (e.g. create an opening to let air in/out)

and to command action within the system. Depending on the heating or cooling trends required inside the home, it will decide whether or not to leverage the outside air.

If outside air is used, it enters into the system via the vertical garden. The plants act as a first filtration layer. The air is then drawn over the **Water Basement** in an air duct where the air takes on the water basement's temperature and humidity.

From here the air is pulled into an **Air Care Unit** where the humidity levels are adjusted and toxins removed. Any water from the de-humidifying process is fed back into the **Water Basement**. The **Air Distribution** system then supplies air to every room of the home. This system is comprised of a number of flexible channels that runs in the floors of the building.

In areas where cross-ventilation is not possible, the **Air Distribution** system is extended into an Air Outlet, facilitating the movement of air out of the home with a reversed fan. This function is specifically important for places like bathrooms and kitchens where moisture and smells can build up.

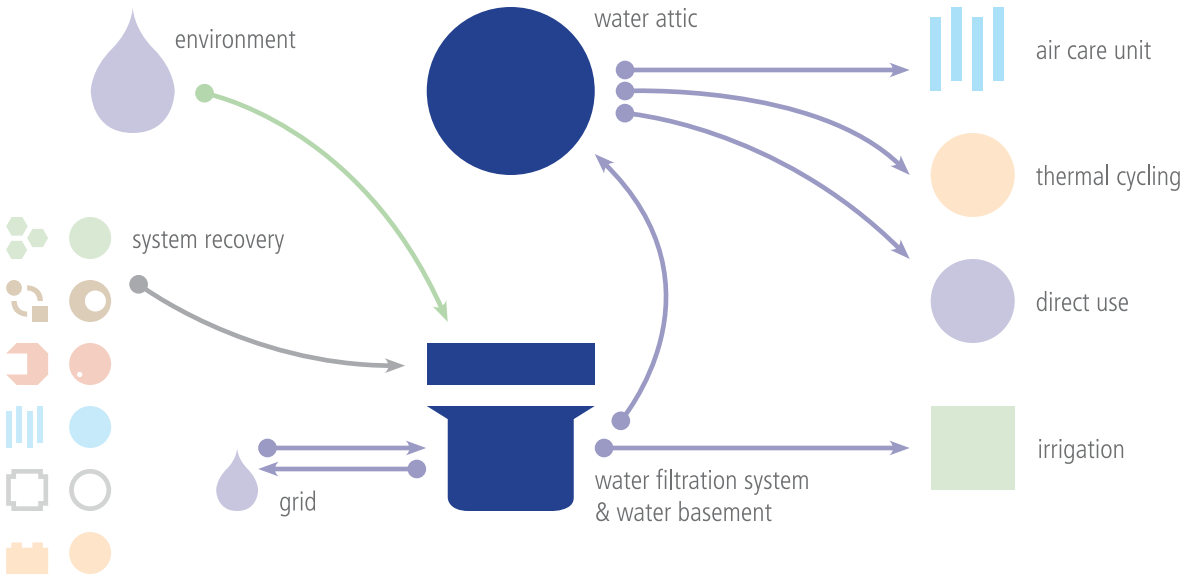
FEATURES

- Draws air over Water Basement, naturally adjusting the temperature to 20°C
- Distributes air into home via air channels
- Provides air drawn in from the outside.

Scenario

It's been a sweltering summer. Margaret's home draws air in from the outside through the side of her home covered in trumpet vines. The air passes over the **Water Basement**, and becomes a satisfying 70 degrees and somewhat less humid. Months ago, when the weather was much colder, the **Water Basement** levelled the air to the same degree. After an adjustment in the Central **Air Care Unit**, the **Air Distribution** gently moves the air through channels throughout the inner walls of the home. After the Local **Air Care Unit** adjusts further, the air enters the room.

Two of the rooms, a spare bathroom and a large walk-in closet, have no natural ventilation. On regular intervals, the **Air Distribution** system activates Air Outlets that pull air out, and back into other rooms with windows for release.



WATER

WATER ATTIC

PROPERTIES

- Site specific water catchment system
- Permanent water storage element

FEATURES

- Collects available water from environment and atmosphere
- Stores water supply for dry spells

The Water Attic is an elevated temporary storage tank, allowing water to be fed to various systems in the home using gravity to generate water pressure. Depending on the capacity afforded by the construction of the home or collection of homes, the Water Attic can save a significant amount of energy. Water is pumped gradually into the Water Attic at low energy until the element reaches capacity, but the element is able to release water at a high flow rate through low impedance distribution pipes.

Discussion

The **Water Attic** capitalizes on the intermittent water usage in typical home activities. It draws water from the **Water Basement** typically at a slow rate of replenishment. This replenishment rate is adjusted dynamically based on water usage patterns by the home's **Response Network**, accounting for anywhere from seasonal to second by second behavior mapping. The system therefore learns to become more and more energy efficient over time. Everything can still be manually adjusted or customized based on user preference.

The **Water Attic**'s capacity is dependent on individual home construction. The pressure, pressure duration, and flow rates are dependent on a mix of home construction and user-specific settings. For the majority of usage cases, the **Water**

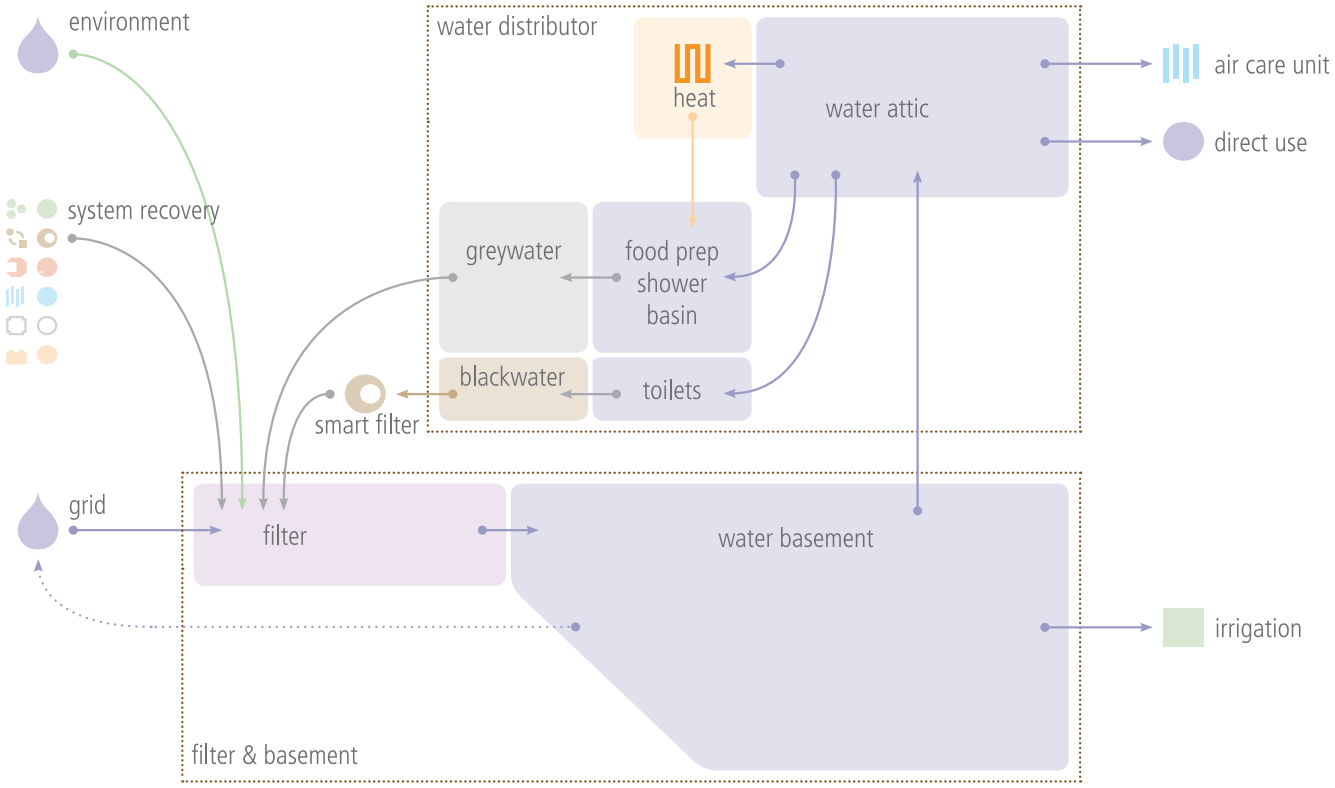
Attic should be sufficient to provide the desired pressure without accounting for replenishment. For long, sustained water usage, the replenishment rate can increase appropriate to demand.

The **Water Attic** is a closed system drawing exclusively from the **Water Basement**, guaranteeing sustained potability. Water exiting the **Water Attic** is heated at point of use depending on the desired temperature.

Scenario

Janice takes a shower in the **Grooming Suite**. The Omni-Shower dispenses water at a moderate rate, one accomplished by gravity alone. The water for her shower originates in the **Water Attic**. Since Janet lives in a dry and warm area, the **Water Attic** was installed inside her home, right under the roof, to keep the water at a more modest temperature. Her best friend Dieter, who lives in Portland, has a **Water Attic** installed outside of his home, on top of his roof.

When Janet toured Scotland a month ago, her **Water Basement** and Attic reached full capacity after a week. Her neighbor Doris, who was gathering Janet's mail, noticed this and called Janet. Doris explained that the home had decided to collect no more water since its reservoirs were full. She also explained how Janet's lawn was drying up due to the unseasonably warm weather. Janet, realizing how much work she'd have to put back into her lawn when she got home,



asked Doris to alter the home's water reclamation efforts, and to activate the sprinkler system. When she returned from touring, her lawn was in good shape, and she turned the sprinkler system off. Within a week, the Attic was back at full capacity.

WATER BASEMENT

PROPERTIES

- Site specific water catchment system
- Permanent water storage element
- Water treatment unit that filters and treats water
- Water heating device

FEATURES

- Collects available water from environment and atmosphere
- Stores water supply for dry spells
- Facilitates treatment of water from different sources
- Pumps water to elevated Water Attic for use in house
- Heats water at point of use

The Water Basement is large reservoir or series of reservoirs beneath the habitable space of the home. As an intermediary between purification and usage, Water Basement is the main source of all water supplied to the home's internal and external systems. Located at and/or below the foundation level, the Water Basement is the central repository for potable water, kept at a depth geographically appropriate to insulate against climatic changes and fluctuations in temperature. In addition, the Water Basement serves as a thermal acclimater for the air entering the home, heating cold air, cooling warm air, and humidifying dry air.

Discussion

The **Water Basement** provides a large reservoir or series of reservoirs in which to store both water collected from the environment and water reclaimed from systems within the home. Collection would be primary from rainfall but potentially from other water collection methods, such as condensation, thawing, or harvesting from running or standing water.

Within the bounds of architectural, geographic, or financial limitations, the **Water Basement**'s size is maximized to provide the largest capacity available. Where this capacity is insufficient, water supplied at a local or municipal level would supplement levels in the **Water Basement** when necessary. Because most natural water sources such as rain are sporadic, the **Water Basement** is scalable to optimize the storage capacity needed to provide constant outflows to last through shortages and dry spells.

The relative depth of the **Water Basement** is variable based on the specific regional needs of the home. As a general rule, the greater the extremes of temperature and climate changes, the greater the depth to which at least the first reservoir of the **Water Basement** is situated in order to find a stable locational temperature. The target temperature of the **Water Basement** should be around approximately 22° C.

Purification of incoming water occurs at the Water Filter before entry into the **Water Basement**, while the existing water in the reservoir(s) is continually cycled through the Water Filter as a safeguard to maintain purity. From the **Water Basement**, water is output to areas such as the **Water Attic**, maintenance and hygienic systems, irrigation, or general use.

Scenario

After a painful breakup, Chris decides to take his mind off of things, and has started growing his own vegetables in his house. The inside of his house is now a jungle of herbs, peppers and even root vegetables. Since his home wasn't designed for internal irrigation, Chris has jerry-rigged an irrigation system. While there are several generalized outputs from the **Water Attic**, Chris was reticent to draw water from the same source that provides water to his **Grooming Suite** and **Meta-Washer**.

Chris has created an irrigation system that draws directly from the **Water Basement** instead. The water that pulls from it is a constant 22 C and is always fresh since it is continuously filtered by the **Water Filtration** system. Since he lives in Tucson, AZ, his **Water Basement** is larger than his parent's home in Chicago, IL. Tucson's rainfall is half of Chicago's, so his **Water Basement** is approximately twice as large. The Arizona rainfall has been much higher than normal, so Chris doesn't worry about his hobby robbing him of water he'll need to live.

Six months later, Chris meets a botanist and falls in love.

WATER FILTRATION

Using a combination of simple filtration and biological cleaning, the Water Filtration system ensures that any water that enters the system is of potable quality.

Discussion

Before the dawn of civilization, there were 326 quadrillion gallons of water on the earth and there will be no more or less in 2050. The problems are the distribution and quality of water. For the home to be efficient, it must collect the necessary water from the environment and reuse every drop of water that goes into the system. With the advancement of nano-filters and our growing understanding of biological water treatment, this is possible.

The first step is to collect water. In rainy areas, the rain that falls on the roof is collected via channels. Any run-off water and water collected from hard surfaces (roads, side walks) are caught through a network of under ground pipes. Water from wells, rivers, sea (desalination), lakes (both under and above ground) are also harvested where necessary.

The **Water Filtration** unit ensures that any water that enters the system is of potable quality. It works on two principles: simple filtration and biological cleaning. The complexity of treatment will depend on the water quality that enters the

PROPERTIES

- Nano filtration, allowing for massively parallel filtration to happen
- Sophisticated chelating system for neutralizing harmful molecules
- Multiple water sampling probes, capable of sensing toxicity

FEATURES

- Cleans black water and grey water from the home and from the outside
- Sustains a continuous cleaning cycle.

unit. As water enters the unit, the quality is tested and the suggested treatment route followed. Water collected from the environment will not need a great deal of treatment unless there are serious contaminants found. Water collected from the home will need more rigorous work. This includes water from the **Omni Shower**, the **MetaWasher**, the basin and sink. The **Smart Waste Filter** is designed that any other liquid such that is contained in waste (such as food) is extracted for re-use.

Once the water is cleaned, it is send to a second chamber in the water basement from which the water is pumped into a **Water Attic**.

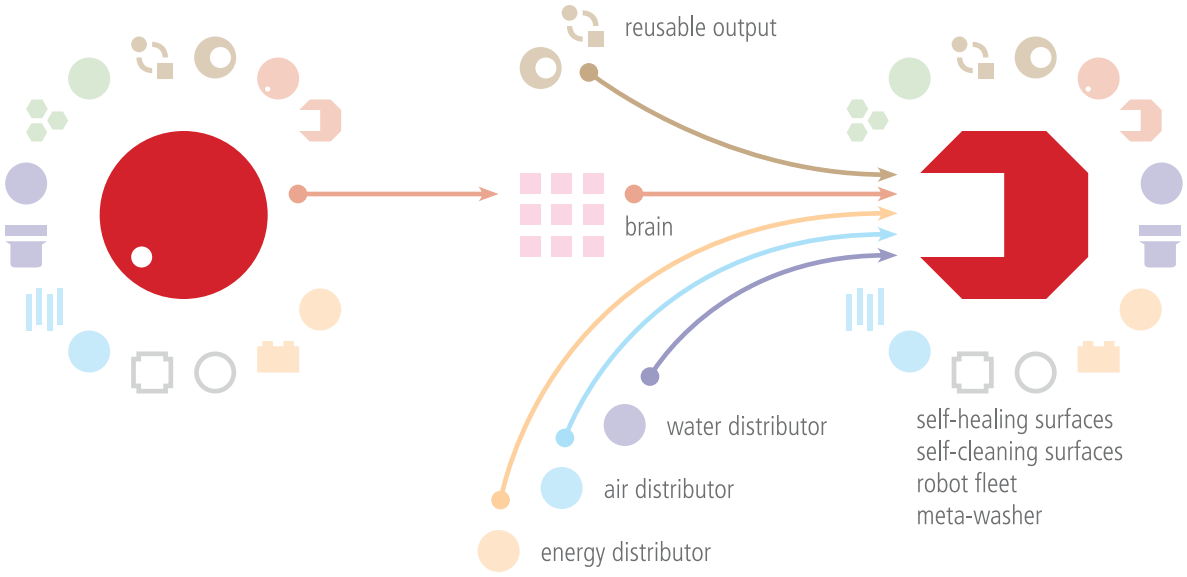
Scenario

The high rise next to Mark's home is being power washed for a week. Water is sprayed at high intensity in order to remove soot, grime and other environmental debris. The power washing crew has taken great care to funnel the rivulets of water into a temporary channel, which in turn deposits the dirty water into the sewer outside of Mark's property.

After a few days of deliberations, Mark realized that the sludgy, slurry-filled water is a golden opportunity to reclaim more water after a two month dry spell. His **Water Basement** was fed water from the grid and Mark was paying a higher water bill. He asked the workers if he can redirect the large plastic hose up his lawn and into the the same outputs as his rain gutters. They approve, and the watery, chunky mess wends its way into Mark's home.

He alerts his **Water Filtration** unit to exercise greater care in monitoring the **Water Basement**'s water. As the watery slurry enters into his water system, the **Water Filtration** unit works at full speed, removing particulates and street chemicals as they come in. These impurities are then fed into the waste system's Smart Filter.

After a week, the cleaning crew leaves and takes their hoses with them. The additional water fills Mark's **Water Basement** to capacity. He breathes a sigh of relief. It will be two months before he'll have to connect to the grid again.



MAINTENANCE

SELF-CLEANING SURFACES

Self-cleaning Surfaces have nanotechnology based coatings, which can be applied to most surfaces, allowing them to repel solvents and break apart organic molecules. These surfaces become impermeable, antibacterial, and odor-repellent: this facilitates cleaning significantly for surfaces inside the house, whereas outside surfaces clean themselves naturally through wind and rain. Overall, this eliminates the need for chemical solvents.

Discussion

Much time is spent in keeping a household clean. The kitchen, bathrooms, and most communal areas, like living and dining rooms require to be cleaned, often to promote a hygienic environment and the well being of the inhabitants. Unfortunately, the tasks associated with cleaning are often laborious and require many different cleaning tools and materials, some of which are toxic and harmful for the environment. Recent research has explored the viability of **Self-Cleaning Surface** coatings that will facilitate these tasks considerably and go a long way towards maintaining a sanitary and sterile environment for the home dwellers.

PROPERTIES

- Nanostructured surface or nanoparticle coating, offers no tactile difference to texture
- Applied to glass, plastics, textiles, and most other materials inside and out of the house
- Photo-catalytic capabilities
- Modified titanium-dioxide particles
- Super hydrophobic characteristics
- Antibacterial, antimicrobial and self-sanitizing

FEATURES

- Repels water, oils, hydrocarbons and other solvents
- Breaks apart organic compounds in reaction to light, killing bacteria and odors
- Eliminates need for chemical solvents and other specialized cleaning materials
- Facilitates cleaning
- Poses no problem for human contact or skin irritation
- Protects the material it is applied on, prolonging its usefulness

Certain organisms in nature like caterpillars, water striders, and the lotus flower achieve super hydrophobia, a high degree of water repellence, because of the characteristics of their surface. It is usually composed of a two-level structure that includes a hydrophobic waxy surface made super hydrophobic by the addition of microscopic hair-like structures that make it impossible for water droplets to stick. Called the "lotus effect", super hydrophobia affords surfaces a self cleaning characteristic by making them non-stick, allowing dirt or other particles to be easily cleaned off a surface without the need for chemical solvents, and sometimes without even water. Research has been focused on recreating this effect through the use of nanoparticle technology to create microscopic pillars, some times called nanonails, which much like the hair-like structures of the lotus flower, form a structure which is impenetrable by water or other solvents.

Another characteristic of this technology is that it is antimicrobial, antibacterial, and in effect self-sanitizing. This is done through a process of photo-catalysis, where microscopic particles of modified titanium dioxide in the material's surface react to light and become oxidizing, killing bacteria and breaking down organic compounds and effectively sterilizing the surface.

The **Meta-Washer** is ideal for cleaning items with these kinds of surfaces, allowing objects ranging from dishes and eating utensils to clothes to be easily cleaned through water rinsing and pressurized air. Other surfaces outfitted with this technology, such as counter tops and floors, can self-clean through the circulation and filtering of air within the home or with assisted cleaning tasks performed by the **Robot Fleet**, while rain and wind help maintain the cleanliness of the house's exterior.

Scenario

Every other Thursday Janet has some friends over to catch up with their lives and then maybe watch a movie or two. This time one of them didn't make it, but the other two showed up at the door at around seven at night: one of them brought over some leftover lasagna, and the other some chips and spicy salsas. The friends are planning on watching a romantic comedy as soon as they're done talking about their own romantic episodes of late.

Halfway through the conversation the place is already messing up. It was raining outside so Janet's friends tracked some mud into the house. The plates where the lasagna was served are now smothered with marinara sauce and bits and pieces of cheese and pasta. Janet isn't that worried, however, as she knows it'll all be a breeze to clean once her friends leave. She drops the plates by the kitchen and brings the chips and salsa with her for their feature presentation.

The **Self-Cleaning Surface**s on both the floors and the plates have been breaking down the dirt and food waste, and by now the floor should be spot free as the dirt got carried away by the **Air Distribution** system, and the plates on the kitchen keep the food waste from crusting. As soon as the movie's over, she'll put

everything, salsa bowls and all, into the **Meta-Washer** and look for anything she might need the **Robot Fleet** to clean.

Little after the movie credits roll and Janet's friends have bid their farewells, there's a couple things that need to get done before Janet can go to bed. There's chip crumbs everywhere, and one of the girls accidentally dropped some salsa on the coffee table. As soon as she's set the **Robot Fleet** to pick up the crumbs and some leftover dirt from the mud, she picks up a dry napkin and wipes the salsa from the table herself. The **Self-Cleaning Surface**s make everything much more easier to clean: sometimes doing the cleaning herself is even quicker than instructing the **Robot Fleet**.

After a successful Thursday get together, Janet is ready to head to bed. In two more weeks her friends will be over again with new dishes and snacks to challenge the cleaning technology the house is equipped with.

SELF-HEALING SURFACES

Self-Healing Surfaces are made of self-healing composite nanotechnology that allows them to initiate self-repair mechanisms to counteract degradation due to wear or tear. These nanotechnologies are based on either liquid-based self healing agents, where microcapsules embedded in the material are ruptured when damage is incurred, releasing liquid healing agents that polymerize when mixed, or on solid-based healing agents, where a supermolecular material reacts to heat (produced by an electric charge) by disassociating its non-covalent bonds, and restoring them in the cooling process.

PROPERTIES

- Composite self-healing nanotechnology embedded in a material
- Composite self-healing nanotechnology applied as a coating
- Compatible with most materials
- Liquid-based healing agents
- Solid-based healing agents

Discussion

A self-healing material is a material that can partially repair damage incurred due to environmental conditions, fatigue, or through the course of its operation. This damage is often on a microscopic scale, degrading the structural integrity of a material over time and eventually causing it to fail: it might break or bend more easily. It can also degrade the aesthetic integrity of a material, where its surface or coating can become dull or scratched. Self-healing materials address the degradation by initiating repair mechanisms in response to microdamage.

Several mechanisms have been proposed and researched, but so far two seem to show the most promise. These can be either categorized as liquid or solid-based healing agents. Liquid-based healing agents are composite polymers or polymer coatings that contain microcapsules which are ruptured when the material is damaged. A ruptured microcapsule releases healing agents through capillary action, permeating the area where the damage has occurred. When the healing

FEATURES

- Responds to micro-damage by initiating a repair mechanism
- Self-heals automatically or through heat reaction
- Extends material's lifetime and usefulness
- Eliminates need for frequent maintenance and upkeep
- Protects surfaces from scratches and dullness
- Sanitizes surface when material is also outfitted with self-cleaning surface

agents mix, a polymerization reaction takes place that hardens the liquid agent, partially healing the area affected.

A solid-based healing material, on the other hand, is a supramolecular polymer formed by reversibly connected non-covalent bonds. These bonds will break when heated, and upon cooling will form new bonds, potentially healing any damage. This method does not require reactive chemicals or catalysts like some of the liquid-based healing agent materials, and is not considered autonomic since it requires external intervention to initiate the healing response.

Self-healing technology has been researched for a number of different materials. Some of these include metals, polymers, ceramics, cemetitious, elastomeric, and fibre-reinforced composite materials, making it an ideal technology for use inside and out of the house to prolong the usefulness and life cycle of the materials, from building materials to kitchen counter tops. The technology also works if applied as surface coating and has been found to increase the reliability of rust-proofing and the longevity of paint.

Scenario

Jessica's out of town on a business trip so it's up to John to take care of their son. Jimmy finished his homework early and is now outside playing some basketball with his neighbor while his dad fixes them some sandwiches in the kitchen. They're both shooting some hoops, but neither of them have been playing for long so most of the balls end up hitting the side of the house. John can hear most of the thumps from inside the kitchen, but he knows that the house not only has superior shock absorption, but it's equipped with **Self-Healing Material** technology that allows the material to self-repair even the microscopic tears that eventually build up to the noticeable wear.

He is using the technology, as he cuts the lettuce for the sandwiches on the kitchen counter top and the slight line patterns carved into the surface vanish almost immediately. The **Self-Cleaning Surface** embedded in the counter tops allows them to also self-sanitize while they heal, ensuring that the surfaces are reliable enough to use for food preparation.

A couple minutes later the food's ready and John calls the kids in. As they rush through the house entrance they're pushing and shoving each other enthusiastically, slamming their feet on the floor and brushing against the walls. John reprimands their behavior immediately, but not because he's worried they'll scratch the floor or the walls. He is assured that the **Self-Healing Material** technology throughout the house has made materials tougher, but he is worried that one of the kids could accidentally fall and hurt himself—unlike the materials, they can't self-heal as quickly. And after all, he needs them ready and able, since John's

NANOSENSOR ARRAY

An array of microscopic, low or self-powered, and wirelessly networked nanotech devices integrated into the infrastructure of the building that will provide pervasive sensing of the environment, system condition, and utility usage through a combination of sensing technologies (e.g. acoustic, chemical, magnetic, environmental, etc.)

Discussion

A sensor is a device that can measure physical quantities and convert them into data that can be read by another device or an individual. There are many different types of sensors, and their applications are innumerable. For instance, a smoke detector which is required by law in the US under the NFPA fire code relies on the data provided either by optical sensors, ionization sensors, air-sampling sensors or carbon monoxide and dioxide detection sensors.

When smoke is detected, the device issues a signal that could then trigger a fire alarm system. We've become further dependant on sensors for other issues as well, relying on infrared, proximity, and acoustic sensors for surveillance and home invasion detection; temperature, humidity, and pressure sensors for climate control and weather forecasting; and flow and current sensors for metering and utility usage, among others.

Nanotechnology will allow these sensors to shrink to microscopic levels, affording them the capacity of becoming pervasive and redundant within the home monitoring system. The redundancy of the sensors acts as a fail-safe against system failure in that monitoring can still take place if a given number of sensors malfunction. Given that these sensors are microscopic, they can be either self or low-powered and could be charged through **Wireless Charging**'s inductive charging capacity.

These nanosensors can be integrated into the floors, walls, ceilings, and other components of the house to effectively produce distributed sensing that can easily be configured and mapped throughout the spaces of the house and their monitoring needs. Rather than require a limited number of smoke detectors in specific rooms of the house, following the previous example, the **Nanosensor Array** will provide ubiquitous sensing through the wireless networking of the devices, and monitoring that will allow the central processing unit to not only detect the presence of smoke, but also be capable of measuring its levels and precise distribution to detect the degree of threat that the incident poses. This is helpful in determining the root cause of the incident, further emergency procedures, and possible false alarms.

PROPERTIES

- Microscopic, pervasive and redundant nanotech sensing devices integrated into floors, walls, ceilings and other components
- Multiple sensing technologies
- Low or self-powered
- Networked with each other
- Wireless data transfer system

FEATURES

- Senses flow, temperature, pressure, humidity, chemical compounds, magnetic fields, vibrations and acoustics, light, density, etc.
- Transmits and relays data within the array and unto the central processor
- Acts as primary means of sensing within the house
- Provides constant and real-time monitoring
- Allows for customized sensing and monitoring parameters

Scenario

The **Nanosensor Array** has picked up movement in the house and has identified that one of the residents is up. Jerry is in his pajamas, yawning as he heads for the bathroom. He likes to set the temperature cold so he can sleep under a padded quilt at night, but as soon as he's up in the morning the temperature needs to be adjusted for him. The **Nanosensor Array** is constantly monitoring temperature and humidity and feeding that information into the **Air Care Unit**, the main air regulator in the house, so that it can promptly and properly make the necessary changes according to Jerry or any other resident's preferences.

While Jerry is brushing his teeth and washing his mouth, the **Nanosensor Array** is determining the amount of water being used, the pressure with which it is flowing, and the levels of chemical compounds present in the water. The first set of data is being used for the purpose of metering and measuring utility usage; the second set, to determine that water distribution is working as it should; and finally the third set verifies that the water is potable, ensuring the home owner's well being. Jerry's activities in the bathroom are unencumbered by these system processes running in the background, but had the water been contaminated, he would have been alerted by the central monitoring system that the **Water Filtration** System was undergoing repairs.

As soon as Jerry steps into the shower, the hot water from the Omni-Shower creates a steam cloud that alters the normal configuration of air and humidity in the environment. The **Nanosensor Array** determines the changes in the environment and identifies them as harmless, and even routine-the data log has long indicated the patterns of occurrence and recurrence of these environmental changes at around the same time every day. After his shower, Jerry will get dressed, have some coffee and head out without breakfast, like he does most of the time.

META-WASHER

The Meta-Washer is an integrated multi-function appliance that assists with the cleaning of items like utensils and clothes, the disposal of food waste and house waste, and the outlet for water provision.

Discussion

Throughout time we have developed appliances that aid in relieving people of most manual labor and assist considerably in carrying out tasks that most households have in common. Garbage disposal units installed under the sink have facilitated the disposal of food waste, while dish washers have substituted the task of manually scrubbing dishes and kitchen utensils. We no longer require the time or space needed to hang wet clothes to dry as the tumbling and heating

mechanisms in a clothes drier make the task quicker and less laborious.

The **Meta-Washer** consolidates a number of functions carried out by appliances like these by making use of technological developments like **Self-Cleaning Surface**s to become more efficient and space saving. The appliance's main functions are washing and cleaning, waste disposal, and water dispensing, and is therefore connected to the water mains as well as the waste system and **Smart Waste Filter**. The appliance is compartmentalized with distinct drawers where either items are stored for washing or introduced as waste for disposal. The connection with the water distribution system affords the integration of water dispensing, and the air compressor and electrical heating used for the wash cycles allow the unit to regulate water temperature on-demand when dispensed.

Items with **Self-Cleaning Surface** coatings, like dishes, eating utensils and clothes, can be cleaned by rinsing with water and pressurized air. The **Meta-Washer** relies in the ability of these coatings to repel solvents and break apart organic molecules. This facilitates significantly the procedures needed to clean the items with these surfaces, reducing the amount of water required and eliminating the need for detergents and other chemical solvents. The **Meta-Washer**, however, is still outfitted with the required mechanisms to appropriately wash and sanitize items that lack self-cleaning functionality by using a larger amount of water and commercially available eco-friendly chemical solvents.

A waste or garbage disposal unit attached to the **Meta-Washer** disposes of food waste and dirt removed from the items it has washed. It also serves as the primary unit for house waste disposal, eliminating the need for garbage bins, where waste is stored temporarily before disposal, by quickly processing the waste into the waste system.

Scenario

It's getting dark outside and Jennifer is walking into her house. It was a long day at work, and she's noticeably tired. Earlier that day she bumped into someone on the street and spilled some coffee on her overcoat, and although the stain is barely visible since the textile is coated as a **Self-Cleaning Surface**, there's still some leftover residue that needs to be cleaned before she would want to wear it again. She'll take care of that, and grab a quick bite before heading for bed.

Jennifer heads for the kitchen as she pulls off her coat and wraps it into a small bundle. She gets some bread slices ready for toasting and reaches for the top compartment of the **Meta-Washer** to throw the neat little bundle in it. The **Nanosensor Array** integrated into the appliance self configures the wash cycle while Jennifer gets the rest of the ingredients for her sandwich: some synthetic bologna, swiss cheese, and greenleaf lettuce. Before putting it all together, she hears the **Meta-Washer**'s rinse cycle start and figures any moment now it'll be done.

PROPERTIES

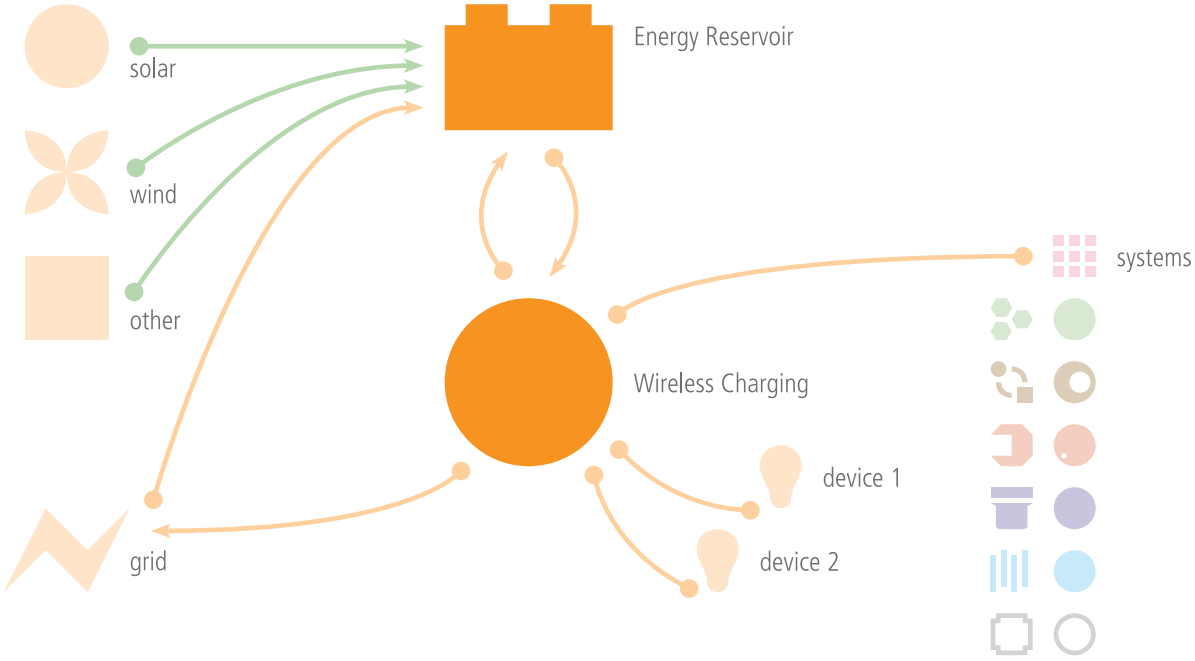
- Self-standing machine component
- Multiple compartments or drawers with racks to facilitate storage or waste disposal
- Touchscreen control interface
- Visual and audio signal and alert system
- Air compressor
- Electrical heater
- Garbage disposal unit connected to waste system
- Water tap

FEATURES

- Removes waste particles with water rinsing and pressurized air
- Disposes of waste into waste system
- Senses contents to determine most efficient wash cycles
- Dispenses water for external use
- Heats and cools water on-demand
- Facilitates house waste disposal for processing

Jennifer piles one bread slice over the other and cuts off the edges, something she got used to since she was younger. The **Meta-Washer** emits a small sound and its touchscreen indicates it is now drying the garment. The sound of pressurized air is barely audible as Jennifer finishes putting her sandwich together. She reaches for the lower compartment of the **Meta-Washer** and disposes of the bread edges she cut earlier, then decides she'll have a glass of water with her dinner when she eyes the water tap on the appliance.

The **Meta-Washer**'s touchscreen display lights up indicating that the washing is over and that the waste has been disposed of as Jennifer fills up a glass with water that's preset at her favorite temperature. The glass is set in the counter as she pulls out her coat and unbundles it. She decides she'll store it in the morning, and puts in on the side as she picks up her sandwich and glass of water: she'd rather go to bed sooner rather than later.



ENERGY

WIRELESS CHARGING

Wireless Charging consists of a system wide energy distribution system based on electromagnetic induction and magnetic resonance. Induction Panels are a unitized and/or custom fit mesh embedded under the floor and within the walls, serially extended to other surfaces such as tables

and counter tops. In some cases, the induction capabilities are be fully integrated into the basic structural materials. This allows small devices and low-demand appliances to receive power by contact or near-frequencies contact with the structural elements of the house. Appliances with higher energy requirements beyond the capabilities of induction are supplied wirelessly through magnetic resonance.

Discussion

The wireless power distribution system provided by widespread induction capable surfaces and supplemented by magnetic resonance allows every single device in the home to be untethered. This alleviates the need for specific electrical outlets except in the rarest of circumstances, or as a backup. Consumer electronics, nanobots, and maintenance systems operate with full freedom of movement within the boundaries of the home, and in some cases, to a limited distance outside the home.

Sensors spread along induction surfaces and electronic tagging embedded in objects and devices allow elements within the home to be recognized by the home computer system. Induction surfaces can thereby configure extremely specific areas to serve different power consumption requirements, or even deny power output.

Magnetic resonance transmitters are embed their resonance with information packets which require a limited reciprocal response from any device with a magnetic resonance receiver. Transmitters encode their resonance by using specific, rapidly changing frequency patterns. This allows energy transmission to be selective by device and protected from energy freeloaders.

Scenario

To Paul and Heidi, family life was an intense, crash-course in constant change and upheaval. As parents, it sometimes felt like a losing battle. With their children, Becca and Robert, passionate interest became a passing fancy. They accumulated physical storage spaces full of musical instruments, sports equipment, special shoes, and art supplies, and consumer electronics, and a far more extensive volume of virtual storage. Frustratingly, neither child had interests or hobbies that another one left behind— instead always finding things completely new.

With each new changing interest came a different vision of their personal space. When the children became teenagers, Paul felt as if every day he walked into their rooms it was somebody else's house. Not just the wall displays, but the furniture and appliances migrated all over the place, and sometimes out of the room. Heidi eventually configured the permissions on both wireless communication and wireless power systems so that Becca and Robert had to bring their devices back to their rooms to make them work.

PROPERTIES

- Embedded electromagnetic induction linked to the energy distribution system
- Standardized magnetic resonance transmitters and receivers
- Encodable magnetic resonance for security reasons
- Responsive surfaces that transfer and optimize power flow to specific localized areas
- Scalable power transfer based on device requirements

FEATURES

- Eliminates the need for plugs and wires
- Charges every kind of appliance that has energy storage capabilities
- Provides wireless power within a radius outside the home
- Allows almost every home device to become portable
- Allows multiple magnetic frequencies

The children eventually left for college. That first weekend, Paul and Heidi rearranged everything in the home in the span of half an hour, without having to plug or unplug a single device, thanks to **Wireless Charging**. Cooking on the south side of the house instead of the north side felt different, but somehow empowering. Sitting down at the dinner table, just the two of them, they had a conversation about getting a dog.

ENERGY RESERVOIR

PROPERTIES

- High capacity energy storage
- Battery/ultracapacitor hybrid systems based on barium-titanate powders
- Modular and scalable, with an array of interconnected, user replaceable storage cells
- High cycle efficiency
- Gated inputs and outputs
- Local sensors integrated with central computer system for monitoring

The Energy Reservoir is a high capacity rechargeable energy storage system based on ceramic ultracapacitors with barium-titanite dielectric technology coupled with next generation batteries. The Energy Reservoir stores electricity obtained from the system's power generation modules or from supplements provided by a larger community, city, country or continent grid. The high yield storage capability coupled with a capability for quick charging and discharging on demand smooths out the patterns/fluctuations in power continuity from renewable energy sources or grid outages.

Discussion

Ultracapacitors are coupled with high capacity batteries into units that both protects the battery health and allows for fast, high delivery charging and discharging. Multiple capacitor/battery units stacked in large arrays form the **Energy Reservoir**. As such, the size and overall shape of the **Energy Reservoir** can vary to fit power requirements or space constraints. In addition, failure of a specific capacitor/battery unit has a minimal effect on performance, as it represents a small percentage of the total system.

The ultracapacitance of the **Energy Reservoir** smooths energy inflows and supports momentary-load devices. All power inflows are therefore routed to the **Energy Reservoir** before distribution. This eliminates load shedding in all but the most extreme of circumstances. With the intermittent nature of most renewal energy sources and the influx potentially created by electrical storms, it is important for the home to capitalize on high energy sources when available without overloading any devices connected to the system.

An abundance of stored energy allows the home to operate at a normal power draw even when there is no power being generated, like a camel storing water in its hump. An overabundance of energy storage capacity can be utilized during times of emergency, sold back to the grid as a private source of income, or shared with neighbors or community.

Each capacitor/battery unit is outfitted with basic sensors such that the entire

Energy Reservoir can provide diagnostic information for the home's computer system. The home's computer system regulates the inflows, outflows, and routing of power through the unit array.

FEATURES

- Provides constant, stable energy output
- Cycles (charges and discharges) almost endlessly without deterioration
- Scales based on region- or use-specific storage demands
- Enables energy to be commoditized by all homeowners
- Provides input and output-specific feedback on energy usage and fluctuations

Scenario

Tyler was born and raised in Wrangell, a small island town off the southern chain of Alaska with five major fisheries but only two thousand permanent residents. Tyler is sixteen years old and on his own, sharing a house with his best friend and co-worker, Andy. Every day, he drives an old beat-up electric station wagon seven miles to work at the docks, a car he bought for one one-hundredth the cost of a new car.

Andy's a born fisherman, and has no strong desires than to own his own boat, with his own crew, and spend hard nights out in the northern Pacific. Tyler, though, counts every dollar, eats pop-tarts and the same ham sandwich every day, hoping to save enough to move to Juneau, a place with more than two bars. From there, he imagines, he'll make enough to head somewhere warm and far away. Like Morocco.

The fishing season in Wrangell only lasts the six months from late spring to early fall. In late July the sun might set at 1am, only to rise again at 3. But the winters go very dark, and there's little work, to the point where state legislation subsidizes a fair amount of permanent residents to support them during the months of the off-season.

Right before winter, Andy and Tyler swap out all their solar panels for wind turbines. Saving energy won't be a priority for them. They fight seasonal affective disorder by leaving all the lights on and putting tropical scenes and women in swimsuits up on the walls. Their **Energy Reservoir**, charged by all the summer activity, comes in handy. The turbines aren't enough to power everything, but every little bit helps, and they most of the summer's sunshine stored away to carry them through.

ENERGY GENERATION MODULES

Based on the premise that houses will be built on a microgrid electricity infrastructure, the Energy Generation Modules represent a set of standardized component options for localized power production. The typical home is outfitted with several universal modules for energy generation: solar, wind, and mechanical. These modules are replaceable and augmentable, allowing the house to be customized to capitalize on site-specific geothermal, hydroelectric, bioelectric, or other future renewable

PROPERTIES

- Built-in optimal structural allocation for photovoltaics and wind turbines with replaceable/ upgradable standard modules
- Multipurpose structural allocations for additional modules
- Universal connection access points.
- Internal recovery systems including environmental vibration electrical generation
- Local sensors with data transmission capabilities in addition to power transmission

FEATURES

- Allows customization with an array of standardized plug-in modules, like large appliances rather than special installations
- Recovers energy from everyday activities, inconspicuously
- Provides enough energy for a large proportion of homes to be entirely energy independent
- Is scalable with size of home/ available surface area
- Enables controlling/monitoring from a central location sources.

location sources. Integrated across these devices is be the ability to interface with the computer infrastructure of the home for monitoring and adjustment purposes.

Discussion

Individual homes are running predominantly off of autonomous energy systems involving 3 main arenas: generation, storage, and distribution, in that order. Due to the diversity of climatic and environmental conditions, nearly every home is be able to harvest solar, wind, and vibrational energy. However, there is tremendous variation in the energy yield from each particular source. Other methods of energy generation, such as hydroelectric, are feasible in some scenarios but not in all. They are highly dependent on both geography, the location of the housing unit in the community, and population density.

All **Energy Generation Modules** are standardized with industry-universal outputs and similar form factors, although internal home energy generation modules tend to differ from those created for the exterior. This allows a high degree of flexibility in creating the optimal mix of generation sources, while maintaining a consistency and accessibility across all types. In addition, the replacement, swap, modification or expansion of any particular energy source is well supported.

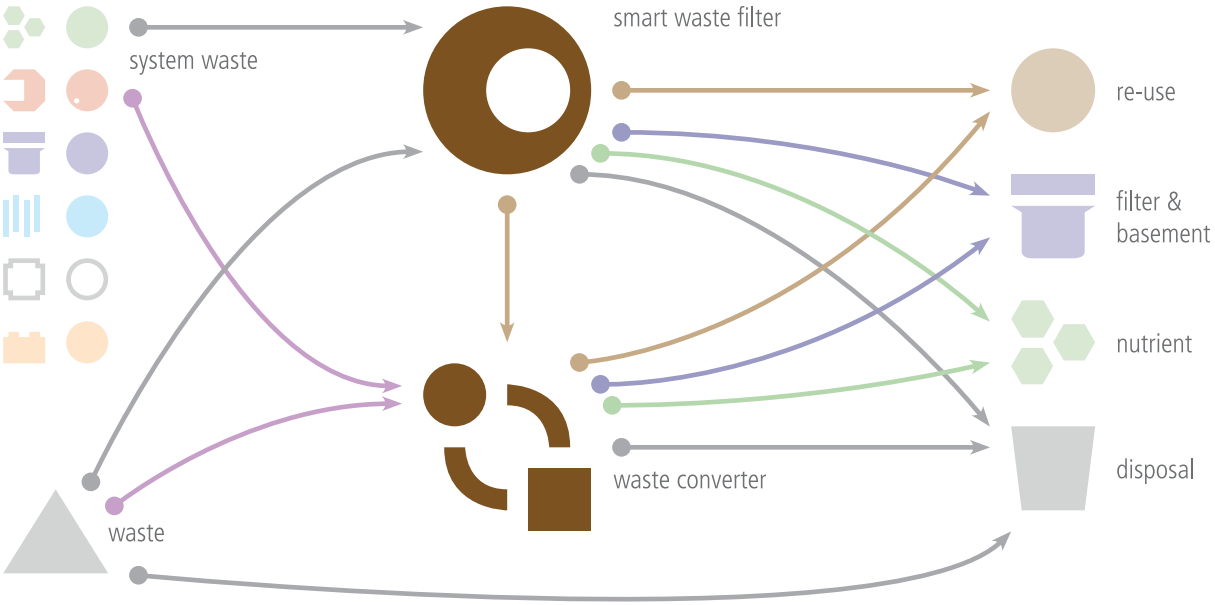
Scenario

Patrick's father had run a small contracting firm, and Patrick had always felt that DIY was in his blood. Patrick was the eldest son in his family, the first one to go to college, and then on to graduate school. His father had always built houses, and never believed in renting. As it was, Patrick worked three part-time jobs in the city: a bike messenger, at a coffee shop, and even tended bar once a week at the Red Lion Pub, a U.S. throwback to one of the old fashioned English pubs. He eventually saved enough to buy his own modest housing unit, one of the smallest units from Owen Design, but which came fully furnished with a region-standard solar unit, turbine, and vibrational box.

One night, bar-tending at the Red Lion, he met a Welsh girl named Charlotte, and the next thing any of his friends knew, he was moving to Ireland, house and all. It was marginally more expensive, he said, to have his unit shipped with all its contents to Llangollen than to simply ship his possessions. He and Charlotte might even be able to combine their housing structures, perhaps trade in a few turbines off his unit for solar arrays. Based on Charlotte's data from her devices on overall utilization from the past year, he felt that he had a very good idea what he would need to make it all balance. Thankfully the Energy Generation Modules were easy to remove and replace.

His best friends made fun of him for becoming so domestic. Patrick used to play video games and shoot pool on the weekends, now he was buying suits, and

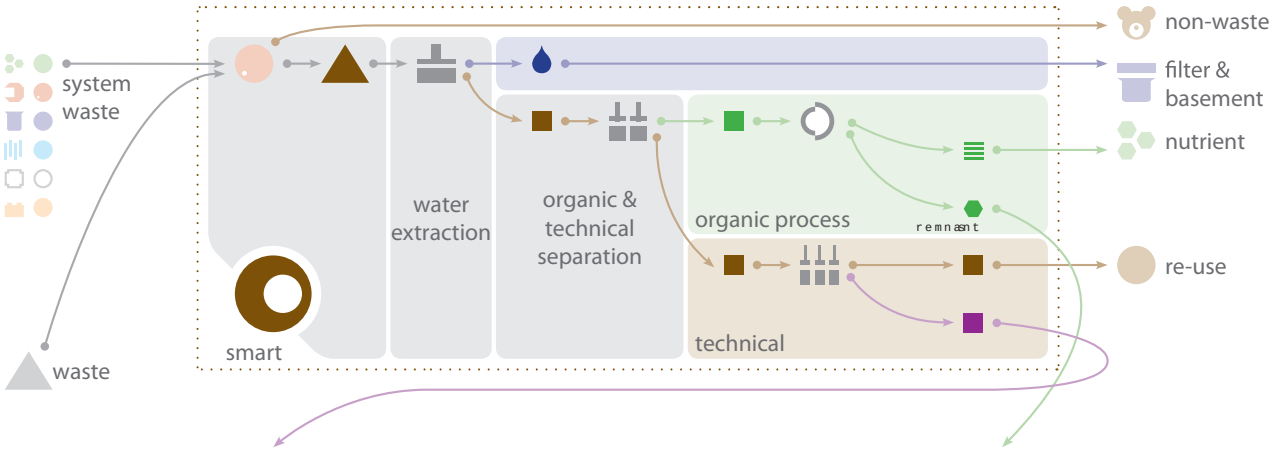
heading to big box stores and shopping for things like **Meta-Washers** and solar arrays. They weren't going to be difficult to install — just a backup cable and half a dozen fastening points. The sort of thing his father would laugh at. Nothing to pay a someone else to do.



WASTE MANAGEMENT

SMART WASTE FILTER

The Smart Waste Filter is the first stage of a waste management super-set, focusing on the identification and sorting of discarded materials. It employs a sophisticated suite of biological and mechanical sensors to distinguish materials into non-waste, biological waste, and technical waste. These are then separated to the highest degree possible through mechanical processing without changing the essential structural properties. Immediate recoverables such as compost, water, and useful solids are computers dispatched to other systems, while any remaining materials are transferred to the Waste Converter for further processing.



PROPERTIES

- Full array of integrated sensor technology, including but not limited to spectral, volumetric, concentration, electromagnetic, thermal, chemical receptors
- Customizable settings through house central computing system interface for quotas and special circumstances
- Automatic, graduated progression through filters and separation methods by increasing difficulty of separation
- Short duration biocides
- Waste tracking
- Connection to central AI and other system computers

Discussion

The **Smart Waste Filter** takes a single stream approach towards the recycling and re-use of materials, with full automation. This unburdens the resident or external party from the health and safety risks of handling waste and allows time to be devoted to other tasks. Sensors and recording instruments integrated into each stage of the filtering process work in conjunction with the home's computer systems and historical data to distinguish between different waste classifications and items discarded in error or carelessness. Input and output tracking along different processes help to provide system diagnostic information, pattern tracking, and metrics to gauge compliance with any relevant codes or regulations.

Through the use of staged, hermetically sealing airlocks and localized sterilization treatment, waste is effectively isolated after being discarded. Most immediately, this protects the home and residents from odor, while further in the system it confines individual processes from one another. This allows for processes whose outcomes may release airborne particles, gases, or liquids.

A large proportion of organic waste passing through the **Smart Waste Filter** should exit the system consolidated as prepared compost either for crop development or environmental replenishment initiatives, with the exception of toxic or destructive substances. Organic remnants will by passed on to the **Waste Converter** for neutralisation and deconstruction. Meanwhile, technical waste, such as glass, different metals, polymers, etc, are separated and sorted by type, then further differentiated by purity and usability. Readily utilizable materials exit into predesignated collection points to be automatically or manually re-purposed. Integrated and corrupted materials are passed on the **Waste Converter**.

Scenario

Brigid's and Parker's son, Ian, exhibits Autistic Disorder. Most of the time, Ian is happy to sit on the couch while one of his three younger sister sings to him. However, his hands are perpetually swollen from compulsive wringing, and on

occasion his tantrums become destructive. Now that Ian is 19 and over six foot tall, with great proportional strength, his expressive behaviors sometimes have great consequences. Objects in the home are broken on a regular basis. It also just so happens that his favorite game is "Is Goodbye", which involves almost anything being pushed out the door, the window, into the trash or toilet.

Brigid and Parker, meanwhile, are raising 3 daughters and believe strongly in active parenting. One parent will sit by the piano, holding Ian's hand while Ian rocks himself back and forth in the rocking chair, to keep him content and distracted while the other prepares dinner. At the table, the girls don't often finish their food and Ian inevitably drops large portions onto the floor, or becomes distracted and tries to wanders off.

Between the haste of constantly divided attentions, the material waste created simply by raising children, and Ian's destructive tantrums, Brigid and Parker appreciate that they don't have to worry about the right and wrong things being thrown out. When Ian sneaks off and drops Jesus from their nativity set down a waste bin ("Is Goodbye Jesus"), one of the girls or parents will find the figurine in the recovery bin and put it back with the set. Polymer toys, broken and embedded amidst last night's dinner scrapings will be transferred over to the **Waste Converter** and come out as blocks ready for their 3D printer. Brigid and Parker can tell their daughters to finish their meals, but ultimately don't worry about wasting food, knowing that nearly all of it will go back into their garden, and hence make it back to the dinner table soon enough.

FEATURES

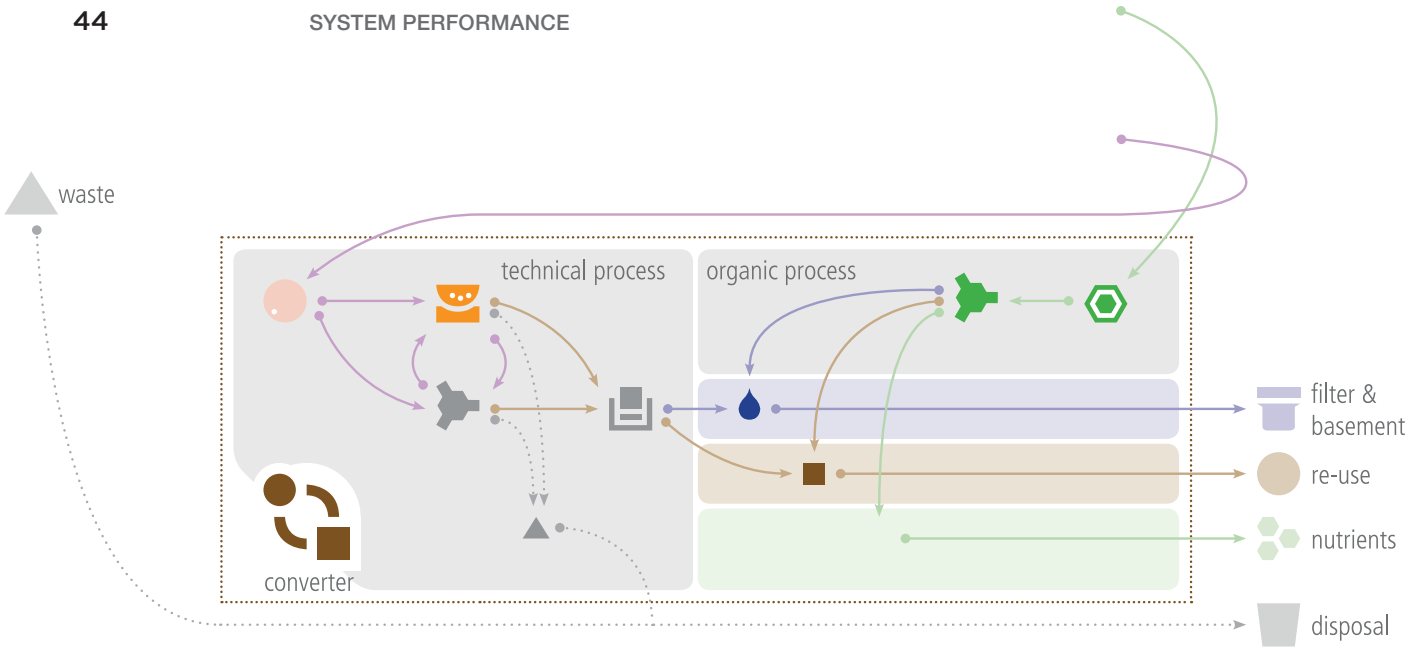
- Identifies and retrieves items thrown out by mistake
- Can be used as an intermediary between waste water and the **Water Filter** system element
- Can be programmed to prioritize the retrieval of specific items
- Consolidates non-toxic organic waste for composting
- Set collection outputs for useful items
- Located remotely within housing structure with airlocks and local sterilization to insulate from smell, gas, or vapor
- Passively tracks waste usage and patterns

WASTE CONVERTER

The Waste Converter is an advanced processor for waste output, representing the secondary stage of the Waste Management supersystem. Fed from the Smart Waste Filter, the Waste Converter deals with materials which requires further treatment or refinement beyond mechanical processing before reaching a usable state. The system employs biological, biochemical, nanotechnology, or thermal treatment where applicable to extract useful materials, nutrients, and water from integrated receptors, solids and otherwise toxic substances.

Discussion

In contrast to the **Smart Waste Filter**, the **Waste Converter** is dedicated to deconstruction processes involving methods that inherently have longer cycle times, such as thermal treatment, use of organic methods, catalyzed chemical baths, and even physical deconstruction at the microscopic level. It is able to accomplish the vast majority of these processes in a compact space through the use of nanotechnology, specially engineered bacteria, and an increasing trends away from a disposable economy.



PROPERTIES

- First pass accelerated decomposition via organic methods (fungal, bacteria, etc)
- Holding tanks with strong chemical catalysts
- Piranha-style nanobot demolition army "Piranhobots"
- Thermal processors for melting technical waste or biomass to release components and/or reform solids
- Standard unit material outputs
- Standard unit unrecoverable waste output
- Waste tracking
- Connection to central AI and other system computers
- Full array of integrated sensor technology, including but not limited to spectral, volumetric, concentration, electromagnetic, thermal, chemical receptors

A full suite of sensors and recording instruments throughout the **Waste Converter** identifies, tracks, monitors, both the organic and technical remnants that feed into the **Waste Converter** from the **Smart Waste Filter**, such as hair, feces, and complex devices components which cannot be safely and/or conveniently returned to the natural or man-made environment in its current state.

Within the **Waste Converter**, polymers, metals, glass, and other technical waste are re-scrubbed, broken down by nanobots, and often melted down into raw materials before being re-shaped into a standard cubic unit, ready to be inserted into a 3D printer, sold or given to another party, or consumed directly by appliances and systems around the home for maintenance purposes. On the organic side, keratins in the hair undergo accelerated decomposition via bacteria, while compounds such as inorganic salts, ammonias, and water are extracted from urine, feces, and other potentially harmful substances via enzyme treatment. This yields compounds finally appropriate for use as nutrients. The remainder from both processes may be fed back through the converter until neutralized.

Unproccessable or unusable waste, if any, that is beyond the capabilities of the home system is chemically neutralized to a stable, nonreactive state. This is then consolidated to be sent to community or municipal facilities with either the scale and facilities to deal with it responsibly.

Scenario

Johanna lives in a graduate student housing complex with her cat, Antonio Bandaras. It's about 6 months into the current year, and she is compelled to purchase the latest personal computing device to keep her busy academic life in order. After syncing and transferring her local data, she tosses the old device into her **Smart Waste Filter** and heads off to the day's lectures, workshops, and networking events. She arrives back home late in the evening, with a bottle of wine, a stack of undergraduate papers to grade, and a plan: take nice therapeutic shower, and then finish the bottle of wine or finish grading the papers, whichever comes first.

Antonio, an academic himself, is in the midst of a research project investigating the best locations and surfaces on which to take a nap. A domestic medium-hair tuxedo cat, his hair would be on everything if it weren't for the nanobots who cleaned up the moment he left the room. Antonio was born feral, and took most readily to the use of a litter box.

Neither Johanna nor Antonio ever worry about the batteries in the trash, drabs of wine left in the bottom of the bottle, strands of hair down the shower drain, the sheer volume of fuzzy undercoat that gets shed every day, or cleaning the litter box. All of it passes straight through the **Smart Waste Filter** into its appropriate place in the **Waste Converter**.

The most successful systems are ones you never have to think about. Johanna doesn't think about how the heat released from the neutralization of the device battery helped her have a hot shower. Antonio, absorbed in his research, doesn't think about his contribution to the soil nutrition of the catnip plant on the windowsill. And neither of them think about all the keratin from the hair being reintegrated into the **Smart Waste Filter** as nano-porous keratin fiber.

FEATURES

- Isolates component nutrients for recombination by the Nutrient Generator
- Forms technical waste into standard units for re-use by maintenance or appliances such as 3D printers
- Transforms toxic materials into neutral compounds
- Releases water and and pure gases are collected and relayed to air and water systems
- Consolidates and molds technical materials into standardized units that can be used as raw inputs for 3d printing, etc.

PERSONAL DEVELOPMENT

OVERVIEW

Today, healthy personal development is achieved through balancing an individual's physical and emotional needs, with the available resources given. As we move towards the future, we can imagine that while individual effort in personal development will not change much, we can anticipate the growing supportive role of advanced technology. Such technology, transforms the home into an environment where individuals' physical and emotional needs, including food provision, storage maximization and personal well-being, are met.

The estimates for food resources in the future is dire. As the population swells from 6.7 billion to 9 billion, in 2050, the amount of arable land per person is estimated to decrease from about half an acre in 2000 to one third of an acre by 2050. In contrast, demand of food will double by 2050. The traditional soil-based farming model may no longer be able to feed all of us. Our future home is self-sufficient in producing food to meet the demands of the residents.

The home's Growth Stadium provides desirable growth environment in order to achieve optimal yield for harvest. By incorporating the Growth Assistant, home grown produce is well protected and their growth cycle is enhanced. Every home is also able to grow meat and proteins by using Food Synthesizer with 3D printing or in vitro technology. Therefore, the harvest from the food production will be incorporated with the Food Catalogue system which tracks the food quantity to interact with users how much they have and how much they can share the surplus within the local community. Food Box manages the quality of the food to detect the contamination and the freshness of the food.

As we see the population growth in 2050, it affects to increased urban migrations which will result in 70% of population living in cities. It is foreseeable that space per person will be much smaller than today.

In our house today, we often dedicate space to be of a certain function, and when we are not using that function, the space is wasted. For example, the kitchen is only being used 3 times a day, for the rest of the time, the space in the kitchen is under-utilized. The main reason of single-functioning space is, our interior structure is rigid and inflexible, and it is hard to change.

In our future house, we are able to adapt the smaller living

spaces for multiple functions. Omni walls which is made possible by using Nano materials to support mutable and flexible structures. We are also able to alter our walls, using Adaptive surfaces and fenestrations to suit our preference, according to different usage and occasion. When needed, our future kitchen can easily morph into a study room. Also, accessing information of the space and what is in storage will be as easy as making a telephone call today. Space is dynamic in our future home.

Future storage system helps people easily get an access to the items in the storage. The Storage Catalogue is an information database that provides the residents with information that they require about items within their home. It is connected with the Scan Closet which is a system that, through a scanning process, enters information about new products to the home into the Storage Catalogue. As items are put into storage for the first time the Scan Closet identifies them as well as any information that may be relevant to the individual user so that the information about the item may be accessible at a later time. The Biometric Security System is embedded in the Scan Closet which is a function of the storage in the home that tailors item security levels to the individual person. Access to items in storage is granted or denied based simply upon who that individual is and whether they are intended or permitted to have access.

The Know-It-All is a platform of assistance programs intended to help the individual understand and make better use of the items within the home. The programs range in content; from wardrobe advise to meal planning, and in degrees of assistance; from subtle suggestions to physical assistance.

Fostering emotional stability and growth in the home is a series of features that adapt to the needs of its residents. The Entertainment Management System is an integrated media system, which allows residents to easily access various media, where ever they may be. Working along side this system is the Biographer, which records residents informal learning process as well as special events and meaningful moments. These elements of the Biographer enables iterative learning and promote positive wellbeing through the recall of cherished moments. The Hamam and Tranquility Acclimator are features of the home that aims to restore and rejuvenate residents by providing private and temperate spaces that support repose and relaxation. The Romance Catalyst supports an active and romantic lifestyle in the home through privacy settings and climate and light controls.

Along with nurturing emotional well-being, the home supports healthy living through a number of features. For many elderly residents, care and safety are important issues to consider in the home. The Mobility Assistant enables secure maneuvering through the home with its integrated way-finding system as well as adjustable fixtures. Obtaining a health lifestyle is no easy task but through the Health Assistant, Health Rewards System and Integrated Fitness Immersion System, the individual can monitor and manage his health, as well as be motivated to live a healthier lifestyle.

The home is not merely a shelter, instead we imagine it to be a space that supports the unique abilities and desires of its residents. With these elements working in tandem, the home transforms into a nurturing environment where residents can grow physically and emotionally.

SYSTEM ELEMENTS

PERSONAL DEVELOPMENT

Food & Storage

FOOD PROCESSING

APPLIANCE HUB

A set of kitchen appliances to provide home owners that cooking to be more accessible and tailored than it is now. Information rapidly available. Intelligent kitchen appliances will reduce time for preparing meals through easy access to ingredients, recipe and cooking methods. Appliances that increase safety, reduce cook time, and improve accuracy/ control that makes cooking more accessible.

PROPERTIES

- Information archive
- Interaction display
- Alert system
- Adaptable cooking surface
- Network enabler (e.g. WiFi, RFID)
- Laser cutting system
- Heating surface

Discussion

People especially who are living in the city should deal with various tasks to complete. They don't have enough time to prepare and enjoy cooking for everyday meal. Especially targets the upper-age segment of the Internet Generation (ages 25 to 35), which is comprised of brand conscious, busy young professionals who are independent and concerned about the environment, and whose lives are intertwined with technology and online social networks. Design tomorrow's home appliances should meet their core interests and concerns as mobility, convenience, time, materials, personalization, entertaining, technology and sustainability.

Appliance Hub makes cooking more accessible and enjoyable then before. Cooking as a tool of family gathering and well-being methods to have good food at home. Cooking will be about sensing people's intentions and making things easier. **Appliance Hub** provides very efficient tools and methods to reduce and save time to prepare the meal.

A radio-frequency identification chip and a thermometer in a saucepan to allow it to communicate with a stove's computer. The **Smart Pot** knows when it's been placed on the stovetop, and can actually regulate its own temperature via radio signals to the stove. The Anti-Griddle, a sheet of stainless steel with refrigerant coils attached to its underside, can cool food to -30°F in seconds.

Smart Spoon, a utensil outfitted with sensors that measure temperature, viscosity, and even the chemical properties of the food that's being stirred, like pH and concentration of ions. A chef, for instance, could dip the spoon into a mixture to measure, say, if it's salty enough to properly brine pickles.

FEATURES

- Save cooking time through heat efficiency (boiling, stir-frying, steaming, grilling and broiling)
- Save cooking time through laser cutting board.
- Provide accurate information and advice during the cooking about temperature, amount, time to complete in a short time frame.
- Cooking surface is adaptable to each cooking tools and kitchen appliances intuitively recognize the weight and temperature.
- Connect with food catalogue to get cooking recipe and ingredients.

Intelligent Cooking Surface recognizes the weight on the surface. If user placed the cookware to the other side, it's automatically cooling down. This is the safe way to prevent burn fingers by accident. And also the surface can be used different activities like heating, chopping, working dough and mixing ingredients. Users don't need moving around to search for the different activities. **Intelligent Cooking Surface** lets users cook and eat wherever they are in the house, alone or with guests, and becomes an extension of the dinner table, coffee table or desk, depending on the situation. For heating and boiling water, it finishes up by 1 minutes. High pressure steam pot will make rice within 5 minutes. High efficiency microwave oven defrosts beef in 3 seconds.

3D Laser Cutting Board helps to create different size of potatoes with dice for curry rice and slice for hash potato. Green onions will be sliced evenly within 2 minutes.

Cooking Coach connects to **Food Catalogue** to provide recipe what is good for dinner plan according to their available ingredients. **Cooking Coach** helps to prepare and process food by advising gradual cooking process through step by step. How much help it offers can be determined by the users.

Scenario

Dan is preparing dinner at home with his girlfriend Carol to celebrate his promotion. He looks up **Food Catalogue** to see what ingredients are available in his **Food Box**. **Food Catalogue** automatically collects data from the **Food Box** and suggests few recipes that can be made with the ingredients he has at home. From the suggested list he chooses 'Scallops Provencal," 'Herbed Basmati Rice' and 'Balsamic Strawberries' for dessert.

However, Dan has never tried these recipes and he would like some assistance. The **Cooking Coach** helps him do just that. It guides him throughout the cooking process from preparation to actual cooking. Using the **Intelligent Cooking Surface** he is able to get direction from the **Cooking Coach** and start preparing the ingredients.

Looking at the ingredient list on the **Cooking Coach**, he gets the scallops and shallots from the **Food Box** and washes them ready to begin slicing. **Cooking Coach** provides information on how they should be cut.. This is easy for Dan as he can use the **3D Laser Cutting Board**. This feature allows him to just place the scallops, on the **Intelligent Cooking Surface** and once he enters the desired requirements (shape, size etc) within seconds the laser completes the task. The rest of the ingredients are cut the same way.

When this is done the **Cooking Coach** advises Dan to season the sea scallops with salt and pepper. He measures 1 teaspoon of salt with the **Smart Spoon**. The interactive display on the Smart Spoon informs Dan of the right amount of salt that he needs. The **Smart Spoon** has a great feature that Dan loves. Whenever

his grandfather John visits, he activates the voice alert system so that John does not have to struggle to read the small display. John who is also an avid cook can hence measure ingredients easily by listening to the **Smart Spoon**.

Dan gets the large pan from the **Scan Closet** and puts it on the **Intelligent Cooking Surface**. It recognizes the pan and already knows the recipe that Dan is following, hence heating up the surface to the required temperature. Once that is set, Dan measures 2 table spoons of butter using the **Smart Spoon**. The voice alert system immediately notifies him that the butter is unsalted and not salted as per the recipe. Once he gets the salted butter the **Cooking Coach** continues to guide him. He melts the butter and cooks the scallops. The **Cooking Coach** reminds him when to turn them over. This way the Dan is able to get a perfect scallop dish without it being under or over cooked. He feels like a chef!

In the mean time, Carol starts to cook the 'Basmati Rice'. She checks the recipe from the **Food Catalogue**. She is an experienced cook and does not need any guidance. Therefore the **Cooking Coach** is silent according to her preference. She uses the **Smart Pot** to cook the rice. Once it is placed on the **Intelligent Cooking Surface**, it recognizes the recipe and sets temperature, pressure and time. Being a Smart Pot, it speeds up the cooking process only taking 3 minutes to cook the rice. Once the Smart Pot starts cooking, Carol gets ice wine from the **Food Box**. While she is pouring the wine into glasses her phone rings. Distracted she leaves the bottle on the Intelligence Cooking Surface and picks up the phone. It is her friend Amanda. Carol forgets about the wine bottle on the surface and continues to speak about Dan's promotion. Fortunately the **Intelligent Cooking Surface** recognizes the wine bottle and immediately cools the surface.

In a couple of minutes, the Cooking Coach notifies that the food is ready. The wine bottle safe and the scallops cooked to perfection Dan and Carol enjoy a nice warm evening at home.

FOOD BOX

Food box manages entire preservation environment including temperature and humidity to keep food fresh. It provides different types of preservation methods to optimize food freshness. The system will inform the users whether this food is eatable or not. System provide food contamination alert and expiry date to the users.

Discussion

A pathogen is a an organism that causes disease in another organism. The Centers for Disease Control and Prevention (CDC) estimates that foodborne diseases cause 76 million illnesses, 325,000 hospitalizations, and 5,000 deaths

PROPERTIES

- Information archive
- Interaction display
- Alert system
- Indicator - visual and voice
- 3D Scanning system
- Network enabler (e.g. WiFi, RFID)
- Bio sensors
- Nano technology
- Modularized compartments

FEATURES

- 3D laser scanner which is embedded in the closet identifies the contents.
- Indicate freshness through light, voice and display.
- Nano Nose detect food freshness or contamination to alert
- Inform users to remove outdated food from closet.
- Adjust temperature, humidity and oxygen inside of closet
- Alert/inform users for food condition.
- Determine which types of preservation is needed.
- Facilitate preservation methods according to optimal food freshness and nutrition
- Nano ziplock (Bio VacPack) food container will be totally composted after use.

each year. In 000, the U.S. Department of Agriculture (USDA) estimated the costs associated with five major bacterial foodborne pathogens to be $6.9 billion. The Food and Drug Administration's (FDA's) 2005 Food Code states that the estimated cost of foodborne illness is $10–$83 billion annually. Food freshness is a key characteristic of overall food quality. And overall food quality is the result of all the desirable characteristics that make food acceptable to eat. Therefore, being able to tell when food is fresh is vitally important, at home, in a grocery store, or when dining out.

Food Box is the compartment which is divided by small section for various food type. Each compartment has different temperature and humidity setting which will provide the optimal environment for keeping food freshness depends on the contents. **Food Box** can be modularized and movable compartments which allows different sizes and functions per each unit. Each **Food Box** compartment embedded **Scan Closet** 3D laser scanning and RFID tagging system which detects what kind of preservation tools should be applied to the contents such as canning, irradiation, salting, jam and fermentation.

Nano-Nose detects food contamination through high-sensitivity and extremely reliable biosensors. Seafood, for example, is one of the most difficult foods to keep fresh. Millions of bacteria are present on the surface, on the gills, and in the gut of virtually all seafood species. If you know when and where the fish was caught, you might be able to make an educated guess as to its freshness, provided that it's been properly stored. Inspecting the fish for color, resilience and sliminess would help. So might a check of its eyes to determine clarity and sheen. But in the end your nose might determine whether or not you buy the fish. If you're trying to determine whether to buy a piece of fish tightly wrapped in plastic and sitting on a Styrofoam tray, however, the decision might be more difficult. **Nano-Nose** sense the production of volatile amines. Specifically, they detect the level of amines given off by certain types of seafood, such as shrimp and most types of shellfish and finfish, an indicator of the degree of decomposition. Also **Food Box** alerts users about food expiry date to eliminate from the compartment through **Freshness Indicator**.

Bio Vacpac contains food to keep fresh and it will be totally composted after use. A sustainable bio-packaging material to replace polypropylene. A new starch based bio-packaging material promises to replace polypropylene, helping the plastic packaging industry to reduce its reliance on oil. Bio-based packaging is increasingly being used as a replacement for petroleum-based plastics. The demand is being driven by anti-pollution legislation and by demand from environmentally conscious consumers. The product is one of a new range of sustainable resins, Cereplast Hybrid Resins, in which between 50 and 70 percent of the traditional petroleum content of the plastic resins has been replaced with bio-based materials. In addition to lower fossil fuel content, the resins are produced at lower temperatures, thereby further decreasing their environmental impact.

Food Box connects with **Food Catalogue** to communicate about food quantities and qualities that help maintain the food for entire family members.

Scenario

Nancy is tired after an entire day of meetings. Days like this when she has more than three meetings that last a few hours each are exhausting. On the way back home, she stops by Wholefoods market and buys limes and some rice snacks. As she is thinking about what to eat for dinner, she remembers that there are a bunch of tomatoes on the **Green Wall** ready to be picked.

She decides not to buy anything for dinner from the market and goes home. After she takes a shower, she picks the ripe tomatoes from the **Green Wall** to make spaghetti sauce. This time the harvest is good and she has enough to share with her neighbors. However she still needs to preserve them till someone comes asking. She puts the extra tomatoes in the **Food Box** compartment. The **3D Laser Scanner** in the **Food Box** recognizes the item and updates the quantity. This new data shows up in the **Food Catalogue**. In her hurry to take a shower she had left the items bought at Wholefoods on the table. As she puts them in the **Food Box**, the RFID tag on the snacks are detected by the 3d laser scanner and information is updated in the **Food Box** and added to Nancy's **Food Catalogue**.

She decides to add spinach in her spaghetti sauce. However as she takes out a packet of spinach from the **Food Box**, the **Nano-Nose** detects contamination and alerts Nancy of it being unsafe for consumption. She will have to be happy with tomato sauce. Not wanting it go to waste she throws the spinach into the **Smart Waste Filter** system so that it is treated and reused in some way or the other. The **Freshness Indicator** lights up in green indicating another packet of fresh spinach that Nancy can use. Taking half the quantity for dinner she packs the remaining quantity in **Bio Vacpac** for future use.

She is happy to finally start cooking and knows that within minutes it will all be ready.

FOOD CATALOGUE

PROPERTIES

- Information archive
- Interaction touch panel display
- Sensors for recognition of food type
- Data transfer systems (Blue Tooth, WiFi, RFID etc.)
- Voice recognition embedded

FEATURES

- Hubs of whole foods
- Communication and data handling tool.
- Food quantity and quality control.
- Makes grocery list based on nutrition needs.
- Order and deliver foods through grocery lists.
- Connects to Food Network for sharing foods
- Tells network and other people which food is extra and available.
- Food input through scan closet - 3D scanning system.

Food catalogue provide quantitative data of food in home. This information connected with automatic grocery list for buying and ordering food. It is connected with social network catalogue system to get information who has sufficient food to share. It easily provide where and when the food should be delivered.

Discussion

It was in the 1980s that food began disappearing from the American supermarket, gradually to be replaced by “nutrients,” which are not the same thing. Where once the familiar names of recognizable comestibles—things like eggs or breakfast cereal or cookies—claimed pride of place on the brightly colored packages crowding the aisles, now new terms like “fiber” and cholesterol and “saturated fat” rose to large-type prominence. More important than mere foods, the presence or absence of these invisible substances was now generally believed to confer health benefits on their eaters. Foods by comparison were coarse, old-fashioned and decidedly unscientific things—who could say what was in them, really? But nutrients—those chemical compounds and minerals in foods that nutritionists have deemed important to health—gleamed with the promise of scientific certainty; eat more of the right ones, fewer of the wrong, and you would live longer and avoid chronic diseases.

Nutrients themselves had been around, as a concept, since the early 19th century, when the English doctor and chemist William Prout identified what came to be called the “macronutrients”: protein, fat and carbohydrates. It was thought that that was pretty much all there was going on in food, until doctors noticed that an adequate supply of the big three did not necessarily keep people nourished. At the end of the 19th century, British doctors were puzzled by the fact that Chinese laborers in the Malay states were dying of a disease called beriberi, which didn’t seem to afflict Tamils or native Malays. The mystery was solved when someone pointed out that the Chinese ate “polished,” or white, rice, while the others ate rice that hadn’t been mechanically milled. A few years later, Casimir Funk, a Polish chemist, discovered the “essential nutrient” in rice husks that protected against beriberi and called it a “vitamine,” the first micronutrient. Vitamins brought a kind of glamour to the science of nutrition, and though certain sectors of the population began to eat by its expert lights, it really wasn’t until late in the 20th century that nutrients managed to push food aside in the popular imagination of what it means to eat. (Michal Pollan. 2007. Unhappy Meals, The New York Times Magazine)

Food Catalogue has nutritious information per each family members and provides proper ingredients and grocery list for being healthy. **Food Catalogue** connects with food pyramid planner to provide daily nutrient information about fruits, vegetables, milk, oil, meat & beans. It collects nutritional information of

each users like protein, fat and carbohydrates. If one of user needs more protein, **Food Catalogue** provide meal plan adding more protein in the meal suggestion.

Food Catalogue is the hubs of whole foods in home. It connects to **Food Synthesizer, Food Growth Stadium** and **Green Wall** system to track food quantity. If there are extra beef which has been produced in the **Food Synthesizer** chamber, **Food Catalogue** automatically inform users to share this information to the outside community through **Food Network**. Within the local community, other members recognize beef is available.

Scenario

Amy is preparing breakfast for five members of her family with two boys, husband and mother-in-law. Each family member has different nutrient needs. Eight years old son and eleven years old daughter should have protein rich breakfast. And for her mother-in-law, Silvia, should have separate meal plan for diabetes. Amy already prepares two eggs sunny side up and two strips of bacon for her kids. She looks up the **Food Catalogue** to get recipe for Silvia. This morning **Food Catalogue** suggests Silvia to have 1 slice toasted whole wheat bread with 1 teaspoon margarine, 1/4 cup egg substitute or cottage cheese, 1/2 cup oatmeal, 1/2 cup skim milk, 1/2 small banana.

Food Catalogue notifies that Amy doesn't have bananas in her **Food Box**. **Food Catalogue** connects to **Food Network** system in local community and gets information that Frank has a bunch of bananas in his **Food Box**. **Food Network** sends a message to Frank that Amy needs bananas this morning. Frank is living on the upper floor of Amy's apartment and he stops by her place to drop his bananas on his way to work.

After everybody left home to school and work, Silvia goes to **Growing Wall** to check the condition of her carrots and onions. In her **Food Synthesizer** chamber 6 pounds of beef and 4 pounds of chicken is growing. It seems almost done. As Silvia planned for Christmas dinner the day after tomorrow, the meat and vegetables will be ready to cook by then. Suddenly, phone rings. Silvia picks up the phone. It is Amy. 'Hi Silvia, I just got a phone call from uncle Jerry and he informed that he cannot make our dinner next week.' Silvia replies 'oh.. if his family cannot make it, our meat will be too much for only six people.' After hang up the phone, Silvia updates the **Food Catalogue** that she has enough meat to share with neighbors.

The day of Christmas dinner, Silvia and Amy prepare a nice and big meal with beef and the bunch of vegetables from the **Green Wall**. Whole family members enjoy dinner.

STORAGE MANAGEMENT

STORAGE CATALOGUE

PROPERTIES

- Centralized system within home
- Inventory of information about items in home
- A guide to help make decisions about storage
- A scanning system that recognizes information tags
- Identification tags
- A control system for storage environment
- A remote access information tool
- An adaptive descriptive language for item descriptions
- Accessible through visual/surface interfaces
- Accessible through vocal/audio interaction
- A common product language.

The Storage Catalogue is an information database that provides the residents with information that they require about items within their home. Information, such as the location, the quantity and the state of the objects are made accessible by the Storage Catalogue through a variety of different interactive interfaces located largely within the home.

Discussion

All objects within the home carry with them inherent bits of information that at any given time may be important to a resident. Information pertaining to the location, the physical state of, and the quantities of objects can be at times necessary for an individual to understand and navigate his or her way through daily life in the home. The primary function of the **Storage Catalogue** system is to provide the resident/user with the information that he or she so requires about any given object(s) within the home.

Users will be able to track the whereabouts of any given object within the boundaries of the home, be it indoors or out. Items that are purposefully stowed away, those that are carelessly strewn about as well as items that are seemingly misplaced, can be located by simple inquiries made to the system by the user. The concept of a lost remote control or misplaced keys will not exist as even the most mundane and commonplace items can be easily located within the home.

In addition to the location of objects, residents may want to know the quantity and the status of an object within storage. Certain items more than others are quality or status dependent; clothes for example can be dirty, or clean; while some items are quantity dependent; for example, the quantity of detergent left in a container. Both carry relevant information that a user may wish to know at any point in time. The **Storage Catalogue** collects the disparate parts of information from each of the items and collates it into a readily accessible and reliable source of information for the user. Instead of having to be cognizant of the quantitative or qualitative status of all items, users can rely on the information being available in a predictable location in the immediate environment.

While the system provides information about items in storage, the **Storage Catalogue** can also provide assistance in process of storing goods in the home. By

understanding what the objects are, the system is able to access information databases pertaining to the physical properties and special requirements of the items and tailor storage solutions for the items. For example, tools will be recognized by the **Storage Catalogue** as having a high steel content; will be provided a storage environment with low moisture of humidity to prevent rusting. This item-centric storage approach can be facilitated by one of two methods or a combination of both: the **Storage Catalogue** can make suggestions as to which storage environment would be suitable for the particular item. Otherwise, the **Storage Catalogue** can automatically adjust the individual storage unit to the particular needs of the item; the humidity, light levels, sturdiness, security etc… of a closet or storage unit can be precisely tuned to provide the optimal environment.

The information that the **Storage Catalogue** collects, organizes and redistributes comes from three broad sources; the items themselves, information databases, and the individual users. Items are recognized by the identification tags that they posses, given to them either upon manufacturing or by the **Scan Closet** system within the home. The many sensors embedded within the home environment, scan the tags and provide constant identification of the items; what they are, where they are, how much they are, and in what state they are. The **Storage Catalogue** can also access information databases external to the home that can provide additional information about the items. This is precisely how the **Storage Catalogue** can adjust the storage environment to meet the correct needs of the items. By accessing additional information, the system can supply assistance to the user regarding certain items, a feature that comprises the **Know-It-All** system. The third source of information is the individual user. Users are able to individualize and add personally relevant information to the **Storage Catalogue** that will make use of the system easier. Part of the **Scan Closet** system, users can attach detailed amounts of information to any given item, and be reminded of it later in time.

In order to input the information, or to simply access the information contained within the **Storage Catalogue**, the user can make use of three interaction systems. Firstly, the visual/tactile interface provides users with the detailed information of the Catalogue through a display interface; this may be part of any of the number of interface screens or interactive adaptable surfaces located within the home. Users can browse, search, and input information to and from the catalogue, as the actual items will be displayed for the user to see on the interface. The second option, similar to this is a remote access interface, which will provide similar types of interaction for the user in accessing the Catalogue, but from a remote location. This will come in the way of a handheld device that users will keep with them in much the same way that cellular phones are currently. The third system is one of voice interaction; whereby a user simply requests information from the **Storage Catalogue** and it is provided to the user in an audible format, a visual format, or both.

In order for the user and the **Storage Catalogue** to be able to communicate about items, a common language must be understood. As humans do not generally refer to household items by barcode numbers, the **Storage Catalogue** will be

FEATURES

- Locates objects within home
- Keeps information about quantity, quality and location of items in storage
- Provides the information about the items in storage upon request
- Provide same information to users while in remote locations.
- Locates requested items within the home
- Adjusts environments to meet the particular requirements of items in storage
- Reads and communicates with descriptive tags
- Makes recommendations about optimal type and location of storage for items
- Informs other systems in the home that require information about items in storage

supported by a Common Product Language system. Items will be identified by formal names and many derivations, physical and material properties, by functions and by names the user gives the products. As a resident makes use of a product and refers to it by a vernacular term or nickname, the **Storage Catalogue** will identify the product by the same term.

Due to its large domain and thorough information structure, the **Storage Catalogue** is used to support several other systems within the home. Systems such as the **Know-It-All**, the **Scan Closet**, and the Biometric Storage Security rely heavily on the information managed and provided by the Catalogue.

Scenario

Nearly dressed and ready for her dinner guests that are coming over this evening, Helen wishes to select a nice sweater for the event so she decides to check the **Storage Catalogue** to see which are available. At the Interface Screen mounted on her wardrobe, Helen, presses the screen with her index finger on a section with the words "**Storage Catalogue.**" Upon selecting this, a number of buttons appear on the screen, each with a category written inside such as food, tools and clothing. Selecting the clothing button, Helen brings up another similar menu on the screen with categories of clothes, from which she selects "sweaters." A listing of all her sweaters that she has within the home, with a description and thumbnail image appear of the screen. She scrolls through the images with her finger, finally clicking upon the image of a grey sweater. The image expands on the screen and more information appears about the sweater indicating that it was purchased 3 years ago from "Joe's Sweater Shop," it is made of wool, it is a medium grey color with a light brocade pattern, and it is currently dirty and in need of washing. Returning to the listing, Helen then selects a dark green sweater, which the Interface indicates is clean and is currently in the main closet. Retrieving the sweater from the front closet and slipping on overtop her undershirt; Helen now looks ready for her guests.

Checking to see if she has what she needs for the night, she spots her bottle of wine on the counter and realizes that she can't enjoy the wine if the bottle cannot be opened. Moving over to the Interface located beside the cook surface in the kitchen, Helen touches the screen, on a button that bears the words "vocal search". Helen then in a mid-volume voice asks: "where is the wine bottle opener?" The **Storage Catalogue** recognizes the vocal input as a request to locate an item. Though there is no item listed as wine bottle opener, the Catalogue checks the descriptions and functions of all the products in the home and recognizes the word "wine bottle" and "opener" as descriptive features of the corkscrew. The system replies in a deep gentle voice: "The Corkscrew is located in the top drawer in the kitchen." The drawer that the voice is referring to begins to resonate a warm red color, identifying itself to Helen. She is able to easily retrieve the item and put it out on the counter for later use in the evening.

Knowing that it would be a few hours until her guests arrive, Helen decides to put the wine into the cabinets to be kept at the correct temperature. As she lifts the bottle to one of the cabinets, an icon pops up on the Interface. Touching the screen, a message appears stating: “due to other contents in that storage compartment, the environment would not be optimized for storing that bottle of wine. You may prefer to put the bottle in the adjacent cabinet.” Helen follows the suggestion and moves the bottle. By accessing information from External Databases, the **Storage Catalogue** is able to identify proper storage environments settings for the wine, and adjust the temperature and humidity inside the cabinet to match.

With only an hour before her guests are to arrive, Helen remembers that she has to return a measuring spoon to her neighbor Carol. Upon arriving at Carol’s home, the two of them start into conversation, talking about the dinner plans for the evening. Carol, a wine lover, suggests that Helen decant her wine before serving it to her guests. Unsure of whether or not she has a decanter in the home, Helen grabs her Mobile Communication Device and checks the “Remote Catalogue” option on the touch-screen. From a menu, Helen selects with her index finger, the “search the catalogue” feature and then speaks into the device: “decanter”. Within a second, the device displays a listing with a small thumbnail image and the caption “glass wine decanter.” She knows now, that she does have one and will be able to return home and decant her wine as Carol had suggested.

SCAN CLOSET

The Scan Closet is a system that, through a scanning process, enters information about new products to the home into the Storage Catalogue. As items are put into storage for the first time the Scan Closet identifies them as well as any information that may be relevant to the individual user so that the information about the item may be accessible at a later time.

PROPERTIES

- 3D Scanner
- Nano Material Scanner
- Microwave Scanner
- Identification Tag Printer/Applicator
- Edible Identification Tags
- Descriptive Tagger
- Tag Disabler
- Database of Physical Properties of items
- Integrated within storage compartments and systems

Discussion

As new items are introduced to the home environment, the **Storage Catalogue** embedded within the home will try to attain information about these new objects. In some cases, where the items have been produced with an embedded Identification Tag, the **Storage Catalogue** will be successful, identifying the tags and subsequently the items that correspond with the tags. In other circumstances, items will enter the home not bearing and Identification Tag, and thus are unidentifiable to the **Storage Catalogue** system in the home. Items such as freshly grown produce or home made objects are simple examples of “tagless” items. In order to introduce new items as recognizable elements within the home, the **Scan Closet** system collects information about new products that have entered the home and tags the new products so that they may be identified within the home

FEATURES

- Identify objects by form
- Identify objects my material properties
- Compare scanned items with catalogue of items and relevant properties
- Communicate new product entries to Storage Catalogue
- Tag items with Identification (RFID) Tags
- Allow user to attach Descriptive Tags
- Destroy, augment, and replace tags

Located within storage units in the home, closets, cupboards, appliances, or collapsible units, the **Scan Closet** Scanner identifies new items as they are put into storage for the first time. As any item is put into any one of the given storage units, the scanning system identifies the items based on formal, material and chemical properties. This process is instantaneous and requires no deliberate activation; items that are not identifiable will be scanned while those that are, will be exempt from the process. The scanner itself is miniscule and commands very little visual and physical real estate.

The Scanner makes use of three forms of identification technologies that simultaneously scan new items. The 3D Scanner inspects the formal external properties of the object, essentially identifying its shape and size. The Microwave Scanner utilizes small harmless levels of microwaves to identify the internal physical structure of the items such as density, moisture levels, structure. The Nano-nose Sensor identifies material and chemical properties of items at a molecular level. Through the multi-tiered scanning approach, a composite of physical properties is amassed which is then used to identify the object. This list of physical traits is compared against a database of all other objects and their correspondent traits; and then matched up to provide positive identification of the item.

Once an item(s) have been identified, the **Scan Closet** attaches tags that are identify the objects within the home. The identification tag itself is miniscule, no larger than 15 microns in diameter providing no interference in everyday life. The tags pose no biological harm and are compatible with food as the tags are edible, completely soluble in digestive juices.

With tags being incorporated into all or nearly all items, therein lays certain risks. Just as a home is able to scan the contained items, so too can aggressive companies or individuals seeking information about the contents of people's homes. With standardized tag information, it would be easy for an individual to scan the contents of another home. In order to combat this, the **Scan Closet** System can disable or augment existing identification tags, replacing them with ones that are unique to the home and have no identification value to outsiders.

Another aspect of personalization that the **Scan Closet** System enables is the Descriptive Tagging System. When a user engages with an item, he or she can, through either vocal command, or through an interface, attach a Descriptive Tag. These tags not actually tags rather are pieces of information that a user wants to "attach" to an item; simple reminders or notes that the individual wants to be reminded of later in time, or to inform another individual in regards to some aspect of the item. Someone may attach a Descriptive Tag to a bottle of wine stating that it is being saved for an occasion; anyone subsequently attempting to open or use the bottle will be reminded of the reservation.

Scenario

Just returning to the kitchen from the green wall, John carries with him a basket filled with recently ripened tomatoes that he has just picked. Unable to resist the temptation, John snacks on a couple of them as he makes his way to the kitchen to put the delicious little products into storage. Opening one of the compartments within the **Food Box** storage food preservation unit, so that the opening the unit is slightly ajar, John begins to dump in the contents of his basket. Detecting that an item is being put into the **Food Box**, the **Scan Closet** System scans the tomatoes for identification tags. Detecting none, the **Scan Closet** understands that these are new items that will need to be identified and tagged.

As each tomato passes through the threshold of the compartment, the Scanners located inside **Food Box** (and most other storage units in the home) simultaneously scan them for physical form, density and structure, as well and chemical properties. The 3D Scanner identifies the round and organic shape as well as the red hue of the skin; the Microwave Scanner identifies the varying density and moisture levels of the tomatoes core; and the Nano-Nose Scanner detects the levels of lycopene, glutation, vitamin A, and vitamin C. With a bill of traits now collected, the **Scan Closet** System consults a Database of Physical Properties finding a match for the traits. The scanned properties allow the **Scan Closet** to identify the scanned products as grape tomatoes.

After the tomatoes pass through the scanner into the storage unit and are identified, the **Scan Closet** then tags them. A dust of micro sized edible Identification Tags is released upon the bunch in the compartment, sticking to the skin of each tomato. Each Identification Tag carries a unique serial code that the **Scan Closet** creates to identify the tomatoes. Now identified and tagged, the Storage and **Food Catalogues** can track the tomatoes with a record of the quantity and a measure of their current ripeness.

As John is just about to close the door to the compartment in the **Food Box**, he grabs a handful of the tomatoes, and puts the entire fistful in his mouth, devouring the bunch. Over the next few hours as he digests the tomatoes, the Identification Tags that were attached to the tomatoes dissolve in the gastro intestinal juices, leaving no trace of their existence. As each tag is destroyed, the number of tomatoes listed in the **Food Catalogue** decreases to match.

Leaving the **Food Box** John wanders over to one of the compartments in the kitchen. Opening it up, he finds a cutting tool that he borrowed from his neighbor a few days earlier. Grabbing the item in his hand he creates a Descriptive Tag for it. Speaking out loud, John says; “Note, remember to return this to Steve tomorrow.” Through this simple act, the system recognizes that John wants to be reminded of this Tag. The information about the tool kept by the **Storage Catalogue** System is updated to keep this message with a schedule of when John should be. Tomorrow, when John is working in the kitchen, a voice will recite back

to him the information he put in the Descriptive Tag, helping him to remember to return the tool to his neighbor.

KNOW-IT-ALL

PROPERTIES

- Assistance system for users
- Guide and advice for item use
- A platform that can be expanded upon with different aspects and programs for assistance.
- Integrated into the interfaces and vocal interaction systems in the home
- Integrated into the controls of the items, devices and systems within the home
- Connected to the Storage Catalogue other information databases
- Programs that help with specific items and activities

The Know-It-All is a platform of assistance programs intended to help the individual understand and make better use of the items within the home. The programs range in content; from wardrobe advise to meal planning, and in degrees of assistance; from subtle suggestions to physical assistance.

Discussion

The **Know-It-All** system leverages the information collected and organized by the **Storage Catalogue** and builds upon on it to present information and assistance to the resident in places and times where they will need it. Through the understanding of which products are being used or needed in the home, the **Know-It-All** can access external databases that provide additional information about the items and then present it to the user in a constructive and organized manner so as to enable and enhance the user's understanding and experience.

Users communicate with the **Know-It-All** through the various interactive devices within the home. A user may choose to interact through vocal/audible feedback with the system whereby the **Know-It-All** provides information and instruction through an audio system. In cases whereby a user's vision and hands are occupied, this system would provide maximum level of accessibility. Other times, users may require visual guidance and assistance, and choose to interact with the **Know-It-All** system through a visual and touch-sensitive interface. This method of interaction is more appropriate for things like video instruction, or sifting through information.

The **Know-It-All** System provides varying levels of support and assistance; in some circumstances the system will provide entry-level amounts of information, while other times it will provide physical assistance of tasks, automating certain tasks. For example, one component of the system may provide a user with written or video instructions on how to reassemble a piece of furniture, while another will completely automate the watering of plants. The levels of support are adjustable to the individual's needs/desires; some more independent able bodied will require less assistance while those more infirm or unsure of tasks will appreciate the extra assistance. These levels are adjustable for individual Assistance Programs that are a part of the **Know-It-All** system.

This process of information access and presentation is a platform for various task specific programs to "plug into". Assistance Programs such as the **iFarmer**, the Cooking Coach, and the Wardrobe Advisor are some of the many possible Assistance Programs that can utilize the **Know-It-All** system to support users

with a specific range of activities and items. The topic and specificity of these programs can vary greatly, providing users with a cornucopia of different types and topics of assistance. There is no limit to the number of potential Assistance Programs for the **Know-It-All** but some of the programs considered at this point are as follows:

iFarmer: As the individual household will be providing much of its own food, the **iFarmer** can help the domestic farmer maximize the yield. The **iFarmer** program accesses information databases about plant growth, weather systems, nutrients etc… as well as the information in the **Storage Catalogue** information to assist with the growth of the food. The **iFarmer** can make suggestions about types of plants, guide in the use of equipment and procedures, help correctly nourish plants, assist in making growth plans, monitor and adjust climates, notify users when plants are ripe etc…

- **Wardrobe Assistant:** By accessing information about clothing kept within the home, Fashion and Style Forecasts, as well as weather forecasts, the Wardrobe Assistant can help assist the individual in choice of appropriate attire. By utilizing an interactive interface, the Wardrobe Assistant can provide the user with previews of how certain clothes will look on the individual, saving time by reducing/eliminating the need to try on multiple outfits.
- **Handyman Helper:** Sometimes users simply require basic "how to" instruction, or general level information about an item. A user can ask questions about certain items while interacting with the audio or visual interfaces in the home, and simple answers will be provided. For example, a user may wish to know how to properly pour a glass of wine, and the **Handyman Helper** will provide a video illustrating the process. Another common situation where the **Handyman Helper** would be of assistance is a user trying to figure out how to clean up a red wine stain, the handyman helper could provide the user with a simple list of possible solutions, ones based on resources available in the home.
- **Meal Pal:** When trying to plan a meal, one must consider available ingredients, allergies, tastes, available tools and preparation times. By accessing recipe sources, nutritional guides, the Home's **Food Catalogue**, as well as information about individual dietary preference and requirements; the **Meal Pal** helps coordinate and plan meals ranging from individual snacks to several course meals for large gatherings.
- **Cooking Coach:** Once a meal plan is chosen the **Cooking Coach** assists the user in the execution of the plan. Depending on the experience and preference of the cook, the **Cooking Coach** offers various levels of support; for people who prefer less interference, the cooking coach can recite the recipe when prompted or display it on an interface; while for those in need of more assistance, the **Cooking Coach** can provide step by step instructions or automatically adjust the cooking temperatures, supporting even the most absent-minded cooks make great meals.

FEATURES

- Access and coordinate with the storage Catalogue and information databases
- Interpret and understand relevant information to present to user
- Provide needed information to user about items in home
- Provide assistance with "how to" regarding items in the home
- Provide varying levels of support and assistance when needed.
- Assist with choice/planning of meals
- Assist with cooking process
- Assist with the food growth process
- Assist with wardrobe choices

Scenario

Maria is an exceptionally busy person; her schedule is always full and her workload is never light. A consolation to this exceptionally active woman is that there is help available to her, even when no one else is around. Throughout the busy day, the many tasks and activities she will have to perform will be made easier by the **Know-It-All** system as it provides her with the information and assistance that she needs.

One of the first tasks on her to-do lists was plan the meal that she is going to serve on Friday, when she hosts a dinner for the ladies in her office. Knowing that a few of them are quite fickle about what they eat, and that some have allergies, Maria knows that she has to be quite careful in her menu selection. In the kitchen, Maria hovers over the interface screen next to the cook top. Maria touches the screen with her finger and selects the "**Know-It-All**" function from the main display, and then follows that by selecting the "Meal Pal" option. She is greeted by a screen display that is divided in half; on one side is a display of categories that can be selected to narrow and focus her choices. On the other side, a long alphabetical listing of recipe options is listed, at the bottom of which is a note indicating: "10 000+ matching recipes." To narrow her options down, Maria starts to input information about the dinner into the one half of the screen. By touching the screen where it asks for information input, Maria simply states the information out loud and it is input on the fitting points on the screen. She inputs that the setting will be a casual dinner, that it will be for 12 guests, and that she would like and Italian food recipe. With this information, the list of possible recipes narrows substantially, indicating "286 matching recipes", which is still far too many to help her make a decision. Maria then, selects an icon on the interface for "guests"; she is able to scroll through a list of all of her contacts and friends and select those that will be attending the dinner. By selecting the guests from the list, the dietary preference and needs are automatically of these guests is automatically considered, eliminating recipe options that do not fit. With all of this information input, the total number of matching recipes is reduced to 45, a number that Maria can work with. Scrolling through the list of these recipes, she can see thumbnail images of the meals, as well as some general information describing as how long the meal will take to prepare and the effort level required. From the meal options she selects "chicken cacciatore", which brings up a larger image of the dish and more information. Maria looks over this information quickly and is satisfied. She selects the "save to **Know-It-All**" function which informs other **Know-It-All** Programs in the home of the chosen meal selection. With a determined recipe, the Meal Pal consults the available ingredients in the **Food Catalogue** to see which ingredients are already available and produces a list of missing ingredients; this list is displayed to Maria and is also uploaded to the **iFarmer** Program.

Maria walks over to the Green Wall, inspecting the bounties of food already growing, noticing that the onions will be ready very soon. She steps over to the small interface that is slightly off to the right of all of the growing fruits and veg-

etables. She can see that the Meal Pal has transferred information about the ingredients that she will need to produce for the meal to the **iFarmer** Program. At the top of the screen is the headline "Remaining Ingredients Needed for Chicken Cacciatore", with other images and information about what those ingredients are listed underneath. It shows that three unavailable ingredients are necessary, as images of tomatoes, and red peppers are displayed along with text beside them detailing suggestions of how and where to plant the specific vegetables. Beside the image of the romano tomatoes, text reads "plant 12 tomato seeds in aeroponic compartment **Food Growth Stadium**, there is adequate space on the 3rd shelf. The tomatoes will be ready for consumption in 6 days. Similar information is displayed beside the peppers, but with recommendations to plant on Green Walls instead. Below the information on the interface, there are two flashing icons indicating that there is a pair messages from the **iFarmer**. Clicking on the first one, Maria reads: "local weather forecasts indicate a high probability of frost during the next 24 hours, the **Food Growth Stadium** on the roof will seal itself to prevent damage to the produce." Clicking on the second icon, the message appears;" the romaine lettuce planted in the Growth Stadium is ready to be picked." Instead of going to pick the lettuce immediately Maria touches the screen on an icon that says "keep message" which informs the **iFarmer** that she wishes to be reminded of the lettuce later on in the day.

While thinking about the dinner she is planning on serving to her friends, the thought occurred to Maria, that it would not be a bad idea to make martinis for everyone. She is aware that she has the right drinks, and even a shaker, but does not have the faintest clue of how to actually make a good martini. Stepping back into her kitchen Maria grabs the martini shaker from the cupboard, holds it up in front of the nearby Interface and says: "Handyman Helper, how do I use this?" On screen pops up several pieces of information, on the left portion of the screen is a selection of tutorial videos she can choose from that will illustrate how to use the shaker, on the right is a listing of martini recipes. Selecting one the tutorials, the video expands to the full size of the interface and starts playing, displaying a bartender going through the steps of making a variety of different martinis. Thinking to herself that it did not seem to hard, Maria decides to try it for herself and makes a martini to enjoy as she cooks dinner.

While at that same interface, Maria touches the screen several times, going through a progression of steps, first selecting the "main menu", then the "**Know-It-All**" and finally the "Cooking Coach". With all of the work she has already put in today getting Friday's dinner ready, she did not want to spend much additional time thinking about how to cook something for herself. Maria's lack of will and effort does not diminish her desire for a unique and tasty meal though. She clicks on the "preferences" option within the Cooking Coach screen, bringing up a series of options; one of the options allows Maria to adjust the level of assistance that the Cooking Coach provides. Usually Maria tends to prefer to be left alone when cooking, so she has the program set to "display recipe only", which simply provides a listing of the recipe ingredients and steps on the interface for

her to check as she needs. Today, to support her lack of energy and effort, Maria changes the setting to “instruct and assist”, which proceeds to help and guide her through each step of the cooking process. Making a new stir-fry from a recipe she selected at an earlier time, Maria is unsure of steps, measurements, proper temperatures and cook-times, each of which is explained to her by a deep warm voice that takes her through the process step by step. As she nears the end of the cooking process, the voice remarks “add last of meat to pan, and allow to simmer. The temperature will self adjust and I will alert you when the meal is cooked and ready.” Knowing that the Cooking Coach will finish the cooking process, she feels it would be best if she get cleaned up and dressed for the night out.

Maria had agreed to meet a few of her best friends at an old pub that she had not been to in many years. Unsure of what to wear, she checks the Wardrobe Advisor for some ideas. At the closet in her bedroom she engages another interface, one similar to one in the kitchen. Instead of touching the screen this time Maria just talks to the screen: “what should I wear?” Recognizing the question as one that pertains to clothing, the Wardrobe Advisor appears on the screen. Continuing to speak to the interface, Maria identifies some details about her evening plans: “I’m going to McDuff’s pub in the city, at 8 o’clock tonight.” Recognizing the type of event, and the location, the Wardrobe Advisor checks for information about the venue, checks databases for the latest style trends, the weather forecasts and the **Storage Catalogue** for available clothing items in the home. From this information the system is able to make a few suggestions. On the screen appear 5 images of Maria wearing different outfits, each very flattering to her. After, mulling it over for a second, Maria decides on the second outfit, dark jeans, white t-shirt and black blazer with black leather boots. Touching this option on the interface brings up a listing of the individual clothing items that comprise the outfit and where these items are in the house. At the bottom of the screen, a message is displayed in large text stating: “fashion tip: the current style is to do up only the top button of the blazer.” After collecting the clothes and getting dressed, Maria, after a long day, is finally ready to relax and enjoy the evening.

BIOMETRIC SECURITY

The Biometric Security System is a function of the storage in the home that tailors item security levels to the individual person. Access to items in storage is granted or denied based simply upon who that individual is and whether they are intended or permitted to have access. Through sensors embedded in the environment, biometric scanning can be performed, thus enabling identification of individuals in the home. This information allows for storage systems to have different reactions for individual people.

Discussion

The **Biometric Security System** makes use of the sensor systems embedded in the home environment to tailor storage security to individuals. Items in the home require security for two primary reasons. First, security for items to be protected from people; theft, damage, and invasion of privacy, and second, to protect the users from the possible harm potentially caused by the items themselves. Sensitive documents, valuable items, and fragile goods tend to be in the first category, while alcohol, tools, knives, firearms tend to fall into the second classification of item security. In order to accomplish this in the most efficient way, security is not simply determined by key or password, but the sheer fact of who the individual is.

Storage units of all forms within the home are governed by a system that recognizes the individual and adjusts the levels of access to match to the individual. Embedded within the home are scanners that identify the biometric signature of each person, recognizing individual; retinal identity, finger prints, pulse, facial structures, movement patterns, scents and more. The scanners within the home will be able to readily identify an individual within the home and can therefore grant or deny access to parts of the home to that individual, in particular, storage environments.

The security and accessibility levels are determined in one of two ways; they are input and specified by the individual utilizing storage, or they are preset standards of a product. The first means, user determined security, is enacted by a user placing an item into a storage unit and while doing so, specifying a general level of security or particular security features and levels. For example, a person putting a package into a storage compartment can specify that no children have access, or that a specific person not have access, or that only a specific individual may have access. The inputting user has nearly complete discretionary control over the security. In the case that a child implements the security measure, the parents would have over-ride capabilities.

The second means of security determination is by preset security standards, security levels prescribed to items by manufacturer or user. Certain items carry with them an inherent risk, both to the person trying to access the storage, and the person who put the item into the storage. This inherent risk level determines the security level of whichever storage unit in may be in. For example, kitchen knives carry a security preset that denies access to young children, regardless of which drawer or cupboard they may be in, children will not be able to access that compartment. Similarly, valuable items such as jewelry carry a security-preset standard that would deny access to anyone other then immediately family.

Access is granted or denied by two basic means, physical and information access. Storage units that contain items that are not to be accessed by an individual will not open the containing compartment to the individual. Items will essentially be locked in the compartment. The other form of access, information, can be denied

PROPERTIES

- Biometric scanners that recognize individuals
- Storage units such as cabinets, closets and drawers
- Preset item security standards
- Audio or visual interfaces

FEATURES

- Security levels predetermined for certain objects
- Denies/allows user access to physical storage
- Hides/ allows access to information in storage catalogue
- Allows individual to input/alter security level of each item
- Security can be adjusted/ determined by individual
- Security specified to person, group, demographic
- Suggests storage for property security

to a person, hiding to that person the whereabouts of an item, or even the existence of the item. This means of security is analogous to a secret hiding place, where the security lies within the fact that others are ignorant to the existence of the item. In some cases, the security level that any given storage compartment provides may be inadequate; in which case the **Biometric Security System** will advise the user on a more suitable storage location. In some extreme cases, where physical security of an object is imperative, the system will recommend using the **Secured Storage** compartment that can offer a high degree of protection.

Scenario

Preparing for his wife Susan's birthday dinner at their home, Michael has a few things left to do. Having just finished wrapping Susan's gift, a new full-length wool winter coat, he has to find a place to hide it from her. While Susan is out of the house, Michael quickly moves the present the utility closet where most of the tools in the home are kept. The likelihood that Susan would open this closet, or think to look for a gift there is small, but Michael does not want to take a chance in spoiling the surprise. To make certain that she doesn't find the present, Michael adjusts the Security Specifications for the present with the Biometric Security System. As Michael puts the brightly wrapped into the closet, he makes verbal requests to the Security System by speaking out loud: "deny access to gift to everyone other than myself." Recognizing the gift is now inside the closet, the system complies with his wishes, and the doors to the closet lock and will remain locked to everyone except Michael.

With Scanners located in many places throughout the environment, the **Biometric Security System**, can recognize the facial structure, retinal identity, walking patterns, heart rate and scents of an individual, and thus identify them. By doing so, it understands which person is trying to access storage, and can tailor the levels of access to match. Michael knows that his 7-year-old daughter Julie has a hard time keeping secrets, and if she were to find the present she would run straight to Susan with her findings. With the Security Specifications for the present now changed, even if Julie tries to steal a peak of the gift, the Biometric Security System will recognize her and will not allow the doors of the closet to open in her presence.

By changing the access levels to the gift, Michael had not only secured the doors to the closet but access to information on the **Storage Catalogue** information system as well. Susan may later try to search in the catalogue for "jackets" or "presents" but will not find anything other than her usual old coat. By specifying a stricter security level, the Biometric Security system ensures that information about the gift would be hidden on the **Storage Catalogue** to everyone other than Michael; there would appear to be no trace of this gift.

Leaving the closet, Michael starts to clean up the home, getting it ready for the dinner that night. As he was putting some items away, he noticed Julie trying vehemently to open a drawer, with no success. Julie, in frustration yells out

"daddy, why won't this open?" Unsure of the answer himself, Michael goes over to the drawer and opens it without any struggle. Looking inside, he sees a set of sharp kitchen knives and realizes that the Biometric Security System is denying Julie access to the drawer because the knives have a Safety Preset. When the knives were manufactured they were done so carrying a Safety Preset that as a safety precaution specifies that young children should not have access to them. The Biometric Security System recognizes this preset, and that Julie fits into this demographic, and keeps the drawer locked to her. Should he choose to, Michael could remove or amend this Safety Preset, but with Julie being as curious as she is, the Safety Presets have kept her out of trouble on many occasions.

SPACE CUSTOMIZATION

OMNI WALL

Omni walls are interior walls that can change shape, position, colour and texture. Made of nano material its material properties can be altered enabling addition, removal and repositioning of interior walls. Functional and decorative features of Omni Walls allow for efficient space and environment transformation.

Discussion

Families have unique configurations and life patterns—consider single moms, empty nesters with visiting kids and grandkids, families with young children and multigenerational families. People are increasingly looking for homes with adaptable and customizable spaces to accommodate changing lifestyles.

Omni Walls are designed to support the unique needs of inhabitants. It enables space customization by allowing the addition, removal and repositioning of interior walls. Breathability Function assists in interior air regulation while Opacity Transformer assists with opacity levels of wall surfaces. Inhabitants can create furniture, shelving and other surfaces as extensions of walls that can be added

PROPERTIES

- Adaptable interior walls
- Functional capabilities for space customization
- Decorative capabilities for environment transformation
- Operational through visual/ surface interfaces
- Operational through vocal/ audio interaction
- Manual manipulation capabilities

FEATURES

- Enables addition, removal and repositioning of interior walls
- Facilitates personalization of space
- Enables functional customization of space
- Facilitates operation through interactive surfaces
- Allows operations through voice recognition and biometrics
- Responds to user requirements
- Confirms completed procedures
- Regulates interior air
- Maintains interior air quality

and removed when required. Decorative features make it easy for personalizing spaces by allowing changes in colour, lighting, texture and surface patterns.

Made of nano material they can be adapted to specific functional and decorative requirements. Nano materials follow simple rules, like those followed by parts of drawings on computer screens. In these drawings, a picture of a rectangle can be commanded to sprout handles at its corners; pulling handles stretches or shrinks the rectangle without distorting its right-angle corners. An object made of nano material could do likewise in the real world: a box made of nano material could be stretched to a different size, then made rigid again; a door could have its position unlocked, its frame moved a pace to the left, and be returned to normal use. **Omni Walls** also respond to stimuli including sounds, movements of people, environmental conditions and electronic information.

Using Space Planner users can set their preferences to operate **Omni Walls**. Functions that are used more frequently can be set to automatic mode. Voice recognition capabilities and biometric sensors allow users to “talk” to the wall and also use gestures to make changes. User Preference Presets further guarantees foolproof performance and control of system operations by specified individuals. This will prevent misuse or possible mistakes by those who are not familiar with the system.

Omni Walls are connected to the **Nexus** of the home. To add, remove or move a wall, user selects the wall on the Space Planner. Dimensions, surface properties and materials are also selected, and with one click the changes are activated. Walls that need to be removed will change its material properties and be pushed to blend in with adjacent walls. Walls that have to be added will be created as an extension of existing walls that will protrude out of the wall and once in place become sturdy and stiff like any regular wall. To move walls from one place to another, again, the material properties are changed, so that the wall becomes light enough to be moved. Users can perform some functions manually. This combination method allows user to feed in required data in Space Planner but push or pull walls manually. Wall structures can be reworked like soft clay, doing their structural jobs all the while. User can also experiment with dimensions and surfaces manually, hence receiving hands on creative control.

Materials can be changed to be as smooth and uniform as a piece of plastic, or as richly textured as wood or cloth depending on the arrangement and appearance of the submicroscopic parts. Materials and products capable of relatively complex behavior due to the incorporation of nano computers and nano machines can change its material properties allowing for easy customization. These features also allow users to create shelves, benches and other surfaces from existing walls for temporary use. It guarantees space utilization by collapsing and enlarging storage when needed. Users can create activity walls by adding nooks and crannies for climbing, thus aiding in the **Fitness Immersion System** of the home.

Omni Walls have diffusion and hygroscopic properties that allow for the absorption and permeability of moisture and vapour. Water molecules dissolved in the vapour phase are spontaneously transported from volumes of higher concentration to those of lower concentration until the concentration is uniform. In addition, **Omni Walls** being Breathable can filter out 99.9% of all airborne particulate, gaseous and other pollutants from the incoming ventilation air. Windows and walls are selective barriers, blocking the passage of physical material, while allowing light to pass. **Omni Walls** and windows, powered by the absorption of light and sound, change the selectivity of the barrier by allowing air as well as light to pass through freely, while stopping liquids and solids. Breezes can be permitted to flow unrestrictedly into the home, or the windows can block airflow entirely when the weather is too hot, cold or inclement. Sensors located on the outdoor edges of the pores of the **Omni Walls** monitor air passing through. When an unwanted particles are detected, the pore is closed at the indoor surface, trapping the particles until it can be transported back to the outdoor surface and released. This not only ensures that building occupants are protected at all times against the harmful effects of airborne pollution, but that such buildings will actually clean up the outdoor environment in which they are located. **Omni Walls** thus, in addition to its other benefits, encapsulates an effective urban cleanup technology capable of reversing, at scale, the hazards of air pollution in cities across the world.

Walls and windows containing nano machines and nano computers sense internal and environmental conditions to adapt appropriately. The nano machines in the walls and windows can also selectively reflect, absorb and transmit light, a useful capability on a hot summer day. The Opacity Transformer is derived from this is a unique feature. Windows can act as one-way, privacy-ensuring screens. By absorbing light on both indoor and outdoor surfaces, but emitting only the outdoor light on the inside, the window appears transparent to anyone in the home, but opaque to an observer on the outside. When it is hot and sunny outside the windows if desired can turn opaque. In other instances where inhabitants want a lot of light, they can make the surface transparent. User Preference Settings will allow these functions to be set to automatic or manual mode.

Nano machines and nano electronics in **Omni Walls** will control sound in the home by changing how a surface moves. The Black Out feature enables surfaces to be able to emit high-quality sound and also actively flex to absorb sound, so that the barking dog across the street seems to fade away. This property allows users to make rooms soundproof and reverse the change when required.

Chameleons and flatfish change color by moving colored particles around, and nano machines could do likewise. Live lobsters are a dark grayish green, but when cooked turn bright red. Much of this change results from the “retuning” of a dye molecule that is bound in a protein in the live lobster but released by heat. This mechanical change alters its color; the same principle can be used in nano machines, but reversibly. Nano materials also allow forever changing decorative features. Walls are programmed to change colour, light, texture and surface pattern

when desired. These can be programmed to change from time to time. Manual options are still available if user wishes to create textures and patterns manually.

Smart Panels is another feature of the **Omni Walls** that allow creative exploration in the home. These panels can be used to paint pictures, write grocery lists and once done can be deleted to obtain a clean palette. Children can draw on walls and floors since the decorations can be erased when required.

The **Omni Walls** thus allow optimum use of space and creative exploration in the home.

Scenario

Molly a graduate student has invited her entire class of twenty-five students over for a dinner party at her place. Though she shares a small two-bedroom apartment with her friend Alice, accommodating a large number of people is not an issue for her. Her apartment has **Omni Walls** that allow her to customize the space according to her preferences. Using Space Planner she looks up various layout options. She can also create her own layout and preview it in this program. Not having enough time, she chooses an existing layout. By removing her bedroom wall and opening it up to the living room she will have enough space to accommodate a large crowd. This time she won't need to borrow Alice's bedroom.

Looking at the Space Planner she selects the bedroom wall she wants removed. By pressing "Enter" on the screen, she activates the process. The material properties of the wall changes so that it becomes light and thin. Then the wall moves and blends in with the adjacent wall giving Molly the spacious party space she wanted.

Delighted with the space Molly decides to create a fun environment for the party. Going back to the Space Planner she looks up User Preference Settings. There are various settings she can choose from or she can create her own. After looking through the Presets Menu : Disco party, Book reading, Date Night, Dinner Party etc, she chooses Dinner Party. The **Omni Walls** immediately change colour, texture and turn luminous. Preferring to keep it simple she decides not to have patterns on the wall. She selects fuchsia pink, her favourite colour to give a pink overcast to the entire space. However she is not satisfied with the outcome and decides to add her own touch to the décor. By using **Smart Panels**, she does a quick painting on the main wall to enhance the space.

Just when she is done and is ready to start cooking, Alice walks in. She loves what Molly has done to the space but there is a problem. She had forgotten to tell Molly about her exam the following day. A few hours left for the party to start, there is no way Molly can postpone it. Instead of getting into an argument, they look at each other and smile. The Black Out Feature of the **Omni Walls** lets them make Alice's bedroom soundproof. So while Molly is having a fun time with friends Alice can study in her room without being disturbed.

To make up for her folly Alice decides to contribute to the décor by creating a relief art for Molly. The Space Planner allows Alice to change the properties of the **Omni Walls**. Choosing her bedroom wall that faces the living space Alice pushes, pulls, shapes and moulds the wall like clay creating a beautiful relief on the wall. Once she is done the wall becomes stiff, like any regular wall. Molly loves the work and is glad to get some help from her friend. Before she starts cooking she uses the Opacity Transformer to change the opacity of the floor to ceiling windows. The chosen effect will make the windows opaque so that no one can see inside, but her guests can enjoy the great night views of the city.

Using Intelligent Cooking Surfaces Molly starts to cook. She doesn't have to worry about the rooms getting too hot or smelly because of the Breathability Function of the **Omni Walls**. After the food is done Molly creates a couple of shelves from the **Omni Walls** to keep the wine glasses out. The space set, the food ready Molly puts on some music and leaves to get ready. Her friends will arrive in half hour.

ADAPTIVE SURFACES

Adaptive Surfaces are surfaces that can be physically altered to user preferences. Made of nano material surfaces such as furniture, tabletops, counter tops and shelving can be created, removed, reshaped, resized and its properties modified. In addition to these functional features adaptive surfaces have decorative feature that enable aesthetic customization.

PROPERTIES

- Adaptive surfaces including furniture
- Functional capabilities to support ergonomics
- Decorative capabilities for aesthetic enhancement
- Operational through visual/ surface interfaces
- Operational through vocal/ audio interaction
- Manual manipulation capabilities

Discussion

Adaptive Surfaces made of nano material allow flexibility and customization of surfaces such as furniture, counter tops, tabletops, shelving etc. It allows creation of temporary surfaces that can be removed once its use is over. Existing surfaces like chairs and tables can be reshaped, resized and its material properties changed.

Adaptive Surfaces work the same way as **Omni Walls**. However they include free-standing furniture and horizontal surfaces like kitchen countertops. Alterations are made similar to **Omni Walls** using Space Planner or manual manipulation or a combination of both. Biometric sensors and voice recognition capabilities assist in the transformation process.

Dining tables are hardly used in homes, especially formal ones that are reserved for special occasions, resulting in underutilization of furniture and space. Tables can be expanded in size, increasing or decreasing seating capacity. It can be raised or lowered according to user needs. For kids the table can be lowered and at the time adults eat it can be raised back to its original height. Inhabitants can achieve optimal usage by keeping a small table for daily use that can be extended when required, ideal for Thanksgiving and Christmas dinners. **Adaptive surfaces**

FEATURES

- Allows physical alterations of surfaces
- Allows decorative enhancement of surfaces
- Enables creation of temporary surfaces
- Responds to user preferences
- Facilitates alterations through visual/surface interfaces
- Facilitates alteration through vocal/audio interaction

not only change shape and size, they also enhance the dining experience. When serving containers are placed on the table, the surface can heat or cool as necessary to maintain temperature. Heating and cooling occur only under containers, because nano material can control heat conduction.

Improving the functionality and comfort of seating is an ideal application for **Adaptive Surfaces**. Users can change the feel of the material and also resize to suit their physical needs. Because thermal comfort levels differ significantly for many, particularly the young and the old, a chair can also warm or cool as desired. Chairs remember the preferences of the home's inhabitants through biometric sensors and hence can automatically change to suit needs. Single chairs can serve multiple purposes because of their ability to change form. Major changes in form cannot be quickly performed, because of limitations in the rate at which nano materials can reform large amounts of material. If a reclining chair is to become a task chair, the change may take some time. Variability at this scale can only be used to satisfy changes in seating foreseen well enough in advance of their need to allow for the time required to change. Varieties of pattern and/or texture can also be created as decoration, allowing an owner to select from a palette of style alternatives.

Typical shelving systems retain the same configuration when fully utilized or when empty. **Adaptive Surfaces** shelving adapts and changes with its contents and can be expanded or compressed to fit a variety of spaces, thus providing access to otherwise unusable space.

Adaptive Surfaces thus serve as functional and flexible surfaces accommodating to changing lifestyles.

Scenario

Molly is preparing for her parents' visit over the weekend. The furniture she has is fine for her and her friends but she wonders whether her parents will be comfortable. Her mother Lisa, has arthritis and she needs to have appropriate seating and sleeping surfaces.

Lisa loves to cook but because of her arthritis her flexibility has reduced making it difficult for her to reach out and access what she needs. Molly decides to redo her surfaces. She pushes down the countertops so that it is low enough for her mother use efficiently. She also moves the shelves down so Lisa has access to all the ingredients she may need for cooking.

While she is rearranging the kitchen she suddenly remembers that the bed may be too high for her mother. Since she is busy in the kitchen she uses the Space Planner to select and lower the bed instead of doing it manually as she did for the counter tops and shelves.

Luckily her father does not have any health issues. The only thing he cares about is his armchair that he misses when he travels. Molly decides to transform her chair into an armchair for her father. Since this may take time she needs to start the process immediately so that it will be ready in a day. Using the Space Planner she selects a 3d model of the armchair she wants, and adds her preferences for colour and feel. After making some manual alterations she activates the process through the Space Planner. The feel and softness of the seating can be finalized once her father is home.

The weekend arrives and her parents are finally at her place. They are happy to see all the changes that Molly has made for them. Her father can't wait to adjust the armchair features. He sits in it and feels that it is too hard. Space Planner allows him to make changes till he is satisfied. He also needs the backrest to be more supportive. This he does manually by bending and flexing the surface.

Lisa, Mollys mother is keener on the aesthetic aspects. She adds colour and pattern to her own chair that was carefully redesigned by Molly. Once she sits in the chair, the chair messages her and also increases the temperature to make her feel more comfortable. Molly brings hot coffee and they all sit around the fire and have a great evening together.

FOOD PRODUCTION

FOOD GROWTH ASSITANCE

The growth assistant is system with a set of tools installed in various Growth Units. It provides controlled internal environments, water and nutrient administration, environment protection, pest protection and growth enhancement.

Discussion

The Food **Growth Assistant** is an intelligent platform consist of a set of tools to ensure optimal growth conditions for plants. It is incorporated into different Growth Stadiums to enhance food production. The **Growth Assistant** functions on three basic levels: maintain, enhance and protect.

PROPERTIES

- Growth Monitor to maintain watering and nutrition level
- Biosensor for nutrient detection
- Gas chromatograph for growth status
- Growth light to enhance growth
- Adaptive Glass panel for greenhouse
- Nano nutrient catalyst to enhance growth
- DNA chip for pathogen detection
- Invisible Fence to protect plants for environmental damage and pests
- Alert system to activate Invisible Fence

The **Growth Assistant** is actively involved in the whole growth cycle of plants. Before growing, the **Growth assistant** communicates with the Seed bank to gather seeds or seedlings. The Seed bank is an internal reservoir of biological resources such as plant seeds, developed seedling for agricultural growing and animal or plant cells for in vitro growth.

The Maintenance feature of the **Growth Assistant** consists of Watering and Nutrient Monitoring System and Growth Stage Detector. During the entire growth cycle, the **Growth Assistant** has Water and Nutrient Monitoring System to ensure adequate supply of water and nutrients depending on the stages of plant growth. The monitoring system includes sensors embedded in the growth medium to constantly monitor the moisture level, soil composition, soil pH, humus content and other factors. When there is a drop in water level and nutrients contents, the Auto Replenish System will transfer water and nutrients to the growth medium until they reach the desired level. Also, sensors are placed for every single plant to track how much and what kinds of nutrients the plant has absorbed. Thus, water and nutrients is delivered to each plant depending on individual plant's growth stage.

A Growth Detector utilizes gas chromatograph technology, will informs the system when to pick the plant by analyzing which flavenoids the produce contains. These flavenoids can be detected from flavors of the produces, particularly for more aromatic produce like tomatoes and peppers.

The Enhance feature of the **Growth assistant** consists of Growth Light, Solar Greenhouse, Growth Regulator and Nano Catalysts. Controlling light and nutrients delivery can promote healthy plant growth and optimal harvest.

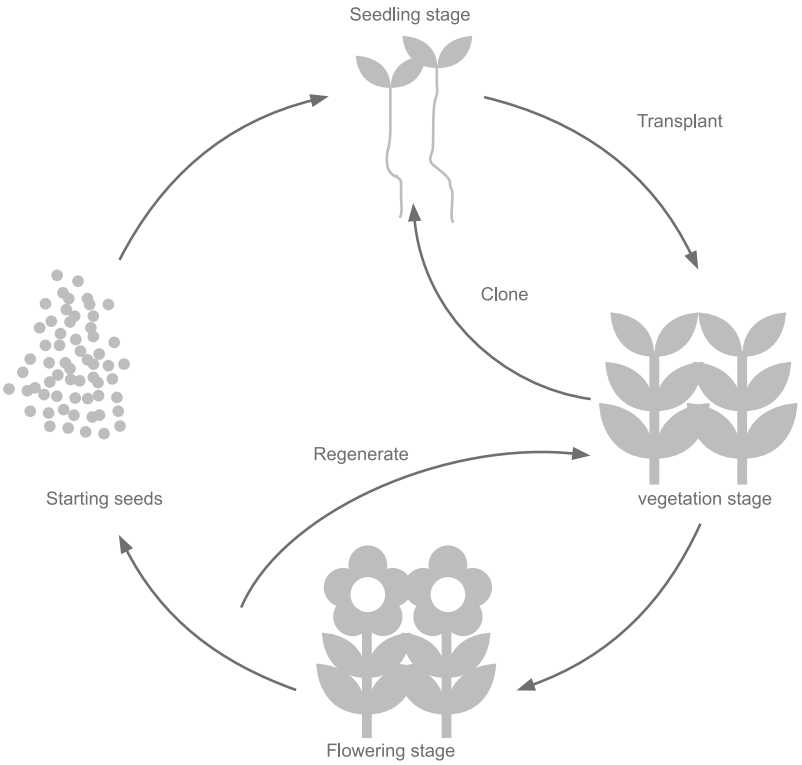
A Growth Light is a device to promote plant growth by emitting an electromagnetic spectrum appropriate for photosynthesis. The emitted light spectrum is similar to that from the sun, allowing indoor growth with outdoor conditions. **Adaptive Glass Panels** works by letting in solar radiation to warm the Growth Stadium, with the structure then trapping the energy to increase and maintain the temperature. Solar Greenhouse works when the sunlight is favorable, and Growth Light supplements when there is inadequate natural sunlight.

Plant Growth Regulators are organic compounds, either natural or synthetic, that modifies or controls physiological processes within a plant. Natural plant hormone or compound with the same function is used to accelerate or retard the rate of growth or maturation, or alter the behavior of plants or their produce. Nano Catalysts are nano-sized nutrient delivery catalysts, which are able to penetrate plant seed coat and enhance seed germination and plant growth.

The Protection feature of the **Growth assistant** consists of **Pathogen Monitor**, Invisible Fence and Plant Growth Threat Alerts.

The **Pathogen Monitor** uses DNA chip technologies that detect the presence

of plant pathogens by simply sampling the air and using snippets from various viral and bacterial infections.



FEATURES

- Maintain optimal condition for plant growth
- Enhance the growth cycle of plants
- Detect malicious changes
- Automatically correct harmful changes
- Protect the plants from threats
- Alert the residents in case of emergency
- Communicate with Food Catalogue to update inventory and catalogue the harvests
- Communicate with Seed bank and Inventory Database to obtain resources for growth

Scenario

Tom decides to grow papaya trees in his **Food Growth Stadium**, which is the Roof Garden of his house located in Chicago. He tells his house that he would like to have 10 papaya trees.

His **Food Growth Stadium** triggers the **Growth Assistant** System installed in the roof garden and send data on the fruit type and numbers of trees to the system. Upon receiving the information, the **Growth Assistant** System checks with the Seed Bank, which is the storage reserve for seeds and seedlings in the house. However, the system realized that there are no papaya seeds in the seed bank, because it is not a natural local plant. Thus, the system notifies the Inventory Monitoring System to purchase them at the local gardening store.

After 3 days, the seeds arrive and are transferred to the roof garden. The **Growth Assistant** System already searched for information on papaya growth, and decided on the type of growth medium, nutrients type, watering pattern and maximum growing environment. It recognizes that to grow good papayas, it needs a frost free climate, lots of sunlight, lots of water and soil rich in organic matter and nutrients. Thus, the system plant 30 papaya seeds into soils with is provided by the Nutrient Compost system.

The seeds takes a week to germinate. Out of the 30 papaya seeds, some are weaker and not suitable for fruiting, the system cull the weaker ones, and keep the best remaining papaya seedlings. Down to the ground. Only keep the very best.

The Water and Nutrient Monitoring System know that papaya growth needs a lot of water. It places sensor next to each of the papaya seedling, and constantly monitors the moisture contents of each plant. Some early grown seedlings require more water so the Auto Replenish System delivers the desired amount of water to each plant.

Papayas need a lot of fertilizing. They are particularly greedy for nitrogen. Frequent and regular fertilizing is needed, and the Nano Catalysts contained in the nutrients boost the delivering of nutrients to papaya's rooting system. Natural papaya hormone, which is a kind of Plant Growth Regulators is added to ensure the growth cycle of papaya in a much colder environment. If Tom wants to harvest papayas at a later time, the Plant Growth Regulators can also help to postpone papaya's fruiting time.

As a tropical plant, Tom's papayas love heat and sunlight. Usually the Growth Stadium utilizes the **Adaptive Glass Panels** to let solar radiation to warm the soil and plant, and trap the heat inside the stadium to maintain a tropical temperature. However, being cloudy for days, there is not enough natural sunlight for the papaya. The **Growth Assistant** switches on the Growth Light to emit electromagnetic wave which is similar to the sunlight, and adjusts the light waves according to the growth cycle of papaya trees.

With plenty of water, nutrients and sunlight, the papayas are flourishing. Despite the stadium being a safe and regulated place, papayas get a whole slew of viruses and diseases, transmitted by sucking insects. The **Pathogen Monitor** uses individually installed DNA chips to watch each plant closely for signs of pathogen and insects. One day, the **Pathogen Monitor** detects brown spots on the leaves of a papaya tree, it immediately turns on the Plant Growth Threat Alert, and the Invisible Fence is triggered to isolate the individual papaya tree to prevent spreading of diseases to its neighbors. The **Growth Assistant** cuts off the branch, and sprays the whole tree with anti-viral solutions. The Invisible Fence encloses the infected tree for days, and restores it after no further symptoms are observed.

Papayas start flowering when they reach 1 meter tall. The Growth Stage Detector recognizes the height and shape of papaya trees, detects papaya fruiting via gas chromatograph technology by analyzing the flavors.

Finally, the papayas are ripe. Tom receives a message by the **Growth Assistant** to alert him for manual picking or automatic picking of fruits. The remaining papaya trees are well taken care of by the **Growth Assistant** for the next round of harvest.

FOOD GROWTH STADIUM

An enclosed system placed inside or outside of the house for growing plants. The Food Growth Stadium selects and maintains suitable growing environment to achieve optimum yield of plants.

Discussion

According to the United Nations, the amount of arable land per person decreased from about an acre in 1970 to roughly half an acre in 2000, and it is estimated to decline to about one third of an acre by 2050. With 38% of population increase in 2005, an estimated 109 hectares of new land will be needed to grow enough food to feed us. Thus, the traditional soil-based farming model developed over the last 12,000 years will no longer be a sustainable option.

By the year 2050, nearly 80% of world population is projected to reside in urban centers. It is foreseeable that urban farming becomes the source of locally sustainable food. Vertical farming, one type of urban farming, is large-scale agriculture center in urban areas, particularly in high-rise "farmscapers." And in-house **Food Growth Stadium** can provide individual household with own food production ability.

A **Food Growth Stadium** is an enclosed system placed inside or outside of the house for growing plants. It can take the form of a greenhouse on the roof top, or a Growth Shelter at the backyard of the house, or a Growth Terrarium inside the house. **Food Growth Stadium**s can ensure year-round production within the household, and provides controlled, organic and clean environment for plant growth. With the support from Food **Growth Assistant** to provide food growth enhancement,1 indoor acre can produce food equivalent to 4-6 outdoor acres or more, depending upon the type of the crop. (E.g. Indoor acre can produce as many strawberries as 30 outdoor acres does)

Physical structure of a **Food Growth Stadium** consists of 3 parts (see Diagram 1):

1. External resources including water and nutrients reservoir. The irrigation and nutrient delivery system actively draws water and nutrients from the reservoir, and returns the unused resources back to reservoir for future consumption.

2. A Growing Platform, which is a structure to hold the vegetation in place.

3. A irrigation and nutrient delivery system to provide vegetation with basic growth needs. It can take advantage of soil-based methods, or soil-free methods such as hydroponic and aeroponic technologies. Hydroponics allows us to grow plants in a water-and-nutrient solution, while aeroponic grows them in a nutrient-laden mist. Soil-free growing requires as far as 90% of water than conventional cultivation techniques.

PROPERTIES

- Enclosed space for plant growth
- Adaptive Glass Panels for controlling internal environment
- Growth platforms installed inside the Growth Stadium
- A growth medium for plant growth
- A irrigation system for continuous watering
- A hydroponic reservoir for irrigation
- A nutrient delivery system

FEATURES

- Choose suitable growth location for different vegetation
- Utilize different growth medium for different vegetation
- Select irrigation methods base on plant type
- Establish irrigation and nutrient delivery system
- Automatically maintain internal environment

The **Food Growth Stadium** also incorporates the Food **Growth Assistant** to enhance food growth.

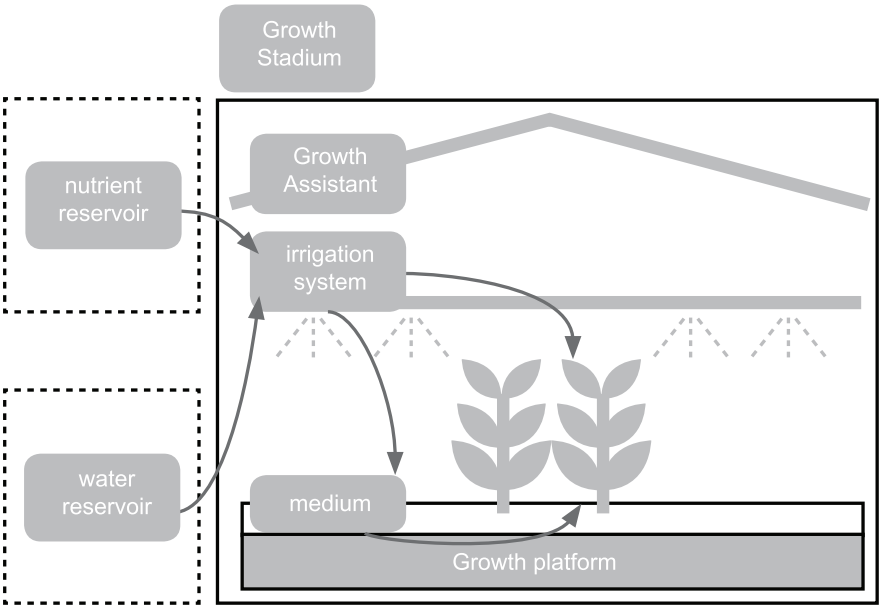


Diagram 1 **Structure of food growth stadium**

Scenario

Jim is living with his wife and 2 daughters in Chicago. The winter is coming, and Jim wants to grow strawberries to make some strawberry desserts for this festive season.

Jim consults the **iFarmer** (**Know-It-All** System) for how to grow the plants. The **iFarmer** lists all available growing locations for him to choose from, which includes: **Food Growth Stadium** at the Roof Garden, Growth Shelter at the backyard and Food pond inside the house.

The Roof Garden is a garden on the rooftop of Jim's house. It is a equipped with a **Food Growth Stadium**, Green Roof, dining and lounge furniture and mood adjusting lighting systems. Jim's family often goes to the Roof Garden for relaxation while checking out their vegetations. The **Food Growth Stadium**, which is a part of the Roof Garden, is enclosed within **Adaptive Glass Panels** to protect the vegetation from Chicago's cold winter.

The backyard of Jim's house is an semi-open yard protected and environmentally regulated by a Growth Shelter. The Growth Shelter ensures transition and blending of human habitat and native landscape in the local community. It encourages Jim to grow native plants and attracts desired local wildlife, such as butterflies, bees and birds, into the habitat to become part of the outdoor environment. The

Growth Shelter contributes to building a balanced ecological community.

Jim also found out that he owns several Growth Terrariums inside his house. Growth Terrariums are miniature, self contained ecosystems. Moisture in the Growth Terrariums evaporates from the soil and plants and constantly condense on the container walls. The condensed water falls down and re-moistens the soil. Thus, plants in the Growth Terrarium are self-sustainable for a long period of time. Low growing plants are the best match for using Growth Terrariums. Jim and his family can watch their Growth Terrariums like watching fishes in an aquarium in their house.

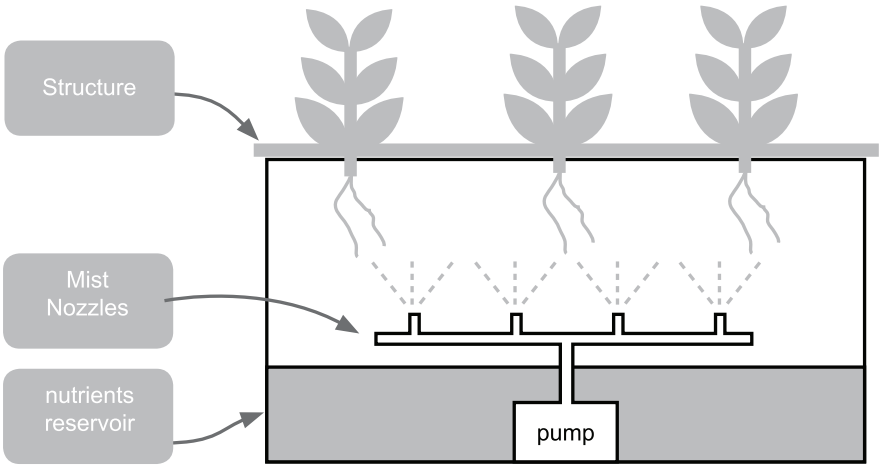
With so many choices, Jim is puzzled. The **iFarmer** gives him a suggestion: since strawberries needs a lot of water, nutrients and a moderately warm temperature, it is best to grow them on the Growth Stadium on the Roof Garden. Next, the **iFarmer** informs Jim that he can choose to grow the strawberries using terraponics, hydroponics or aeroponic.

Terraponics uses traditional soil-based agriculture methods. Hydroponics is a method of growing plants in a constant flowing nutrient-enriched water. In Terraponics, soil acts as a mineral nutrient reservoir but the soil itself is not essential to plant growth. When the plant can get required mineral nutrients through their water supply, soil is no longer required for the plant to thrive.

Aeroponic grows plants in a closed or semi-closed environment by spraying the plant's roots with a nutrient rich solution. The plants' roots are suspended in an environment where the roots are exposed to plentiful supply of oxygen, water and nutrients. The Aeroponic systems comprise high-pressure device hardware and biological systems. It has embedded sensors for precision timing, thermal control of solutions, and nutrient content controls. It also connects to the **Growth Assistant** and various other systems for data gathering, monitoring and analytical feedbacks.

Jim lets his **iFarmer** to decide the appropriate irrigation methods. The **iFarmer** then starts to calculate the quantity needed, growth cycle of strawberries, water and nutrient usage, energy consumption and maintenance issues related to each irrigation methods. It finally selects Aeroponic for Jim to grow his strawberries, and proceeds to communicate with the Seed Bank to get the seeds, Nutrient Compost System for nutrients, and Food **Growth Assistant** to prepare the desired growth environment.

The strawberries seeds are pre-germinated to grow to seedlings. The seedlings are held by a structure in place and suspended in the aerophonic growth chamber. There is a nutrients reservoir underneath the chamber. A pressure pump is placed in the nutrients reservoir which connects to the mist nozzles. The nozzles constantly sprays nutrient-rich medium to the suspended roots (Graph 1).



Graph 1 **Structure of Aeroponic Growth Stadium**

Because strawberries like warm temperature, the **Adaptive Glass Panels** harnesses solar radiation from the sun, and warms plants and soil inside the Growth Stadium. The **Adaptive Glass Panels** are made from liquid crystal panels, employ crystals that are suspended in a resin in-between two pieces of film that are treated to conduct electricity. By adjusting the electric currents, the crystals orient themselves either in random manner to reflect off light waves, or align themselves to allow light waves passing through. The panels can be adjusted to allow various amount of heat to escape the structure, thus modifies and ensure optimal growth temperature for strawberries.

The Growth Stadium also embeds a Food **Growth Assistant** to monitor water and nutrients level and to enhance the growth cycle of strawberries.

MODULAR GREEN WALLS

A flexible and modular growing platform which is integrated into the housing structures. It utilizes hydroponics/aeroponics technology to provide non-invasive irrigation methods.

Discussion

Green wall discussed here includes indoor green wall, green façade (outdoor green wall) and green roof, and it is also referred as living wall, biowalls or vertical gardens. Besides being able to grow fruits, flowers and vegetables in the household, green walls have several environmental benefits.

An indoor Green Wall is a indoor free-standing or integrated wall that is partially or completely covered with vegetation and growing medium. 1(wiki) Based upon the

principles of biofiltration and phytoremediation, an indoor green wall can incorporate plants as biofilters to increase air filtration and air circulation. The plants draw air through their rooting system, and microbes can actively cleanse the pollutions in the air, before releasing filtered fresh air back to the indoor environment.

A Green Façade describes an outside wall of vegetations. It is usually made up of climbing plants either growing directly on the building wall or on a supporting structure attached to the walls. Similarly, a outdoor Green Roof refers to a roof of a building that is partially or completely covered with vegetation. Exterior green wall and green roof can act as a good insulator and significantly reduce heating and cooling loads on the building. It can also reduce storm water run-offs, dampen sound pollution and filter pollutants in the air (see indoor green walls). “The plants layer can shield off as much as 87% of solar radiation while a bare roof receives 100% direct exposure” (Life cycle cost analysis of rooftop gardens in Singapore. Wong N Tay, S Wong, R Ong, C & Sia)

The basic system of a green wall includes: mechanical frames, modular panels (can be containers, geotextiles), an automatic irrigation systems (aeroponic, water drip line system), water reservoir, a growing medium, and choices of vegetation.

Scenario

When Tom moves into his new house, he wants to implement green plants into his house. He consults the **iFarmer** (**Know-It-All** System), and is informed that he has several locations to grow green plants.

The house is able to incorporate a Green Façade by using the **Omni Walls**.

Green wall is a structure to be attached to Tom’s living room walls. The structure of interior green wall consists of removable green panels where the plants live, a frame to hold the panels, irrigation pipes embedded inside the frames to transport water and nutrients to the plants and a water reservoir to connected back to the drip pipes. (Graph 2)

Plants are individually fed using the drip irrigation system. These drip emitters are designed to deliver, at a set rate, a preset volume of water per hour. Each dripper is wired to an infrastructure of drip delivery pipes, which is fed by one master pump using high pressure or low pressure to control the drip rate. There is a water reservoir positioned at the base of the Green Wall. Water and nutrients returns to the reservoir to be pumped back to the plants.

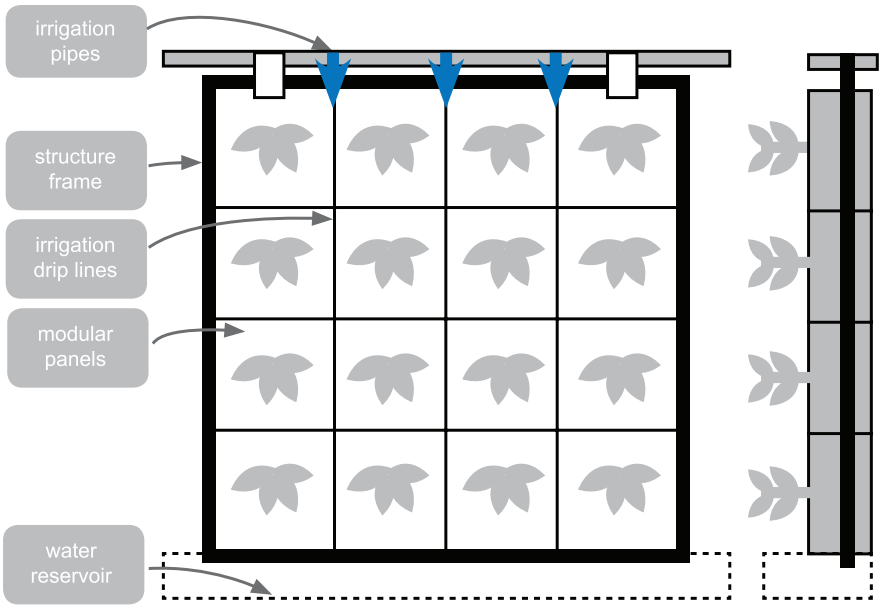
Tom would like his panels to have a mixture of edible plants and orchids. He decided to plant lettuce on some of the panels, and to have some panels growing orchids. If he wants to grow more lettuce on the green wall in the future, he can easily take down the panels with orchid and change to panels with lettuce.

PROPERTIES

- Integrated supporting structure with the walls of the house
- Modular or flexible panels for growing plants
- Medium for plant growth
- Automated irrigation methods
- A water drainage system
- A water reservoir for irrigation and collection of excess water
- Suitable vegetation to growth on the structure

FEATURES

- Provides a frame structure for indoor plant growth
- Allows interchange of plant growth modules/panels
- Maintains continuous water and nutrient delivery
- Has minimum invasive environmental adjustment to the internal environment of the house
- Supports Plant Assistant system to facilitate growth



Graph 2 **Structure of interior green wall**

FOOD SYNTHESIZER

PROPERTIES

- Raw edible nutrition ingredients
- Binding agents such as enzyme, coloring, flavor
- Tool to synthesize ingredients and binding agents into food
- Interface for user input and feedback
- Link to external database to recipes, inventory and user

An in-house food production system that synthesize food from raw ingredients to produce food which resemble natural grown food.

Discussion

The population is projected to grow to 9 billion people in the year 2050, a 38% increase from current population. According to the United Nations, the amount of arable land per person decreased from about an acre in 1970 to roughly half an acre in 2000, and it is estimated to decline to about one third of an acre by 2050. (Sources: FAO and NASA). A severe shrinkage of resources for food production is projected. Thus, we can foresee a future where every household can be self-sufficient for food production.

It is resource consuming for growing livestock in farms. According to Illinois Times, 4.8 pounds of grain fed to cattle can only make one pound of beef. And Harvard nutritionist Jean Mayer says that reducing U.S. meat production by 10% would free grain to feed 60 million people. Thus, cutting down farm-based livestock can save us a lot of land and food resources.

It is comparatively more convenient to grow plants within individual household by utilizing **Growing Stadium** and **Green Walls**, however, raising farm animals in each households is troublesome. There are 2 main methods for food synthesizing.

1. Food Printers:

Food Printer accepts different edible ingredients, combine them and "print" them into food with desired shape and texture. It uses much the same way as tereolithographic printers create 3-D objects. Currently, ingredients such as flour and suger is used to print donuts by using Food Printers from CandyFab. Philips also develops Food printers based on 'molecular gastronomists'.

2. In vitro plants and In vitro meat:

The production of in vitro food starts by taking animal/plant cells. The cells are then proliferated in a nutrient medium. A sponge-like central structure is placed for the cells to multiply and attach to. The end product can be mechanically processed to alter their shapes, size and texture. Nutritional contents can also be added to adjust the nutrition composition of the in vitro food. The resulting food can be cooked the same way as sausage or meat patty.

According to New Harvest1, meat is estimated to be a $1 trillion global market, and demand is expected to double by 2050. With the decreasing amount of farm land mentioned above, meeting the demand for meat is difficult. In vitro plants or meat production is able to provide in-house food production instead.

The advantages of in vitro food are many:

- **Controlled nutrition:** it is possible to precisely control the nutrition composition of food, e.g. the ideal fatty acid ration in beef.

- **Reduced risk of diseases:** in a sterile environment, growing in vitro meat can prevent potential diseases such as E-coli, Salmonella.

- **Reduce wastes:** we can grow the exact amount that we want for the next meal, in stead of preserve the food for future use.

- **More environmental friendly:** conventional farm-based meat production releases greenhouse gas which contributes to global warming. In vitro meat production can help reducing carbon emission of meat production.

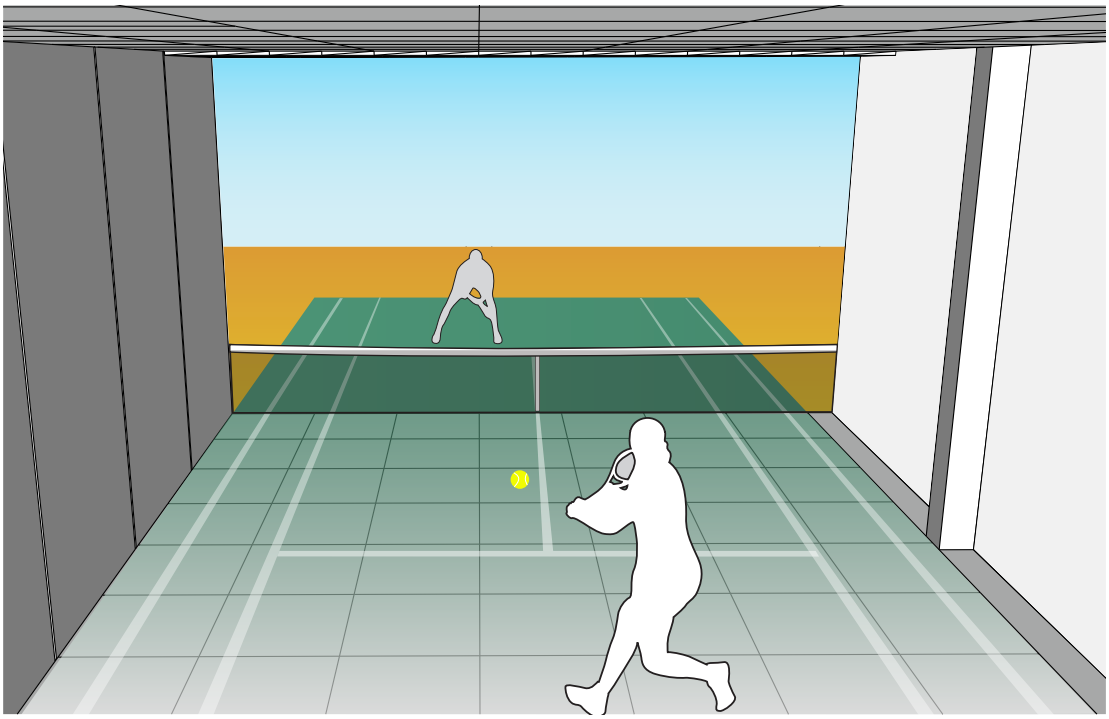
FEATURES

- Synthesize edible food from raw ingredients, binding agents or flavors
- Control nutrition composition of food based on user needs
- Incorporate user taste and preference to food production
- Preserve texture and taste of food to be similar to natural grown food
- Permits user modification of nutrition content, texture, taste and other parameters
- Communicate with external systems for information of user health status, recipes choices and inventory

SYSTEM ELEMENTS

PERSONAL DEVELOPMENT

Lifestyle Management



REINVIGORATING MIND AND BODY

INTERACTIVE FITNESS IMMERSION SYSTEM

A technology-based system designed to encourage and facilitate fitness for the inhabitants by being conveniently integrated into the space of the house and by providing immersive activities in place of exercise machines. The system implements physical elements for exercise as well as virtual reality to enhance the fitness experience and provide a variety of options for the user. Also, to strengthen the communal aspect of fitness, the system provides channels for users to exercise with friends or to follow a regimen with the help of a virtual personal trainer.

Discussion

As more of the global population steadily adopts western urban culture - complete with fast food options and sedentary lifestyles - we will see continual increase in

PROPERTIES

- Moveable interior walls for customizable spaces
- Shape-shifting walls that configure for wall climbing
- Shifting floor panels for inclined walking and treadmill activities
- Variable-depth stairs for step exercising
- Biometric sensors
- Virtual reality sensors and projection units (Simulated Scapes)
- Air Care Unit which adjusts climate to specific individuals
- Omni-Walls which allow breathability to provide fresh air and circulation

health issues related to physical inactivity and obesity. In some countries, such as those in the developing world, fitness is naturally integrated into daily life through walking, outdoor play, or physically-intensive work. Some developed nations, however, are a different story. In the United States, only 3 in 10 people engage in moderate physical exercise on a regular basis (CNN 2002). In spite of its enormous count of fitness gyms, the U.S. is still one of the most overweight countries in the world, and many others are following suit.

A lack of physical fitness is correlated to a number of medical conditions including diabetes, heart disease, high blood pressure, and, of course, obesity. On the other hand, the practice of good physical fitness has been shown to address not only these medical conditions, but also cases of depression and anxiety (Mayo Clinic). Despite its powerful effects, exercise is largely ignored for a number of reasons, among the most prominent being motivation.

The issue of motivation has many facets. Some people may not have easy access to an activity they actually enjoy, such as rock climbing or skiing, while some may prefer activities that involve interaction with others. Still others may lack the time or may simply be lazy.

The **Integrated Fitness Immersion System** aims to address these issues by encouraging physical activity through channels beyond the typical workout room. It opens up possibilities to engage in activities that people genuinely enjoy in spite of constraints such as geography or lack of time.

Utilizing the **Interactive Exploration Surfaces** and the **Simulated Scapes**, one can create a tennis court - where the living room is their side of the court and the wall is the boundary of the net - and play remotely against a friend who is doing the same thing in their home. The tennis ball is a 3D holographic image that can be "hit" with a racket just like any real ball, creating a virtual and immersive experience of a tennis game within one's home.

This concept can be varied to fit a number of sports activities, such as boxing, volleyball, and batting cages, all of which can be done with a friend from anywhere in the world. Taking it one step further, the treadmill floor (Drexler 1991), integrated right into the home's living space, becomes a surface that moves to the motion of the user's body. When used with the visuals of the **Simulated Scapes**, it transforms the space into the user's favorite running path, whether that is a street, a park, or even a mountain trail.

Furthermore, the **Omni-Wall**, with its shape-shifting properties (Berger 2008), can transform its own surface in limitless configurations to become a climbing wall. Whether wall climbing is a person's passion or just a more enjoyable alternative to the stairs, it is a fresh means of exercise that is otherwise relatively inaccessible for a person to engage in.

"Latent exercise" follows from the idea that some individuals or cultures do not proactively exercise but are, nevertheless, physically fit by virtue of the banal activities they naturally engage in on a daily basis - walking, or using certain equipment for a job, for example.

The shifting floor panels are designed to create work for the body without the user knowing it. By gauging the user's motion, the floor panels angle such that the user is walking on an incline, no matter where they are. The amount of incline can depend on the user's preset preferences or can automatically adapt to the user's real-time heart rate via biometric sensors. Similarly, the fitness system can adjust the height of each stairway step such that climbing up and down the stairs can create physical resistance as well. All the meanwhile, the home's **Air Care Unit** helps the inhabitant maintain a normal body temperature even as they get a workout. Together, the shifting floor panels and the variable-depth stairs allow an inhabitant to engage in constant productive exercise by simply walking around their own home.

Ultimately, physical fitness is a choice left to the individual. The **Integrated Fitness Immersion System** does not push exercise on an individual who does not want it, but opens up engaging options to make exercise much more attractive and accessible for the fitness junkie as well as for the couch potato.

Scenario

Dean is conscious of his health and knows that physical fitness is important, but has never been fond of exercise machines or gyms. While he enjoys playing sports with friends, he lives and works in the heart of downtown and, consequently, does not have easy access to any parks for sports and, more significantly, does not have enough free time to coordinate games with friends. Years ago, he purchased a treadmill in an attempt to exercise regularly, but he ended up with a $300 coat rack instead. Today, he enjoys consistent and accessible exercise with his home's **Integrated Fitness Immersion System**.

After a long week of meeting with clients and creating powerpoint presentations for his company, Dean finally comes home for an evening of unwinding. Stuck sitting in board rooms all week, he is excited to move his body and get some blood flowing, so he turns on the **Interactive Exploration Surfaces** and finds his buddy, Filip, online. A few words later, they decide to play a match of tennis together and suddenly Dean's living room becomes an outdoor tennis court where the court boundary lines are holographically drawn on his floor, the surrounding walls become the landscape of an outdoor tennis court, and the **Interactive Exploration Surfaces** in front of him reveals the net, as well as his friend on the other side the net.

Dean quickly grabs his tennis racket and, as the 3D holographic imaging system projects a virtual tennis ball onto the floor, Dean "picks" it up and serves it over to

FEATURES

- Moving walls allow for flexibility on where to exercise in the home
- Allows more difficult-to-access activities, such as wall climbing, to be done in the home
- Enables "latent exercise", which helps the user to work out even when they do not intend to
- Provides in-home running that simulates the feel and environment of outdoor running
- Tracks biometric data and gauges progress
- Helps users create a regimen
- Adjusts workout routines in real-time to the users' current vitals and condition
- Virtual trainer coaches users through activities
- Supports space and equipment-dependent sports through an immersive virtual experience
- Facilitates connections to other users for group activities
- Adjusts the space's climate conditions to the user's real-time physiological needs

Filip as a warm-up. The virtual ball bounces off his racket as he swings and, once it makes contact with the wall, seamlessly transitions from a 3D image to a 2D image as it flies to the "other side" of the net. The **Omni-Walls** and **Air Care Unit** also aid in creating the feel of an outdoor court, providing extra breezes over time to help Dean from overheating.

Three victorious matches later, Dean briefly chats with Filip and then says goodbye for the evening. Ready now to change out of his clothes and step into the **Hammam**, he puts his racket down and walks across the room to the stairs. As he does so, the floor panels angle upward, causing him to walk on an incline as a form of latent physical exercise. He does not even notice this anymore as it happens every time he walks across his floor. Likewise, once he starts to climb the stairs to his bedroom, the height of the steps become steeper. As he continues to climb the steps, the **Integrated Fitness Immersion System** detects that he is exhausted from the tennis match and levels the remainder of the stairs to more shallow heights so that Dean does not expend as much energy to reach his room.

Once he is fully cooled down and refreshed in his **Hammam**, he is excited by the thought of playing again tomorrow for his rematch with Filip.

BIOGRAPHER

PROPERTIES

- Audio/video capturing system embedded around the house
- Compatibility with the home entertainment management system
- Data management program that automatically tags and organizes events
- Storage unit for data
- Playback on any Interactive Exploration Surface

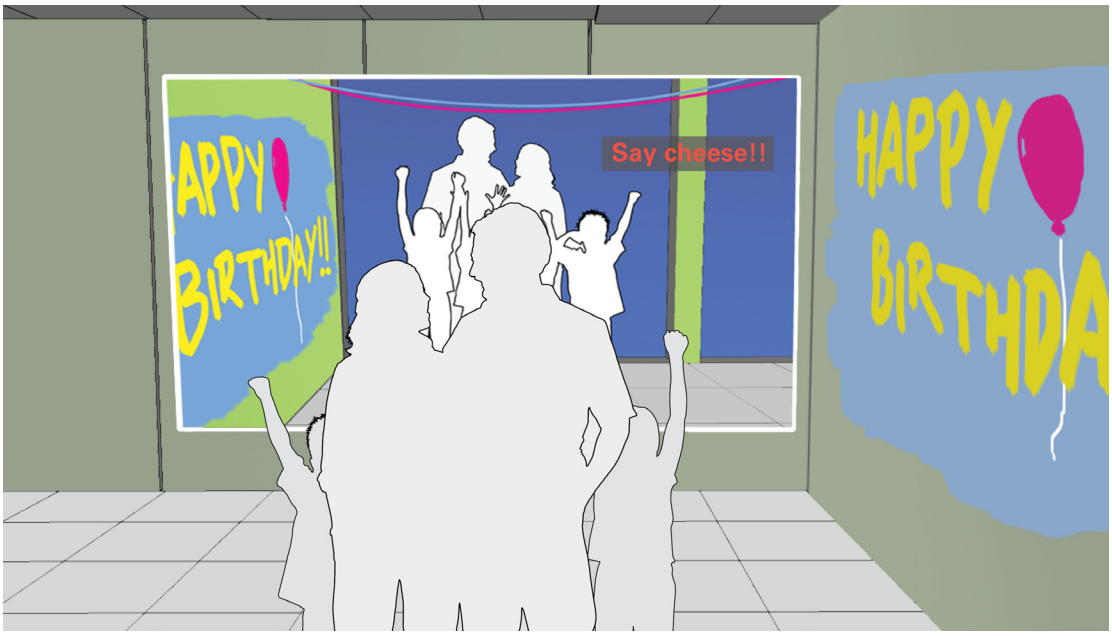
A passive system that is user-enabled to record events that occur within the home. By capturing these events, the user is able to cherish memories, learn from past activities, and, ultimately, develop personally.

Discussion

To support inhabitants reflecting on their memories or activities, the **Biographer** is an environmentally-integrated passive system designed to preserve, manage, and play back memorable events for the family as well as facilitate personal development through content recall and goal tracking.

The **Biographer** is able to utilize pre-defined patterns to capture designated events such as birthday parties and family reunions. Those events can then be displayed in photo frames throughout the home, sent to family and friends, or simply stored away for safekeeping. It can also support personal education by recalling the inhabitant's learning experiences and past activities.

Along with recording and replaying events, inhabitants may want to process those events for more in-depth reflection at a later time. The **Biographer** allows inhabitants to annotate and descriptively tag recorded activities in order to easily retrieve them in the future. They can also be edited quickly and intuitively via the **Interactive Exploration Surfaces**.



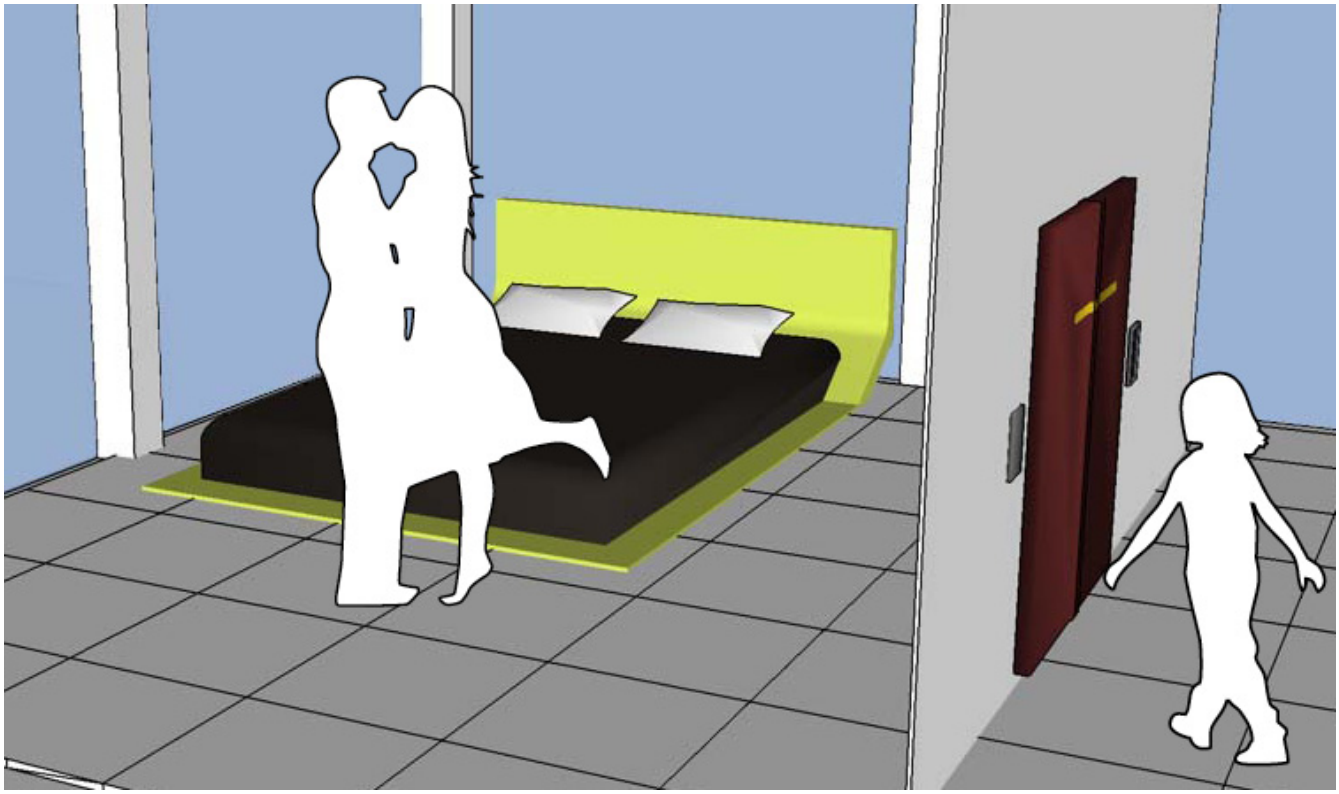
Scenario

Dean is having a birthday party where relatives and friends will be attending. To prepare, he tells the **Biographer** which types of activities to record to ensure nothing is missed. He additionally retrieves images and videos from his previous party and, using the tagged events, identifies key moments - such as the arrival of the guests, the cutting of the cake, and the karaoke time - which he wants the **Biographer** to automatically track and document.

Once the party begins, the **Biographer** captures significant events and immediately sends photos to all of the guests at the party. Dean later decides to take a look at some of the video that was captured and, picking the funniest moments, he makes some quick edits on the **Interactive Exploration Surface** and creates a short, entertaining movie of the party and sends them to all of his guests.

FEATURES

- Captures events in both audio and video formats
- Playback of captured events
- Manages all content automatically according to user preferences and trends
- Synchronizes seemlessly with other audio/video capturing devices
- Allow users to tag data based on emotions and events



RELAXATION

ROMANCE CATALYST

PROPERTIES

- Soundproof partitions
- Two-way noise filter
- Automatic door lock
- Smart detection prompting system
- Automatic aromatherapy dispenser
- Mood lighting
- Ambient music

Romance Catalyst is a dual function system that enables a romantic environment for sexual intimacy and ensures privacy during spontaneous intimacy.

Discussion

Intimacy plays an important role in providing healing benefits to the mind, body and soul. Sexual activity helps to improve one's immune system, leads to better heart health and can help with depression.

Outfitting the home to promote an environment for private sexual intimacy is the **Romance Catalyst** which can work in conjunction with other systems in the home such as the **Tranquility Acclimator**, **Privacy Partitions** and **Hammam**.

The **Romance Catalyst** is a dual function system; it creates the mood for intimacy and protects against unwanted disruptions. To create a romantic mood, the **Romance Catalyst** uses automated mood lighting, aromatherapy that dispenses

through the house's air conditioning unit, and ambient music from the home-wide entertainment system. To ward against disruptions and embarrassing situations, the distinct features in the **Romance Catalyst** are the two-way noise filter, smart detection prompting and automatic locks.

The two-way noise filter confines noise during sexual activity within a space and can completely block disruptive noise from coming into a space. The latter has control levels permitting different noise levels inhabitants' wish to hear during sexual activity. This feature is particularly helpful for parents engaged in sex who still want to keep an “ear” out on their child or children.

The smart detection prompting system is an alarm system that detects when sexual privacy will be invaded and warns inhabitants in advance. This system, also tied into the User Environment Preference Preset system, can be relayed in changes in the light and auditory cues. Biometric automatic locks also enforces a high level of privacy and reduces unwanted disruptions because access permitted is based on biometric hand and facial recognition.

Scenario

Dean and Zoe, who work from home, are parents to a son and daughter both in middle school. After coming back from her late morning errands, Zoe sees that it was a particularly stressful morning for Dean negotiating business deals with his partners in Johannesburg.

Zoe decides that Dean needs a little bit of pampering to relieve his stress and plans to invite him into the bedroom for a mid-afternoon frolic. She enables the **Romance Catalyst** that dims the room to a warm amber glow. She knows that the scent of jasmine and ginger and the music of Barry White have an erogenous effect on him but she decides to let the system choose a sensual scent. As she sets the noise filter to be fully contained but low enough to hear the kids come home, she remarks how much she loves the wild card chocolate scent.

Before she could do anything else, Dean arrives prematurely in the room and within seconds they find themselves in bed making love. The **Tranquility Acclimator**'s human-sensitive climate control mode automatically adjusts the temperature within the room while things are heating up. The Acclimator's air ionizer ensures that fresh, clean air is constantly being circulated.

In the middle of their session, they hear the kids come home arguing. They call out for their mom and dad and approach their room to resolve the dispute. The smart detection prompting system detects that the kids are approaching. Although he closed the door behind him, Dean forgot to engage the biometric automatic lock system. Fortunately, the smart detection system gives them enough time to enable the locks and pull themselves together to change from lovers and emerge as parents.

FEATURES

- Provides sound damping by reducing sound waves and vibrations
- Allows users to adjust the level of noise coming into a space
- Includes privacy controls, e.g., high, medium, low
- Enhances privacy through smart detection sensors that automatically locks doors if privacy level from outside is in danger of being violated
- Creates a romantic atmosphere through the creative use of mood lighting, ambient music, and aromatherapy

PROPERTIES

- Acoustic and adaptive paint
- Multi-spectrum lighting
- Surround sound speaker system
- Continuous-dim windows
- Soundproof-capable walls
- Configurable walls
- Sleep detection sensors
- Light/audio sensors
- Human-sensitive climate control
- Oxygen regulator
- Ergonomically adaptive smart bed

TRANQUILITY ACCLIMATOR

The Tranquility Acclimator enables and enhances rest and meditation by adapting the physical, sonic, and atmospheric environment to the inhabitants' individual needs.

Discussion

Globally, our lifestyles have become increasingly hectic with demanding schedules. As a result, sleep has become more of a luxury instead of a vital imperative like food. Similar to not eating a healthy diet, sleep deficit leads to many adverse affects. Restful sleep and repose helps to maintain our biological and psychological health and balance.

The **Tranquility Acclimator** promotes optimal sleep and repose for inhabitants by adapting the physical, sonic, and atmospheric environment to the inhabitants' individual needs. The **Tranquility Acclimator** is based primarily on advanced technology that incorporates biometric sensors that provides automatic, real-time adjustments.

It also features specific products like an ergonomic-adaptive smart bed which provides the ultimate experience in sleep. The bed has massage capabilities and

a special system that blocks harmful electromagnetic waves and radiation to help optimize sleep. It is also manufactured using an ultra thin, light weight breathable material and has the properties of a memory foam that adjusts to the inhabitant's every movement. Using nanotechnology, the bed is also adjustable to an inhabitant's specified sleep comfort. Though the mattress is ultra thin, an inhabitant can feel like s/he is sleeping on air.

To ward against seasonal affective disorders especially in regions like Scandinavia, the multi-spectrum lighting mode of the **Tranquility Acclimator** includes light therapy. Mimicking outdoor light, this kind of therapy effects a biochemical change in the inhabitant's brain that lifts his/her mood and lessens the disorder's symptoms.

Brain entrainment capabilities are accessed through the home-wide entertainment system. Brain entrainment helps inhabitants move into a positive, relaxing and meditative state of mind through deeply relaxing sound recordings, commonly known as binaural beats. The **Tranquility Acclimator** also addresses other sleep related disorders such as sleep apnea that can disrupt a quality sleep. An oxygen regulator through use of the home's A/C system controls the oxygen levels in tandem with inhabitants state of rest.

Scenario

Zoe has quickly fallen ill with just a few noticeable symptoms. Dean accesses her doctor through the **Health Assistant** and along with some standard medication, Zoe's doctor tells him that the cure is really long periods of rest. Her doctor envisions a full recovery.

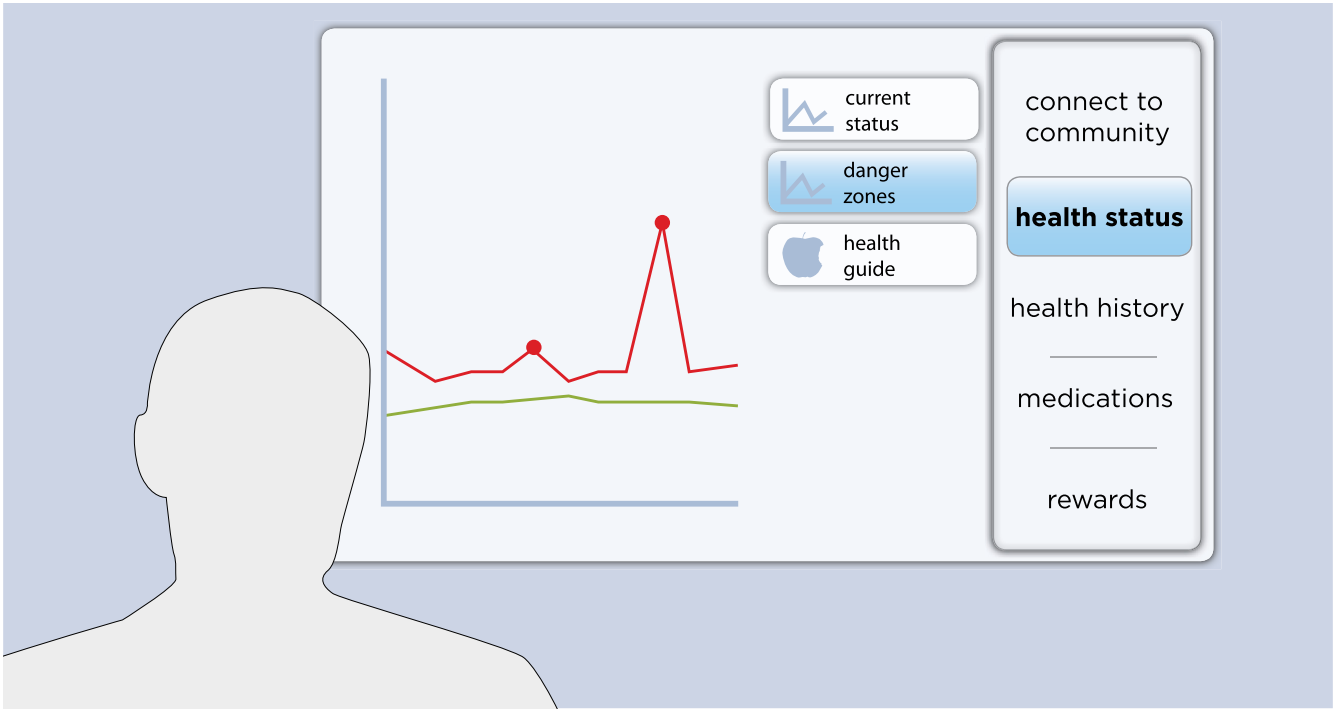
Choosing the **Tranquility Acclimator** mode within the User Preference Preset system, Dean readies the bedroom for Zoe to rest. She's been complaining about body aches and pains, so Dean sets the bed comfort to extreme plush. When Zoe lays down she feels like she has snuggled in 100 layers of plush feathers. Every movement that Zoe makes, the bed adjusts accordingly so as to give the impression that Zoe has not moved at all. The air ionizer from the home's A/C system removes all pollutants and odors from the air and allows Zoe to rest free of radicals.

Zoe is a worry wart and although she gets to sleep peacefully, when she's awake, she can't seem to put to rest all the thoughts that are racing through her head. The binaural beats from the entertainment systems coats and soothes her mind like a lozenge. Instead of fretting over the state of things, these deep relaxing sounds calms and detoxes her mind.

It's been a few days since being confined to the bedroom and Zoe misses going outside to soak in the rays on the patio. The presets in the multi-spectrum lighting adjusts for outdoor lighting that Zoe likes which helps to lift her mood and continue to keep her at ease. The light is also dimmed automatically if Zoe dozes off to sleep.

FEATURES

- Detects and measures visual/ aural elements that enter the room and determines its frequency of occurrence to establish how familiar it is to the user
- Detects and measures the user's sleep patterns and qualities and understands their responses to various external stimuli
- Emits white noise to cancel external aural sounds, as appropriate, through acoustic paint
- Adjusts windows to allow only the amount of light appropriate for the user's sleep conditions
- Utilizes brain entrainment to facilitate deeper relaxation for sleep in instances of high external stimuli
- Adjusts strength and color of artificial lighting
- Regulates oxygen levels according to inhabitants' state of rest/meditation
- Bed adapts to the ergonomic needs of the user in real-time to prevent incidents of sore necks and facilitate better airflow



PROPERTIES

- Retrieves information from embedded sensors
- Analyzes biometric data and makes calculated physiological predictions
- Smart technology enables the assistant to learn from user's behavior and health history
- Touch screen control
- Integrated video camera
- Flashing light for special advisories
- Integrated speaker for announcements
- Simple interface design
- Wireless internet connection
- Integrated into the house, it can even detect user's health status along with anomalies in routine.

HEALTH

HEALTH ASSISTANT

The Health Assistant is a monitoring system that tracks the user's biometric trends, and actively manages his health. The assistant has a friendly user interface that can easily be understood. It also has a database of health history for each household member and as it collects information. The system shares advice, makes diet recommendations, and suggests healthier practices in daily living.

Discussion

Today managing one's own health can be difficult and frustrating. Records are distributed across the medical professionals and even seeing a doctor may take months to set. The **Health Assistant** on solution that brings healthcare home and into the hands of the user.

A network of sensors, embedded into the flooring of the home and within fixtures in the **Hammam**, continuously feed household member's biometric data into the **Health Assistant**. Using camera video technology with standoff laser vibration measurement techniques, the **Health Assistant** internally charts the data and visu-

alizes the information to the user to inform him of physiological trends, including weight, cholesterol, and blood pressure. The data is analyzed to make informed predications on user's health trajectory. Such information is used to warn user's of potential disease or illness should the user stay the course of unhealthy behaviors.

The recorded data is transmitted daily to designated health professionals, friends and family members who can have informed data on the household member's health. Additionally, utilizing sensors placed on medication boxes, the **Health Assistant** can sense when the user has forgotten to take the medicine and can give reminders verbally. The **Health Assistant** tool will also blink as a form of alert. Utilizing sensors embedded in the ground, the **Health Assistant** can recognize when gait is abnormal and alert the designated contacts. In cases of emergency or dire situations, the system will also contact authorities.

With image and text recognition capabilities, the system can scan information and record it. For example, medication scanned will be recorded and at the user's request. Complimentary and alternative medications can be suggested to the user.

With advanced high definition video technology, the **Health Assistant** allows users to connect face-to-face with health professionals or perhaps others in the community dealing with similar issues or illnesses.

As a smart system, over time, the **Health Assistant** learns the users habits and routines and makes recommendations for a healthier lifestyle. With information fed to it from the AR Fridge, Interactive Fitness Immersion Space and **Tranquility Acclimator**, the **Health Assistant** will translate the data into informative advice and suggestions for users to better track and manage their health.

An additional feature of the **Health Assistant** is a gentle reminder initiated when the user is engaged in unhealthy behaviors. Again, using data from sensors, the system recognizes sedentary behavior or unhealthy eating habits and will remind the user to engage in healthy practices. Reminders will be initiated through verbal and visual cues as well as through the **Interactive Exploration Surfaces**.

Scenario

Dean recently returned home from knee surgery. With the doctor's recommendation, Dean starts a low-impact daily exercise regimen. Using the **Health Assistant**, Sandy goes online and searches for online communities with people who have had similar surgeries. She is able to get in touch with Lester and set up a video chat. During the chat, Lester shows Sandy several exercise techniques he had used during his knee recover process. Sandy takes note and modifies her regimen with his help.

During this recovery process, Sandy's daughter was receives text messages of

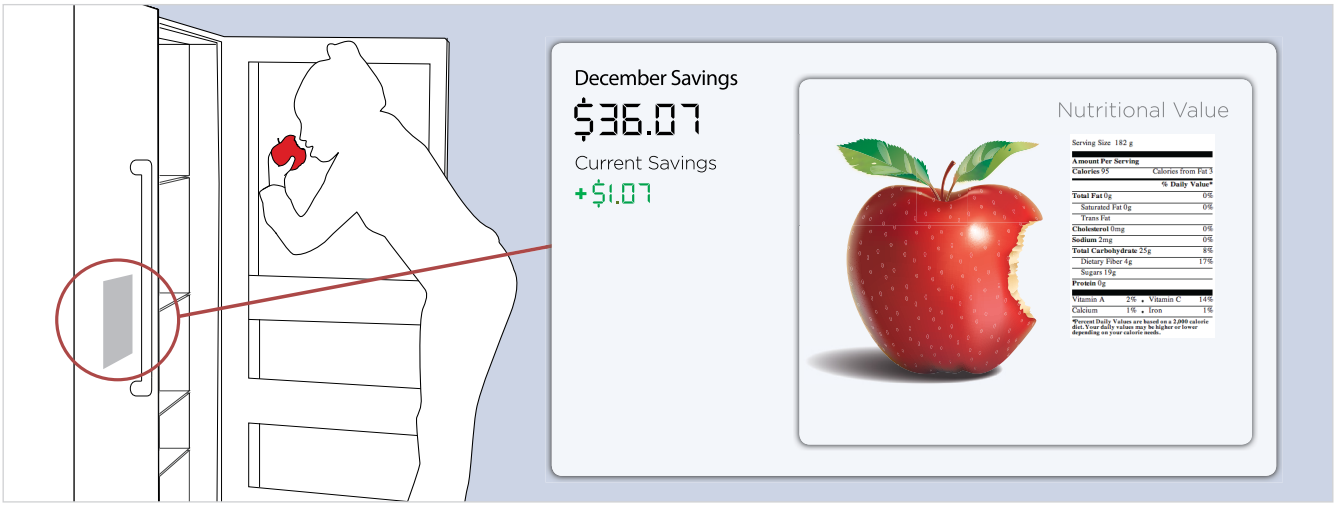
FEATURES

- Deep understanding of members' past and present medical history as well as patterns of health, including sleep regiment, diet, and exercise
- Calculated predictions on member's health based on available data
- Tracks members' current diet and offers suggestions for alternative diets or medicines
- If member is considered unhealthy, system will offer a health plan for how to become healthy again
- Wirelessly transmits medical information to designated health professionals, friends and family
- Quick, easy video connections
- Offers medical advice and dietary and exercise recommendations alternative therapies
- Offers medication reminders
- Gentle reminders for users to engage in healthy behaviors
- Anomalies in routine or health will be recorded and officials quickly alerted
- Integrated risk assessment tool
- Provides personal support, encouragement and motivation to individuals

Sandy's activities. These alerts reveal that Sandy was performing normally with her activities of daily living.

In one instance, the **Health Assistant** discovers that Sandy had forgotten to take her evening dose of medication. The **Health Assistant** blinks and beeps to alert Sandy. After checking the system, she takes her medication. On screen is a new note that alerts her of alternative medicines popularly used instead of aspirin. She touches the screen to learn more about these alternatives.

A month later, Sandy sees that her cholesterol had increased from her sedentary behavior and the **Health Assistant** recommends a nutritious diet in addition to exercise to control her cholesterol again. On screen, the assistant also notes that her current biometric trends indicate that she is at risk for heart disease and could face serious problems in 2 years if she continued in the current trajectory. The **Health Assistant** also suggests an exercise regimen that would compliment her current low-impact regimen.



HEALTH REWARDS SYSTEM

The Health Rewards System promotes and supports healthy living, through an engaging incentive system. As users engage in healthy or unhealthy behavior, a virtual bank translates the data into measurable monetary gains. As healthy behaviors increase, so will the savings in the virtual bank, and conversely for unhealthy behaviors.

Discussion

In America, the trend of rising health care costs has become a great pain point

for many people. Responding to the crisis are companies turning to incentive programs to promote wellness and preventative care. Such programs are proving to be popular and successful in helping people maintain good health.

Taking heed from this trend, the **Health Rewards System** is an incentive system that calculates users' behaviors and biometric trends as financial gains and losses. By accessing information from the **Health Assistant**, the **Health Rewards System** predicts the long term financial impact of the user's health as a means to motivate and encourage healthy living.

Networked with financial institutions where the user is enrolled, the **Health Rewards System** creates a virtual bank account with a virtual deposit of the user's total assets. As the user engages in healthy behaviors, such as exercising and eating nutritiously, virtual currency is added to his/her account. Through the home's **Interactive Exploration Surfaces** or the **Simulated Scapes**, the **Health Rewards System** displays earnings and suggest activities for increasing earnings. Should the user engage in unhealthy behaviors such as smoking or lethargy, the virtual account devalues and shows the losses.

As a smart system, the **Health Rewards System** analyzes data from the **Health Assistant** and overtime learns the user's habits, routines and preferred activities. This deep understanding allows the **Health Rewards System** to recognize the user's capabilities and give feedback and rewards appropriate to the individual. Additionally, the information allows the **Health Rewards System** to give a weighted value to healthy behaviors users don't normally engage in to encourage and motivate participation.

Synced with the individual's computer, the **Health Rewards System** also receives information on the user's browsing history. This information allows the virtual account to translate gains into potential purchases. Users also have the option to input monetary goals or desired purchases into the system. The system recommends the types and duration of activities the user needs to engage in to obtain the goal.

Scenario

Upon receiving news of his promotion at work, Dean decides to celebrate by hosting a party. He prepares a short list of his friends and invites them over for the celebration. During the festivities, Dean loses count and has several beers too many. By the end of the night, he is feeling slightly light headed.

When the last guest finally leaves, Dean is relieved to call it a night. Before retiring, Dean decides to check his Health Rewards account. With the upcoming holidays, he had inputted into the system a goal of buying a Wii for his niece. Smiling to himself, Dean remembers earning $20 yesterday by simply taking a quick run in his living room.

PROPERTIES

- Converts biometric data and user behavior into financial measures
- Smart system learns and records user activities
- Detects, gathers and analyzes personal behaviors, such as exercise and eating habits, that influence users' health
- Access to financial information
- Simple interface design
- Voice activated controls

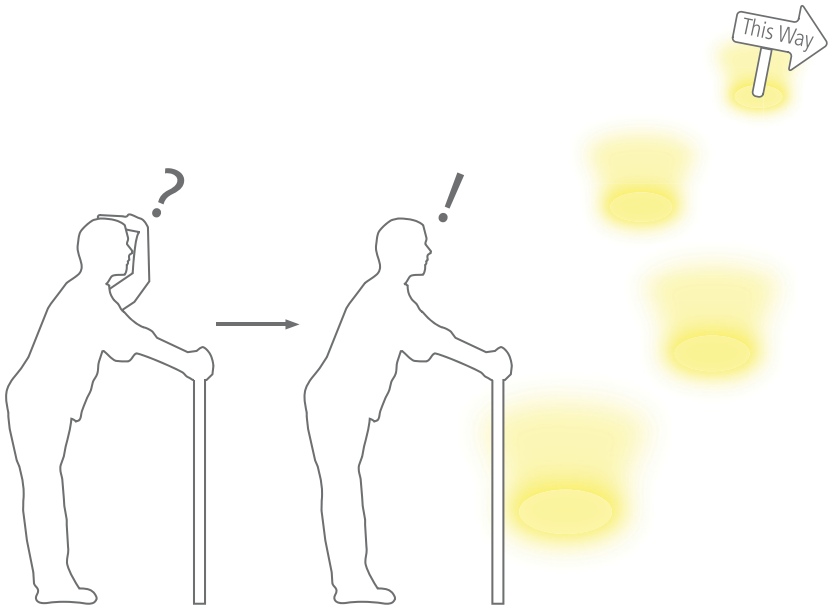
FEATURES

- Encourages healthy behaviors with financial incentives
- Helps users to understand the financial impact of their health
- System will suggest alternatives to unhealthy behaviors
- A fun and engaging way to engage users in preventative healthcare
- Users can input monetary goals to work towards

Dean reaches at the **Interactive Exploration Surface** on his wall and pulls up the blinking Health Rewards screen. According to the system he was consistently making gains, until today. With a quick glance at the screen, Dean suddenly gasps; his account reveals a loss. Touching the screen, he pulls up a note that explains his loss of $20 was because of the over consumption of alcohol. Delving further into the note, he learns that his over consumption of alcohol would have made him riskier to insure, thus increasing his insurance premiums in the long term.

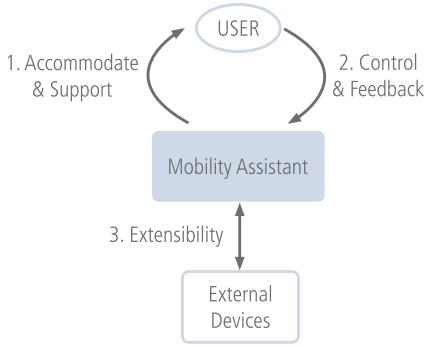
The system recommends Dean return to a regular diet and make a 30 minute run in the morning to earn the $20 back. The system also details a consistent diet and exercise regimen that would help him achieve his goal in 2 weeks.

Making a mental note of the loss, Dean resolves to take action and heads to bed on that thought.



CARETAKING

MOBILITY ASSISTANT



This is a universally accessible and integrated system that provides mobility assistance to residents of all ages and abilities.

Discussion

Mobility in the home is often taken for granted by able bodied individuals. For these individuals, maneuvering through the different parts of the home is quick and easy.

Yet, for individuals with impairments, accessing the different parts of the home requires a mix of skill and resourcefulness. The Mobility Assistant is one such solution that is aimed at reducing the difficulties of navigating one's own home while promoting autonomy and independence for handicapped persons. In short, it is an integrated system inside the home that manages the user's mobility.

The Mobility Assistant is comprised of three major components: "Accommodate and Support", "Control and Feedback", and "Future Extensibility".

Accommodate and Support: This assistive system provides lighting and audio cues to support wayfinding in the home. Users' bio-metric information and environmental controls are elements that inform the Mobility Assistant; Adjustable furniture and fixtures accommodate different activities including standing and sitting.

Yet, even with the help of the Mobility Assistant, there will still be accidents. During a critical situation that goes beyond the abilities of the Mobility Assistant cannot handle, the **Guardian** Preventive/Response System takes over. Both system elements share the same monitoring infrastructure and continuously offer feedback to one another.

Control and Feedback: The system can also be controlled through voice or gestural commands, to accommodate users with sensory or limbic disabilities. The feedback corresponds to the preferences set by the user.

Extensibility: During periods when the home has supportive mobility devices such as wheelchairs, the system manipulates the physical space through adjustable fixtures, furniture and walls, to maximize maneuverability. Spaces are designed to be flexible and support emerging technologies as they develop. Such technologies would easily be retrofitted into the existing infrastructure.

Scenario

Dean is recently involved in a car accident that forces him to be wheelchair bound for a short period of time. When Dean arrives home from the hospital, the house recognizes that Dean is in a wheelchair through sensors embedded in the house and information provided by the local health authority. The home records Dean's physical status and the Mobility Assistant automatically adjusts the fixtures in the house to accommodate his physical needs. Dean is now able to move through him home easily with ease.

PROPERTIES

- Integrated lighting and audio system
- Voice activated controls
- Flexible storage units
- Wayfinding textured railing integrated with light
- Automated lighting system
- Appropriate integrated safety devices
- Communication system that provides feedback to residents

FEATURES

- Provide sufficient lighting and audio support to the disabled and elderly
- Accept and respond to voice commands
- Provide feedback in an appropriate format and media to the residents
- Allow adequate space for easy maneuverability of mobility devices
- Adjustable fixtures and furniture accommodate for different heights
- Allow for easy access to the integrated safety devices when required
- Assist the resident in wayfinding around the house using appropriate communication channel and feedback

ENTERTAINMENT

ENTERTAINMENT SYSTEM

PROPERTIES

- Voice and gestural controls
- Analyzes information from embedded sensors in home
- Wireless connectivity
- Focused
- Unidirectional and surround sound speakers

FEATURES

- Based on multi interactive media
- Central repertoire replete with music tailored to users' preferences
- Automatic and deviceless operated
- Wireless access to TV, movie, games, and music
- TV, movie, video games, recording and slideshow are modes on the Interactive Exploration Walls
- Modes work simultaneously in any part of the house
- Removes the needs for storage of DVDs and CDs
- Effortless on-off and selection modes

The entertainment system is a central system within the home that offers a full range of capabilities including music, TV, movies, games, recording and slide shows.

Discussion

Advancements in technology are blurring the lines between real and simulated reality. The notion of embodiment is increasingly becoming pervasive in technology. Interactive media is requiring individuals to perform and physically interface with media to activate it and get it to respond. The idea of recreating the world that we imagine is at the core of the entertainment system.

The Entertainment System is a smart home system that's integrated fully integrated to include home movies, TV, radio, video recording and slide show to peruse your digital photos. It works in concert with the Interactive Exploration Walls and does not take up real estate like most modern day entertainment systems. It is seamless and unobtrusive.

Accessing the **Entertainment System** can easily be done gesturally. The system also recognizes the user's preference and easily recalls his most recently played songs, games and other activities. Should the user choose, the system can also suggest new activities based on the user's mood or activity history.

Often times users living under the same household may differ in entertainment preferences. The entertainment system's uni-directional noise feature enables users to engage in simultaneous activities. Two users playing two separate pieces of music are able to do so uninterrupted.

Reading information from the home's sensor network, the Entertainment System also responds to the physical location of the user. Instead of being stationed in one location, the entertainment system travels with the user, relocating to rooms and interfaces where the user is.

Scenario

Dean and Zoe generally reserve the weekends as family time. The kids enjoy it because they get a break from homework and can play fun games and activities in the home. Saturday, late afternoon, when the family comes home from visiting Dean's parents, Dean and Zoe decide to relax in the family room over a glass

of wine. Sitting in the room, he remarks that it's always good to see his parents, but that it takes a lot of energy out of him because of the drive and because he seemingly becomes his parents' handyman for most of the day. To further unwind, Dean enables the entertainment system to play a compilation of operas by the Italian tenor Andrea Bocelli. As they both lie at each end of the sofa, the well-balanced acoustics of the entertainment system make them feel as though they are at a private concert.

Meanwhile, in their respective bedrooms, their children are doing their own thing. Their daughter, Max, is also listening to the latest hip-hop songs in her bedroom. She tells the system "skip" when she doesn't like a random sample it has chosen. Midway, she decides to call her best friend to tell her about the latest converse "skins" she saw in the mall that day when her family made a quick stop before heading home. Through the Interactive Exploration Walls she videophones Madison and they become engrossed in the minute details of feet fashion filled with laughs and giggles. Madison asks Max about the image she sees on her wall and Max explains that while getting ready the day before she had an idea of a sneaker design, which she quickly sketched on the **Smart Panels** to which Madison responded "that's HOT!"

Across the hall Kingston, her brother, could care less about what he wears. He's happy that his closet chooses his outfits on a daily basis. But he cannot get enough of new game of War Craft and is pretty bummed that he can only play it on the weekends and for just a couple of hours. But Kingston believes that a little is better than nothing. He wasted no time when they arrived home to enable the video game from the Entertainment System. In his room, the game is virtually simulated as if the environment and all the characters are actually in his bedroom.

Both Max and Kingston know that their individual fun time will be soon over because in minutes Dean and Zoe call them down for a family movie and snacks in the family room. As they pan through the movie selection, the system lets them know if they have already seen a movie, when they have seen it, and the reviews it was given. They are having trouble choosing a movie and decide to choose from Kingston's list of favorites. With a couple of bowls of freshly popped kernel popcorn and dimmed lights, the family gets comfortable to watch the movie.

SOCIAL DEVELOPMENT

OVERVIEW

As we build new structures for living in the coming century, it is incumbent upon us to consider how our homes can help to foster social development. Positive social development must take place at two levels, both inside the home and among the larger community.

At the household level, the home's features support social development through the communication of information, particularly as part of the processes of learning and creating. The house aims to encourage informal life long learning which results in stronger social systems via a pattern of informed decisions. By enabling ubiquitous access to information and providing useful new ways of understanding that information, the house of the future can give residents the tools they need to make these informed decisions. The Workshop, Privacy Partitions and Simulated Scapes create spaces that enhance the processes of learning and working for residents. Interactive Exploration Surfaces make information available to people when and where it is needed for maximum impact. The Visualizer makes complex data more useful by presenting abstract information in formats that are easily understood. Finally, the Nexus ties all these pieces together, allowing data to flow seamlessly from one service to the next and beyond.

Security is a concert for both residents and for the community. For residents the All Weather Protection System establishes a uniform level of protection for the entire structure from the elements. In extreme instances when this protection is insufficient, the Safe Pod insures that residents can survive. Secured Storage protects valuable belongings, and when everything else fails, the Black Box records and secures critical data to provide residents and designers with valuable data to inform future decisions. The Guardian System brings together all of these security features. It not only automates some decisions during critical incidents, it further enhances the ability of residents to make good decisions. By insuring the safety of individual homes, these security systems also help to insure the safety of the community.

Outside the home and into the larger community the house incorporates features that nurture collective identity, enable collaboration between people, build trust, and leverage the independence of communities. Adaptable Housing Skins offer residents choices in adapting architectural and cultural traditions to a standardized housing structure. The Local Data Filter helps to support local social identities while people increasingly focus their attentions outside the community via media and virtual environments. The community Kupah acknowledges that

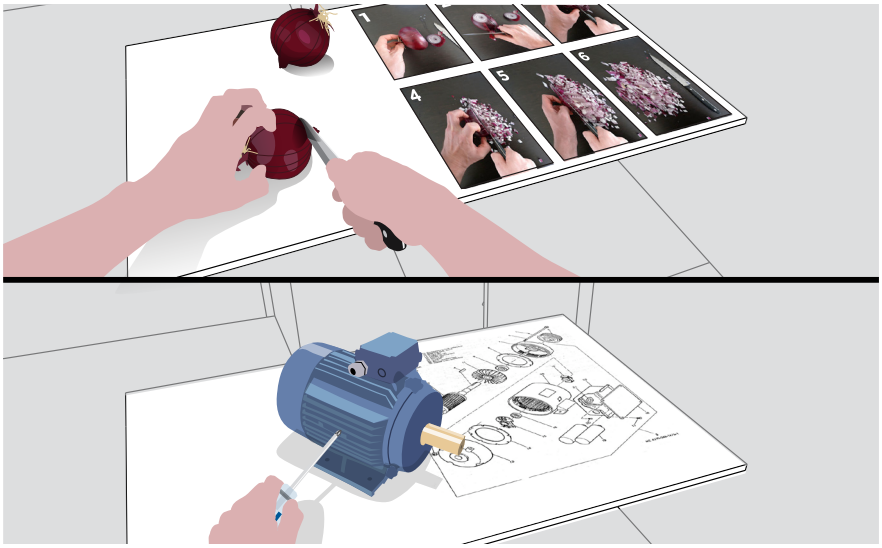
sharing physical tools and useful assets with neighbors can be as valuable to collaborative efforts as sharing information. Trust is built through volunteerism and outreach in the Specialist Volunteer Network and the Neighborhood Watch Plus systems. Lastly, a comprehensive Community Micro Grid ensures that the fundamental energy needs of communities can be met when large scale infrastructure fails.

Ultimately, these elements work to connect people and help them communicate and accomplish their mutual goals. Together, all the elements within the home provide the space and the tools to assist residents as they prepare for and make important decisions. And outside the home social and technological systems ensure that people can feel like they have a place in community and receive support in times of need.

SYSTEM ELEMENTS

SOCIAL DEVELOPMENT

Informed Learning



LEARNING & WORKING

INTERACTIVE EXPLORATION SURFACES

Interactive Exploration Surfaces provides ubiquitous access to digital media from anywhere in the house. Recognizing that different activities have different interaction requirements, these interfaces are available on walls, embedded displays, and mobile tablets and utilize several modes of interaction including voice, touch, and gesture. The presence of these displays allow for easy data entry and retrieval as well as communication between people. The ubiquity of these interfaces makes traditional computing hardware unnecessary. Recognizing that there will be times when users will want to remove themselves from these interfaces, Interactive Exploration Surfaces can be turned off.

PROPERTIES

- Walls, tables, and devices that create universal access to information.
- Uses reflective and emitting displays for strain-free access.
- Results in room size flexible displays.
- A system of sensors enabling multimodal interaction.

Discussion

Interactive interfaces are developing at a faster rate than consumer expectancies. This is a clear when looking at new opportunity spaces for their applications. In the future, there will be new modes of interaction that are difficult to completely predict today. However, interactions that are required in the learning and creation process can be predicted to a large extent, as the basic pattern of needs remains unchanged. In the learning and creation process, **Interactive Exploration Sur-**

FEATURES

- Allows fully multimodal interaction through gesture, voice, and touch.
- Enables communication with friends and family.
- Preserves thoughts, ideas, and memories by connecting to the Nexus.
- Provides universal ubiquitous access to data.
- Allows any surface to be used for interactions.

faces will help the resident to access and interact with data individually or in a group from wherever and whenever he or she needs.

The way in which distributed intelligence and ubiquitous computing are evolving indicates that exclusive physical artifacts such as monitors and screens will be replaced by embedded interaction units. Data that is both ambient and omnipresent will enable the users to selectively use surfaces at home to access and interact with embedded information. Rather than working independently at small screens, residents can collaborate on any surface within the home. They might work on a table to create a poster, with several people working together to arrange the information. Then they might use a wall to present the poster to the larger group.

In the early days of digital information devices, the device was completely embedded in physical artifacts that were comparatively static. As time passed by these devices became mobile, transforming into laptops and mobile phones. With the emergence of Internet and cloud computing, with processing and software as a service (SAS), information is becoming independent of the device. The result of this development means that **Interactive Exploration Surfaces** will allow residents to access this central pool of data from anywhere in the home. Rather than being chained to a single device or surface, residents are free to move around the house, work standing up or sitting down.

Unlike the learning process, in which the data is paramount, the creation process uses data to inform decisions about the work process. During this process, if data is not readily available it frequently gets ignored. Rather than halting the working process to look up some piece of data, users will frequently push ahead using their best guess as a guide. **Interactive Exploration Surfaces** put data, not just at residents' fingertips, but also at their beck and call. Using fully multimodal interaction, and ubiquitous displays, instructions and background information will always be where it is needed most.

Interactive Exploration Surfaces give residents freedom to access and manipulate data anywhere. By freeing residents from static devices and fixed locations, residents can vary their working environment, which will result in many benefits from improved health benefits to increased productivity. This is due, both to the physical benefits of working in a varied physical position, rather than sitting idle for hours, and also because it puts data where it will be most useful.

Scenario

Teresa is a single mother and editor who occasionally writes from home so she can keep an eye on her young daughter, Bess. Working from home is great because it means that on the days when Bess isn't in school, she can stay involved with her daughter, but it is also a real challenge. Between keeping an eye on Bess, preparing meals, and writing, Teresa is really stretched thin. To keep up with everything, Teresa is a brilliant multitasker, but even so, without **Interactive Exploration Surfaces** she would never be able to do it all.

On this particular day, Teresa has a report due, and was working diligently at an Adaptive Surface, which has been transformed into a desk. Projected onto this surface, by **Interactive Exploration Surface** technology, is the script she is trying to polish. Bess, however, has different plans, and keeps pestering her mom for attention. Her play date was cancelled and she has excess energy to burn.

Recognizing that Bess needs something to do, and that her work will not get finished at the current rate, Teresa decides to mix things up. “All right Bess, why don’t you help me with this report,” Teresa asks?

Bess, looking confused at this turn of events, tentatively agrees, “Okay?”

With that Teresa sits down on the floor and with a quick gesture to the **Interactive Exploration Surfaces** has her document moved down to the floor too. “Now, this is the problem. Mr, Perec is producing a new play, which I am helping him write, but no one knows what it will look like. Can you help by drawing some pictures to illustrate the play?”

Bess catches on quickly, “Who is in the play?”

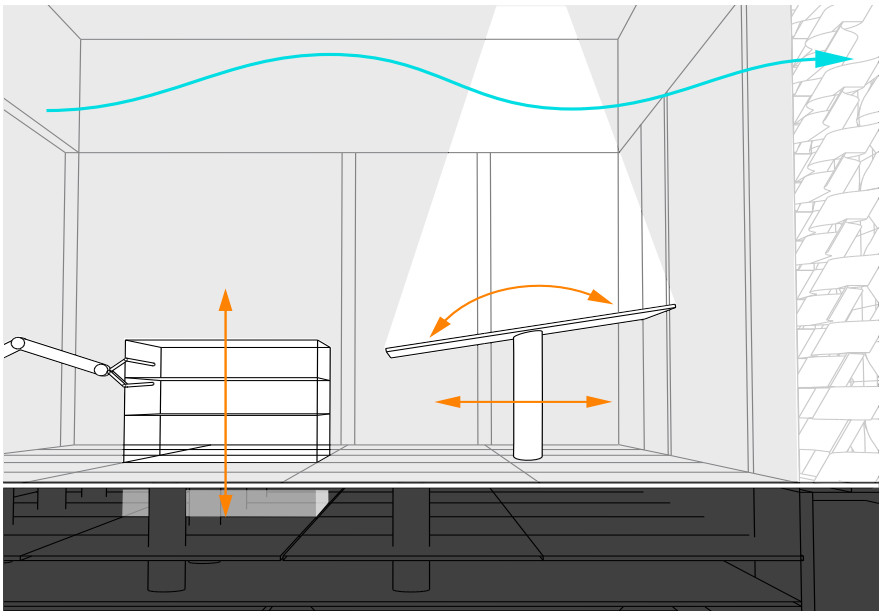
“Well…”, and Teresa describes the basic characters and how the play starts. With that, Bess is off, drawing pictures across the **Smart Panel** floor.

After working for a while on the floor, Teresa starts to get a little stiff. She gestures and the script moves up to the wall, another **Interactive Exploration Surface**. This is convenient anyway, because Bess’s drawings were starting to impinge on the text she was editing. Teresa takes a seat in her favorite chair and continues editing, using the wall as a display.

Pretty soon, Bess is interrupting again. “I’m hungry.”

Teresa checks her watch, and sure enough, it is long past time for lunch. Progress has been pretty slow so far, and Teresa keeps struggling with the same passage. Now is really not the time to stop and make lunch, but Bess does need to eat. Selecting and moving the stubborn passage to the counter, which is also an **Interactive Exploration Surface**, Teresa starts preparing lunch while rereading the passage. “And for desert… madeleines! That’s it… Proust!” Why hadn’t she remembered earlier? Seeing the text beside the cookies for Bess, Teresa suddenly recalled the reference that would tie the passage together.

Interactive Exploration Surfaces, by allowing Teresa to work anywhere, had certainly saved the day. Bess was entertained, and Teresa had found the nugget that would make the play really hold together. By the time dinner arrived, both Bess and Teresa were exhausted and pleased. Bess had departed from the narrative and created her own story, which had been captured and was now displayed on the walls, while Teresa had submitted her revisions.



WORKSHOP

Workshop is a group of support elements, which allow any space to transition into a work zone appropriate for many dissimilar activities. This new space catalyzes the creation process by accelerating setup and cleanup. Wireless Charging eliminates extension cords, reducing clutter. Fully adjustable sturdy furniture guarantee that the space works well for any task and utilize Smart Panels to self-clean and self-repair when cut. Scraps, dust, and fumes are removed by the ventilation and waste collection systems. Interactive Exploration Surfaces provide access to needed instructions without interrupting. Tool Caddy insures that the right tool is always within reach. Biographer automatically documents the process, reducing wasted time.

PROPERTIES

- A series of elements that can be added to a room.
- Fully adjustable stable surfaces that are self-healing and chemical and cut resistant using Adaptable Surfaces and Smart Panel technology.
- Easily adjustable task and atmospheric lighting.
- Access to instructions via Interactive Exploration Surfaces.
- Automatic process documentation via Biographer.
- Wireless Charging provides power supply for electric tools.
- Automated cleanup and tool retrieval via Tool Caddy.
- A ventilation and scrap removal system utilizing Robot Fleet.
- Storage to archive works utilizing Storage Safety Standards.

Discussion

History tells us that humans have been using their homes as a production site since we began to make things, and we will likely continue to make things in our homes for the foreseeable future. Today, we still use our homes to make a wide variety of things, despite the invention of factories and mass production. These new places of production spawned new disciplines that have tried to optimize factory design and maximize productivity. Our homes however, have gained little in this respect; we continue to inhabit and work in poorly optimized spaces. Unlike factories however, homes are not dedicated to one task or even to work in general. Thus homes bear the additional burden of being adaptable to many tasks. Workshop uses advances in material engineering to effortlessly transform any space to meet a wide array of needs.

Utilizing adjustable task and atmospheric lighting, Workshop Lighting addresses the biggest challenge to any task. Herschong and Mahone have shown that good lighting conditions can improve student learning, performance in math and reading by up to 20% (Herschong). Other studies how found similar gains in office, retail, and factory locations (Mills). The answer however is not always more light, flexibility is key. The optimum level of illuminations varies by task and also by the age of the people involved. In a Workshop space, the optimum lighting conditions are easily achievable.

Lighting isn't the answer to every problem however. Surfaces should also be adjustable to meet the needs of the user and also the task at hand. At worst, improper ergonomics can lead to repetitive stress injuries. Ill configured surfaces always result in lost time and frustration as users struggle to make do. Workshop Surfaces are universally adjustable in three dimensions. Not only can the height be adjusted from a low table to a high counter, the surface can be tilted, or even removed as the task demands.

This functionality might alone be sufficient if the task were always the same, but in the home we can be assured that the tasks will require both clean smooth hard surfaces, and moments later be covered in grease, paint, or glue. Furthermore, they will undoubtedly be used for a variety of cutting tasks, and suffer untold abuses. To insure that Workshop Surfaces are always ready for any task, they use the same nanomaterials found in **Smart Panels** making them self-cleaning and self-healing at the molecular level (Forbes). These materials will also allow the surfaces to change shape, growing and shrinking, as the task requires.

While all this flexibility is great, it does nothing to expedite cleanup. The Workshop uses several technologies to address this including, integrated floor cleaning, ventilation, and the **Tool Caddy**, which can pickup tools and return them to their proper storage location. Storage Safety Standards, insure that everything remains safe and secure while not in use, and that work is archived properly. Together, these improvements expedite cleanup and setup, encouraging frequent use and a lifetime of exploration.

Since the Workshop is not a fixed space but a portfolio of services, this functionality could be incorporated into any room. Furthermore, residents may pick and choose which elements of the Workshop they wish to include. While a children's room may need an adjustable surface, cleanup capabilities, and organizational support, ventilation may not be as high a priority. However the components are configured, Workshop will enhance residents' abilities to create and explore.

Scenario

Dorthy is passionate about electric car racing and is working on a new AC motor design. Gertrude, on the other hand, would much rather sugar glaze a cake than lacquer a coil. Since Gertrude isn't home at the moment, Dorthy has taken advan-

FEATURES

- Accelerates setup and cleanup by eliminating extension cords and automating tool collection and retrieval.
- Provides ideal surface arrangement for the task.
- Automatically cleans and repairs surfaces at the molecular level.
- Modulates hardness of surfaces to fit the task.
- Fully controls the atmosphere including particulates, temperature, and humidity.
- Adjusts task and atmospheric lighting to optimize productivity.
- Archives work so that it is preserved for later access.

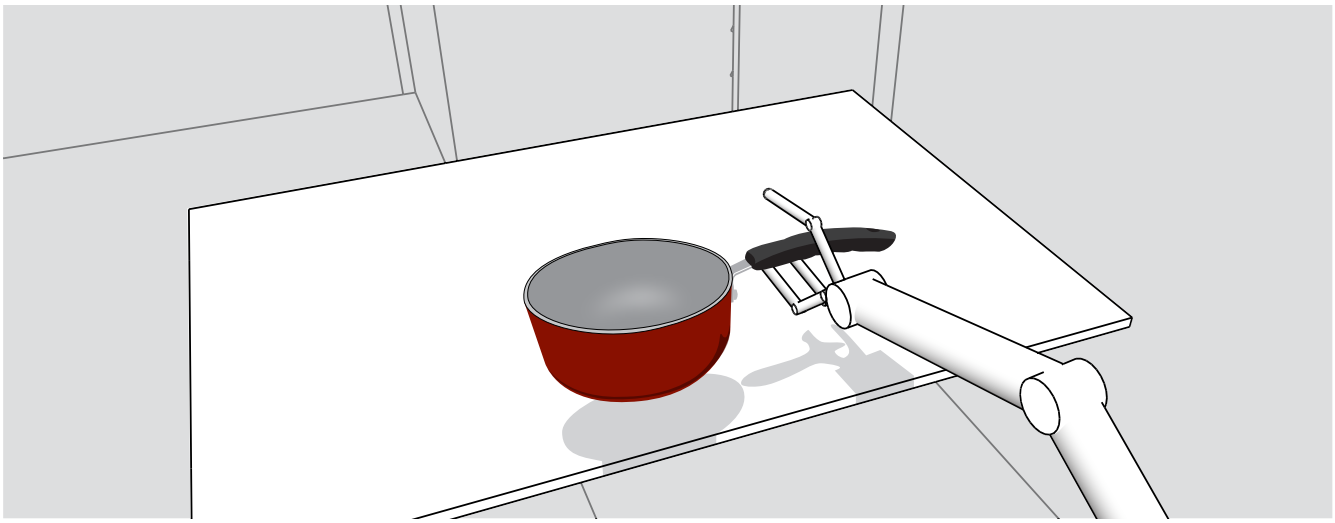
tage of the moment to put in some time on her new motor. She has been waiting for a moment like this for some time since Gertrude hates the smell of solder. First things first, Dorthy activates the User Preference Presets for her work mode, and the lights get brighter, the counter lowers to become a table. **Tool Caddy** got the message and started getting out the tools that Dorthy usually needs.

Meanwhile, a storage container rises from the floor revealing a half built motor and a heap of wire and discarded motor casings. Dorthy pulls out the windings she had been working on and sets them on the table. Where was she? It is hard to remember. She gestures on the table, an **Interactive Exploration Surface**, and a menu appears. A moment later and she has a few notes that she made last time she was working that were recorded by her **Biographer**. She had noticed last time that the winding seemed off and she should redo it before assembling the motor. No problem, **Tool Caddy** is just now delivering the bench vise, and in a few moments she has the coil repaired. She clips off the excess wire, and asks the **Tool Caddy**, to put away the pliers and wrenches; she won't need them anymore.

Tool Caddy doesn't have permission to open the cabinet with the chemicals so Dorthy goes to get the solder herself. Storage Safety Standards were set that require her fingerprint. Assembling the motor can be a bit messy, so she puts on an apron and gloves. Back at the bench, she starts soldering the final connections. Workshop senses the fumes in the air and activates the ventilation system. Then it is just a matter of greasing the bearings and sealing the casing. Grease always has a way of getting everywhere no matter how careful she is, and today is no exception. As Dorthy packs the completed motor into a box, she notices a big greasy smear on the table.

Gertrude will be home soon, so it is time to clean up. **Tool Caddy** has already returned most of the tools to storage, and at a push of a button her storage unit retracts into the floor. While Dorthy is putting away the chemicals, she activates the waste collection system, which whisks away the metal scraps that had fallen on the floor. As for the greasy smear, she notices it has beaded up on the table's Smart Surface, so she just tilts the table and with a little encouragement it slides off into a cup. Unsure about what to do with it now, she puts it in the waste collection system, which identifies it as hazardous and reroutes it. Just to be sure that the table is clean; Dorthy runs a diagnostic, and indeed, no trace of chemical remains.

Shortly after, Gertrude arrives and immediately launches into cooking dinner. Her User Preference Preset is activated and the table rises again to become a counter, and its surface changes from hard to soft so she can use it as a cutting board. She looks admiringly at it, noticing that it hasn't seemed to age at all since they first moved in several years ago. Not a single cut mark remains.



TOOL CADDY

Tool Caddy is a robotic assistant that helps the resident in the creation process by collecting and delivering tools required by the user. The caddy is also capable of collecting and returning tools to storage. Utilizing RFID or equivalent technology utilized by the Storage Catalogue, the caddy is able to track the location and maintain the inventory of objects within the home. While it will be able to organize and retrieve these objects, the Tool Caddy is not equipped to operate these tools.

Discussion

As anyone who has spent time in a workshop can attest, setup and cleanup require a large amount of time. This is especially true in group-shops where one cannot leave projects out between sessions. Setup and cleanup are relatively easy tasks however, and there is no reason that these tasks should take a lot of time. These tasks involve managing an inventory, moving a set of items from one location to another and back again, and can be automated. This is routinely done industrially, but advances in inventory management have yet to enter the domicile.

Using **Storage Catalogue**, the house already maintains a database of what items are in the home and where they can be found. **Tool Caddy** extends the **Storage Catalogue** into the physical world, providing a small simple robot that can locate, transport and deliver items upon request. Together these elements can provide a complete inventory management system. **Tool Caddy** can collect the tools needed for the activity and can return them to their storage location afterward, thus freeing users from the tedium of setup and cleanup.

PROPERTIES

- Small mobile robot.
- A grasping arm that can collect and distribute tools and objects.
- Technology capable of determining precise tool location.
- A database that contains the current storage location for every item in the inventory.
- Navigational and communication hardware for interaction with the environment and objects.

FEATURES

- Assists the creation process by eliminating tedious setup and cleanup tasks.
- Responds to user cues to retrieve, or return tools.
- Tracks the locations of tools.
- Navigates its surroundings easily and rapidly.
- Insures that tools are in operational condition by charging batteries and alerting about tool dysfunction.
- Stays out of the way during the creation process.

Sometimes the situation is more problematic than merely moving tools from one location to another. A common problem found in group-shops is "wandering tools". Too frequently, people can be heard lamenting, "where did that screw driver go?". Even in the home, unless items are always placed back in the same location, people will spend time looking for items that are not in their usual storage location. When this happens while working, the interruption of looking for the missing tool can really inhibit productivity.

Tool Caddy ameliorates this problem by finding the item for you. **Storage Catalogue** uses RFID, or equivalent, technology to keep tabs of most items in the home, thus making **Tool Caddy**'s job very easy. When an item isn't in the database, or the precision of the data is lacking, **Tool Caddy** uses optical recognition, which is also used to manipulate objects, to locate the missing item (Ishikawa Komuro Laboratory).

Having a **Tool Caddy** results in faster setup and cleanup times, and a net improvement in productivity. By streamlining tedious tasks, **Tool Caddy** lowers the hurdles to engaging in new activities. Residents can spend more time thinking about the actual work they are trying to do, and are hopefully more likely to engage and explore.

Scenario

Rudy loves his 1964 Ford Falcon. Gasoline is unattainably expensive, but that was never his concern. For Rudy is was about the open road, and a bench seat. Currently he is working on replacing the gasoline drive train with a new electric kit. He is pretty green when it comes to electronics, so it seems every time he crawls under the car, he has the wrong tool. Thankfully, his new house came equipped with a **Tool Caddy**.

Now, he just reaches his hand out, gives a shout for what he really needs, and the caddy delivers it. While **Tool Caddy** is not much of a companion, he is a much better retriever than Rudy's dog. Best of all, when Rudy is exhausted from working, **Tool Caddy** does the entire cleanup. Everything gets returned to it proper location. Sometimes there are a few extra pieces lying around, mostly old car parts, which the caddy hasn't seen before. Rudy instructed the caddy to put them in a box in the closet, so now everything has a place.

Later, Rudy is looking up parts on the Internet and needs the part number off one of the pieces he removed. A quick verbal request for the box from the closet, and moments later, **Tool Caddy** rolls up with the box. That's it, TZ733. Rudy puts the part on his desk and tells the caddy to return the box to the closet and to leave the part on his desk. While tidying up, the caddy recognizes the part and leaves it there, knowing that Rudy wants to leave it out.

PRIVACY PARTITIONS

Learning and creation require concentration and focus. Privacy Partitions help residents avoid distraction to enhance productivity and concentration. By effectively communicating the status of residents, they can establish themselves as busy without being interrupted. Together, by enhancing concentration and limiting interruptions, Privacy Partitions can allow a small space to be used effectively by several people.

PROPERTIES

- Strong light sources.
- Fog vents.
- Physical partitions.
- Sound canceling.

FEATURES

- Controls the environment to enable concentration.
- Assists the learning and creation process by limiting distractions.
- Communicates the status of individuals without interruption.

Discussion

A challenge in any environment used for studying and working is the presence of distractions, both visual and acoustic. These interruptions can be a nuisance, but they can also create more serious problems. In hospitals, when nurses are interrupted while filling prescriptions, serious errors can be made (MedRite). While life-threatening errors in the home are rare, there remains the need for concentration.

Traditionally, avoiding the bustle of an active house necessitated seclusion. However, as the space of the home shrinks and occupants are forced to coexist in tighter quarters, a new approach must be taken. Similar to the strategy employed in some hospitals to reduce medical errors, **Privacy Partitions** demarcates spaces and their occupants as not to be disturbed (MedRite). This has the beneficial effect of telling other residents that the occupant of the sequestered space is busy and allows the occupant to remain focused on the task at hand, free from interruptions.

Demarcation is not sufficient however. Just because other residents are not interrupting does not mean they are not disturbing. Rather, their visual presence may still be distracting. **Privacy Partitions** utilize **Fog Walls**, **light pools**, and Flexible Walls visually studious busy individuals from other residents. While these partitions may not wholly block ones view, they help reduce the amount of visual noise and distraction.

Even this however may not be sufficient for maintaining focus in a small space. Other residents may be causing a ruckus that can infiltrate the pocket of calm. Therefore, **Privacy Partitions** uses audio cancellation for creating secluded spaces. Again, full isolation is not the goal here. Rather, the system is designed merely to reduce the level of noise so it is not distracting. It should still be possible to communicate with the studious individual if the situation requires.

At the most extreme end of isolation within the home, the **Romance Catalyst** blocks sight, sound, and entry by outside individuals. **Privacy Partitions**, on the other hand, are intended for working and studying, and do not require such stringent isolation. Indeed, some connection to the outside is preferable. It has been shown in some studies that views and visual stimulation in classrooms can

improve performance (Hobstetter). This should not be construed as a reason to shun **Privacy Partitions** all together though. As we can all attest, it is much more difficult to study in boisterous study halls than quite ones.

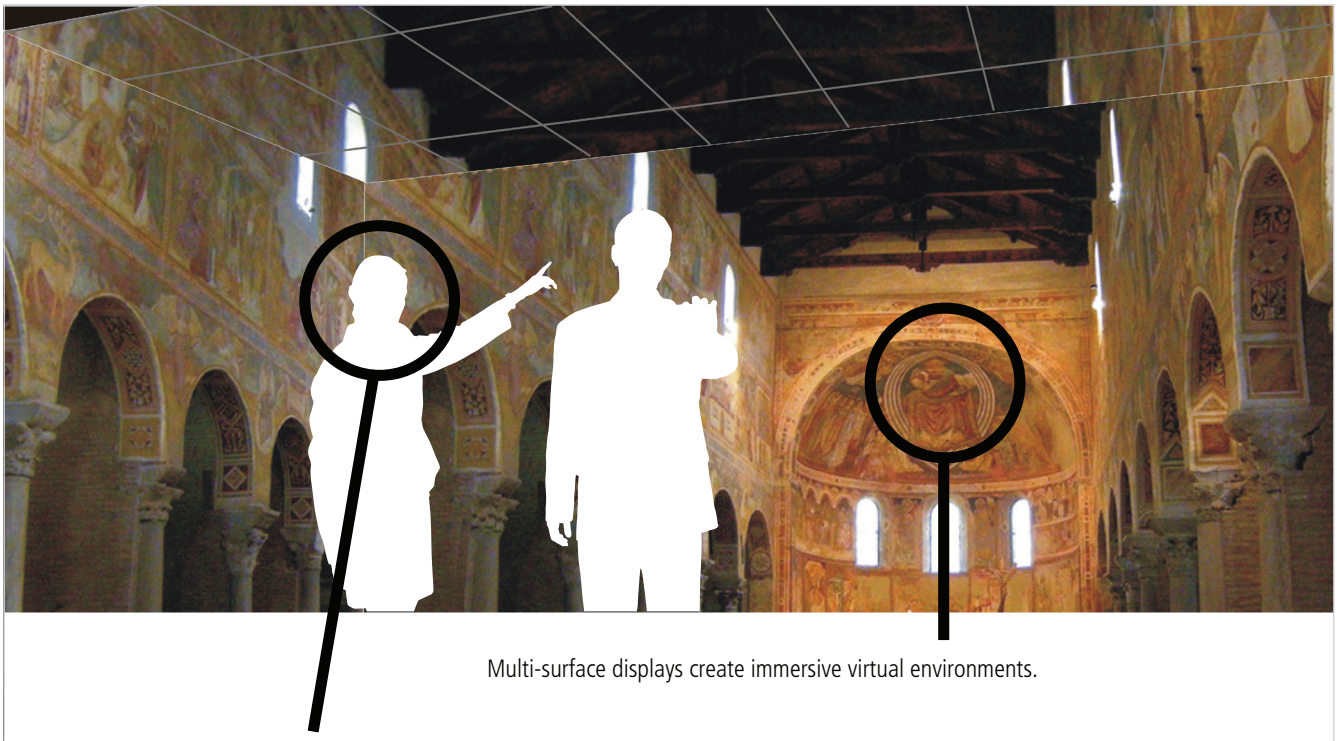
Together, **Light Pools**, **Fog Walls**, **Screens**, and sound canceling can make a small space extremely functional for working and studying. In fact, they may even increase resident performance by allowing residents or families to remain close and supportive while still being productive. **Privacy Partitions** provide every member of the household with the space to study and work while still supporting their relationships and communication.

Scenario

Sally and Eugene's house is small and they do not have a workspace that is separate from the main living space. Tonight, Sally is busy working on some remaining project work. For a little seclusion, she activates the **Fog Wall** to create a partition between herself and her husband, who is distracting her by watching an intense football match on their big television screen. The **Fog Wall** gives her a clean white enclosure cutting off the visual noise caused by the match. While the **Fog Wall** cuts off the visual noise, ambient noise still remains. This way Sally keeps a ear on their daughter, Emily, while she is working, as Eugene is deeply engrossed in his game.

Emily is restless, as she is not receiving attention from either parent. She starts playing peek-a-boo with her mom through the **Fog Wall**. Sally decides her daughter needs some discipline and sits Emily down to do homework. She activates a **Light Pool** on the table next to her. The **Light Pool** is optimally bright, creating a space for concentration to help Emily work with focus without getting distracted or restless in the comfort of her mother's presence. Emily has learned that being under the **Light Pool** means it is time to focus on work. It is a serious learning space. This way Sally and Emily work quietly side by side. By the end of the evening, both have completed their work.

The next day, Emily's friends come over and the house is filled with the sounds of children playing. Unfortunately, Eugene is working from home and cannot concentrate with the ruckus. Using a physical partition and sound canceling to cordon himself off from the noise, Eugene is able to get his office work done. He is even able to join the fray before everyone leaves. This way the house of the future provides individualized learning and working space for all family members.



Multi-surface displays create immersive virtual environments.

Group interaction within the virtual environment.

SIMULATED SCAPES

Simulated Scapes generate synthetic experiences for multi-sensory exploration within a safe environment, and for escape to highly controlled virtual spaces for studying and other activities. It should be possible to integrate real objects into the virtual environment to create an augmented reality.

Discussion

Our ability to learn and experience new things is limited by physical and temporal boundaries, energy and effort. **Simulated Scapes** provide users with close to real experiences by generating synthetic realities. Through **Simulated Scapes**, one can experience objects in three dimensions, take virtual tours of distanst or imagined spaces, and be transported to foreign realms. **Simulated Scapes** is an interaction model that is running on **Nexus**. The same data can be accessed in a two-dimensional interface too. **Simulated Scapes** projects regular images into three-dimensional holograms or multi surface displays.

PROPERTIES

- A system of wall sized screens that can cover from one up to the six surfaces of a room, offering a range of immersion.
- 3D holographic projections can also be used for this experience.
- Haptic, olfactory, visual and auditory inputs.
- Connection with the Nexus and data networks for telepresence.

FEATURES

- Allows multiple people to interact in the space together for learning or creation.
- Enables a personal experience.
- Permits a range of experiences from full virtual reality through mixed experiences to interaction with physical augmented reality objects.
- Provides a full sensory experience, including haptic, olfactory, auditory, and visual senses.
- Allows tele-presence at multiple locations without the actual physical travel to those destinations.

In the future house, year 2050, virtual travels will be as common as physical travel. Teleconferencing and online chat systems are initial glimpses of this situation in today's scenario. As fuel charges increase and lifestyle schedules demand that people exist in multiple locations simultaneously, digital existences will be a critical facility that future residents will employ. With applications like Second Life existing today, new platforms for online interactions are developing. **Simulated Scapes** addresses this need by providing complete virtual reality within the home. Residents will be able to not only experience foreign worlds; they will be present within those distant spaces.

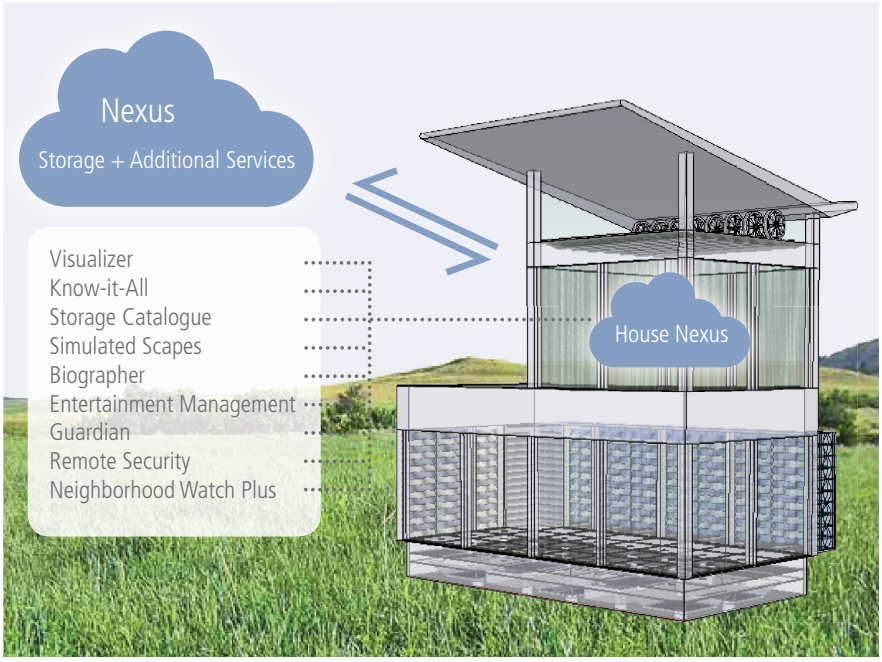
Simulated Scapes also help to envision information in a completely new way. Today we see the trend of large display screens becoming accessible within the home. The new interaction models changes this paradigm, including the viewer as part of the interaction. Multiple people can interact in the space together for learning or experiencing. By allowing a range of experiences from full virtual simulations on multiple senses to augmenting reality on physical objects in the space, **Simulated Scapes** enables a new way of learning where simulations are close to human imagination. This is achieved with multi sensory experience including, haptic, olfactory, auditory, and visual senses. Thus **Simulated Scapes** accelerates curiosity by allowing experiences that aren't normally possible using synthetic simulations.

Scenario

In the year 2050, Maya, an architecture student, came to the US from India for her higher studies. Her roommate Jess, who is also an architecture student welcomes her in and shows her around. One of the most interesting things the Jess shows Maya is the **Simulated Scapes** tool. Jess describes how she tests her designs using walk-throughs of the virtual models via **Simulated Scapes**. Soon after being introduced to this new interactive medium, Maya takes Jess through the monuments in India, revealing all their intricate architectural detail.

Realizing that if she could visit the monuments of India she could also visit home, Maya has one of these devices installed in her home in India. Now whenever she misses home, she uses **Simulated Scapes** to have a chat with her family members there. Her house in India with her family members is projected live into a **Simulated Scape**. This window, created by **Simulated Scapes**, is so immersive that Maya feels she is really there.

Although she can't give her mom a hug, she is able to touch her hand and feel the texture of he mother's skin using the haptic feedback. The olfactory sensors capture the smell of the cooking and fill her apartment with the scent of India. Oh, if only she could sit down to a meal! While this isn't quite possible, just being able to have a real conversation with her family is enough to make the distance bearable.



NEXUS

The Nexus is a direct descendant of "Cloud Computing" brought to the home in the future. It is a computer system, which provides centralized information technology for the house. It stores data and provides software applications. The House Nexus provides some capabilities from within the home to insure basic functionality during service outages and privacy of sensitive data. In addition to the House Nexus, an external nexus is used for backups, additional services, and provides access to the House Nexus from anywhere. This central data repository is utilized by many other system elements, including Biographer, Guardian System, and Interactive Exploration Services, to enable access to data anywhere.

Discussion

The **Nexus**, much like the concept of "Cloud Computing," allows users to access increased computing capacity or add capabilities on the fly without investing in new infrastructure, training new personnel, or licensing new software for computing data. It encompasses any subscription-based or pay-per-use service that extends existing IT capabilities.

When a service provider uses public cloud resources to create their private cloud, the result is called a virtual private cloud. Private or public, the goal of cloud computing is to provide easy, scalable access to computing resources and IT services. This idea is what we are extending in the **Nexus** for the house of the

PROPERTIES

- Computer servers.
- Centralized storage, memory, processing and bandwidth.
- Maintains an index of data for easy retrieval.

FEATURES

- Provides computing services to the user.
- Aggregates and archives data for the user.
- Maintains and records for learning, creating and troubleshooting.

future. The House **Nexus** is much like a private cloud, a proprietary network or data center that supplies hosted services to a limited number of people.

Significant innovations in virtualization and distributed computing, as well as improved access to high-speed Internet and a weak economy, have accelerated interest in cloud computing recently. Moving business applications from the enterprise server to the service provider's has the powerful advantage of disconnecting the price of output from the cost of production, and reconnects price to the value of output.

In the home similar benefits are realized. Residents are able to utilize computing services that they might otherwise be unable to afford. They can access their data anywhere within the home. Finally, digital services within the home are more easily integrated using centralized computing services. Together these services improve residents' ability to understand, learn and create within the home.

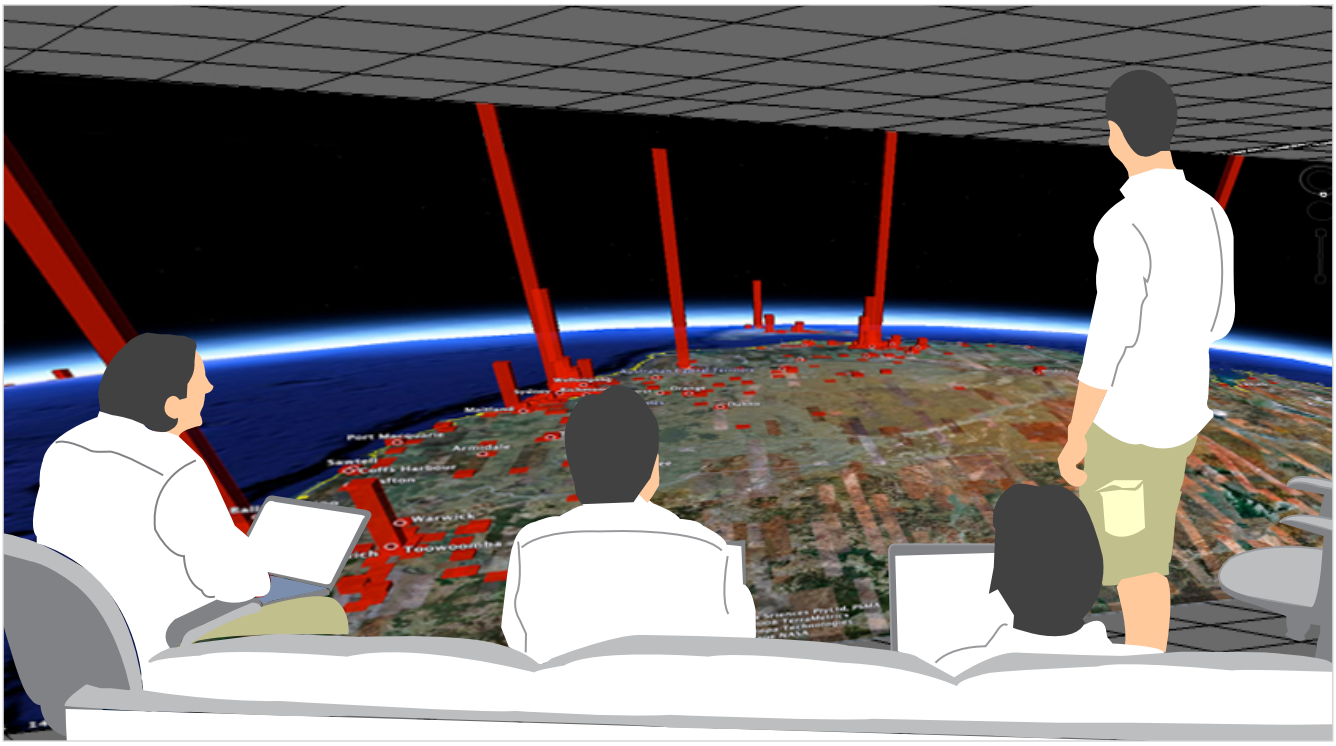
Scenario

Sally wants to do a project on waste management for her environmental science class. Her school encourages her to use the Nexus to build her project. The Nexus gives every one an opportunity to see complex data in many forms for analysis. The key is to pick the right tools for analysis. Along with setting up the Biographer to capture waste segregation activities, Sally plans to use the Visualizer to support her research with rich visuals.

The **Visualizer**, hosted on the **Nexus**, will visualize data such as the kinds of waste produced, the nature, texture and composition of residue from the Metawasher and Robot Fleet, and the contents of the waste monitoring systems within the house.

Over time the **Visualizer** shows a number of compelling visuals, like level of toxicity in the home waste, the pH value and embedded energy values. These visuals help Sally to develop solution options and prototypes to test at various points during her research. This learning and formulating process is being documented by the **Biographer**, and simultaneously stored in the **Nexus**.

On the day of presentation at school, Sally connects to here Home **Nexus** and pulls up the work captured by the **Biographer**. She presents her rich body of research and analysis to the class. She shows them how she was able to change the nature of waste generated in her home by carefully studying the toxicity graph that the **Visualizer** created using the data stored in the **Nexus**. Everyone is duly impressed.



VISUALIZER

The Visualizer is a software service running on the Nexus, which aggregates raw data into compelling visualizations that aid cognition and learning. The Visualizer does not make decisions, but it can enhance the residents' ability to make informed decisions. It will also suggest visualizations for particular problems posed by the user. The Visualizer is accessible from all Interactive Exploration Surfaces.

PROPERTIES

- Software that generates compelling graphics.
- Access through any digital interface.

Discussion

Imagine a world where data becomes the everyday, simply embedded in everyday life. Today, we use charts, graphs, and visualizations to make important decisions with investments, businesses, and to stay informed on the news. Why not use these analytic tools in our domestic lives?

Perhaps the reason is that we don't have any data to analyze. While this is certainly a problem, another is finding compelling visualizations, which help us understand the new forms of data. The **Visualizer** transforms data collected by various other systems in the home into compelling understandable graphics. By making data more relatable, the **Visualizer** makes the wealth of available data actionable.

FEATURES

- Visualizes data to reinforce cognition, hypothesis building and reasoning.
- Simulates on screen for learning and experimenting.
- Translates queries into visualizations.
- Suggests what could be visualized for better comprehension and understanding.

The purpose of these visualizations is two fold. First, making data understandable, relatable, and actionable can help residents use it to manage their lives. Second, being able to visualize complex data sets easily can foster life long curiosity.

No matter what residents are concerned with, whether it is their energy consumption or dietary patterns, the **Visualizer** can map the trend to enable comprehensive historical understanding. The **Visualizer** makes it easy for residents to understand the consequences of their actions. How much did that shower cost? What is the most efficient way to wash the dishes? These questions can be easily answered when the data is coherently displayed.

Furthermore, the **Visualizer** can extrapolate into the future, assisting residents as they make decisions. This ability to find trends is a powerful tool in a complex world. As residents consider two possible options, the **Visualizer** can project these actions into the future and provide a better idea of what might follow. Considering taking up jogging? This system can illustrate how such a decision would impact your physique.

The larger goal however is to encourage life long learning. As residents take advantage of the ability to visualize different aspects of their lives, they may ask, "What is going on here," and request a whole new graph. Furthermore, since all this data is stored in a centralized location, the **Visualizer** can allow users to investigate the connection between two previously unrelated phenomenons. "What is the relationship between the weather and how long I snooze," a user might ask. While there may reasonably be no connection at all, the **Visualizer** did allow the questions to be asked. Curiosity, after all, is not dependent on the answer.

When integrated into the home, the **Visualizer** provides an entry point for residents to learn more about how they live, and how the house functions. As the data changes, and residents ask new questions, the **Visualizer** will help insure that residents stay informed and engaged. Now when it comes to informed decision making, the home, instead of the business, will lead the way.

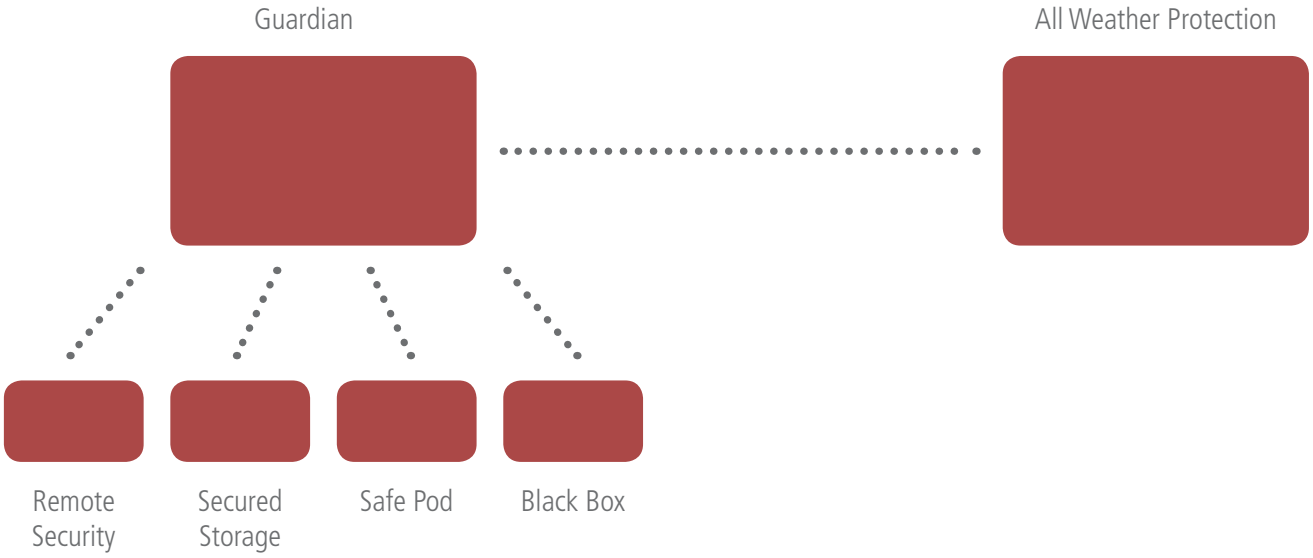
Scenario

Eugene wants to get fit. He is monitoring his daily calorie intake by checking in all his food into the **Scan Closet**. The **Scan Closet** sends the information about the food to the house **Nexus**. In spite of this close monitoring however, Eugene is not losing weight at the rate he wants.

He wants to see how his current pattern of eating with his metabolic rate will help him become thinner over six months. He uses the **Visualizer** application on the **Nexus** to help him see this. The data from the **Scan Closet** is sent to the **Visualizer** that builds an avatar of Eugene in six months, with the current eating pattern. To his dismay the avatar does not show a great transformation. Through this visual he able to reconfigure the food contents in the **Scan Closet** only to

check via the **Visualizer** again, for what progress might look like. Eugene discovers that a certain quantity of protein and carbohydrate intake will help him achieve his goal in six months.

In this way Eugene is able to adjust his routine, make diet alterations, and include exercise in his lifestyle with the help of the **Visualizer**. Further, he plans to track this journey of weight loss by capturing it on the **Biographer** so he can share it with his sister who wants to lose weight as well. Without the **Visualizer** he would have never understood his body and how it responds to nutrition in order to implement and track his weight loss management.



SECURITY

GUARDIAN SYSTEM

The Guardian System is the center of the home's security system. It utilizes the Nanosensor Array to passively monitor the external and internal home environments and responds accordingly. The system communicates to inhabitants as well as external parties when applicable.

PROPERTIES

- Embedded sensors inside and outside the home
- Non-harmful materials throughout the home's interior
- External materials that withstand climatic forces
- Visualizations of internal and external activity
- Biometrics, passwords and permission based access
- Visual and auditory alarms
- Communication device between home and outside individuals

Discussion

Homes today rarely respond adequately to external or internal threats or safety issues. The **Guardian System** allows the home to be more autonomous, thus freeing the residents from worry and providing peace of mind.

The **Guardian** is at the center of the home's security system. It utilizes the **Nanosensor Array** to passively monitor the house and its inhabitants to ensure everything is safe and secure. Internal physical components of the home are outfitted to reduce harm to residents (i.e. floors that soften upon impact to prevent injury). It cautions residents before potential crises, and in the event of urgent or emergent situations, it guides and instructs residents in order to alleviate the situation as much as possible. While the home should be as self-sufficient as possible, even in terms of security, we must admit that there are occasions when external help is required. The system will also reach out to the community–family, neighbors, police, firefighters–to expedite handling the situation appropriately.

General Interaction

The **Guardian System** is accessible from any **Interactive Exploration Surface** in the home. Interacting with the **Guardian System** directly allows residents to stay informed on their environments and thus the safety and security of their home. Residents can choose from a variety of visualizations that pertain to the structure of the home, maintenance status, exterior surveillance and weather effects.

Remote Access

Residents become anxious when they are away from their homes. Remote access to the **Guardian System** lets residents remain at ease knowing their home is safe while they are away.

Accessed through mobile computing devices (and other potential communication devices of the future), the **Guardian System** functions in essentially the same way to residents as it would if they were accessing it directly in the home. Alerts, messages and status updates are sent directly to remote devices so that residents can remain informed from afar. As with all intelligent system elements, the preferences are entirely user controlled and residents can choose to limit or entirely forgo some of these features.

Emergency Situation

When residents are home and the **Guardian System** detects an external threat–whether weather related or intruder related–it will execute a series of responses

- **Communicate the nature of the threat**

  Flood, fire, earthquake, hurricane, etc

Intruder, breech, etc

- **Communicate the home's physical response**

  All Weather Protection System response

- **Instruct residents on how to respond**

  Attend to another person (medical issue)

  Stay calm and wait

  Move to Safe Pod

- **Communicate with the community**

  Call for help from family and friends

  Call for help from authorities

Practice Mode

The system includes a user-selected mode in which residents can simulate the experience of a disaster or emergency. This ensures they are knowledgeable on how they should respond in a variety of circumstances and can stay calm in highly stressful events. The practice mode will produce simulations that are as close to reality as possible. This will include reactions from the **All Weather Protection System** as well as visible and auditory guidance.

Scenario

Jana is at work, a few miles away from home. Over the last few days, everyone at her office has been talking about the strong wind storms and rainfall they have been experiencing. It is worrisome given the increase in the number of storms that have been passing through their region over the past few years.

Meanwhile, Jana's son Jack and her mother Lauren are at home. Lauren has been living with her daughter ever since her husband passed away. Physically she isn't doing so well, so it's nice for her to be in close proximity to family.

Back at work, Jana's mobile computing device lights up and sounds an alert from the **Guardian System**. It tells Jana that her mother has fallen down. It goes on to tell her that it is now advising her son Jack on what to do to handle the situation. It now relays to Jana that the fall is worse than expected and that her mother may have broken her hip. It asks Jana if she'd like to call in a neighbor or contact the local hospital. She opts to do both. All the while, her device connects her audibly and visibly to her family back at home so she can communicate with them while she rushes home.

As if things couldn't get worse, the **Guardian System** alerts Jana (remotely) and Jack and Lauren (directly) that one of their windows upstairs is in danger of being blown off by the strong gusts of wind. It's a good thing she's already on her way home.

FEATURES

- Links in with other intelligent elements of the home (inventory control, general information storage, energy monitoring, etc)
- Detects internal activity
- Detects abnormal activity inside and outside the home
- Detects weather conditions
- Corresponds with other Guardian Systems in the neighborhood
- Provides visible and audible guidance and alarms to inhabitants
- Can be accessed remotely on mobile devices
- Communicates externally when there is an emergency situation
- Provides information to officials who come to the home to help inhabitants; replays recorded data of incidents

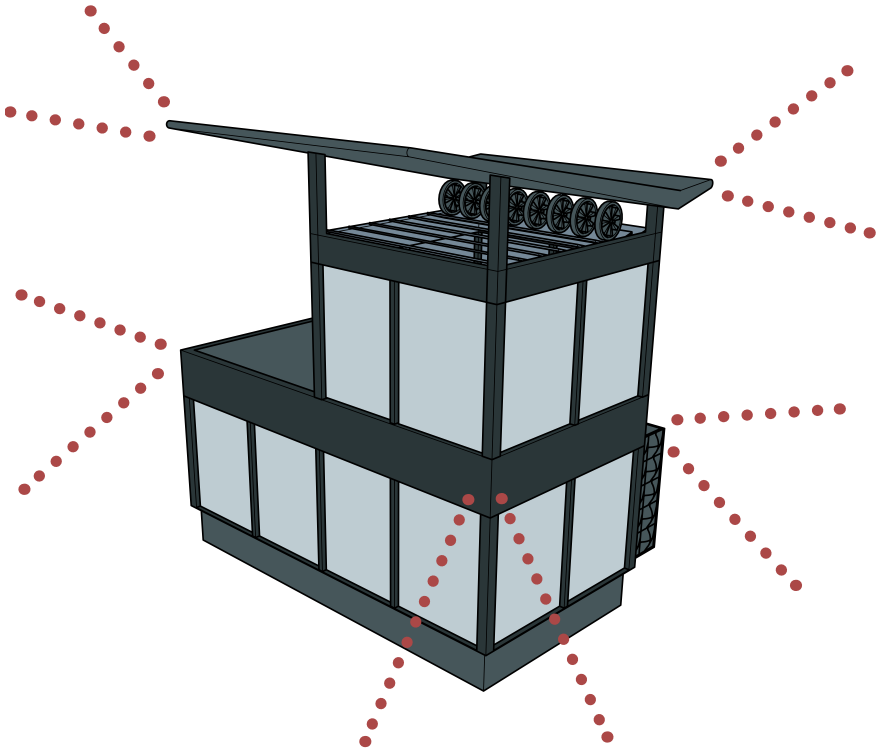
Before Jana arrives, her neighbor Todd is already there and so are the paramedics from the local hospital. The paramedics were able to access a replay of Lauren's fall and can now relay it to the hospital to better inform their care. Lauren leaves with the paramedics while Jana selects some preventative **All Weather Protection System** measures from the **Guardian System** to inhibit the window from being blown off in the storm.

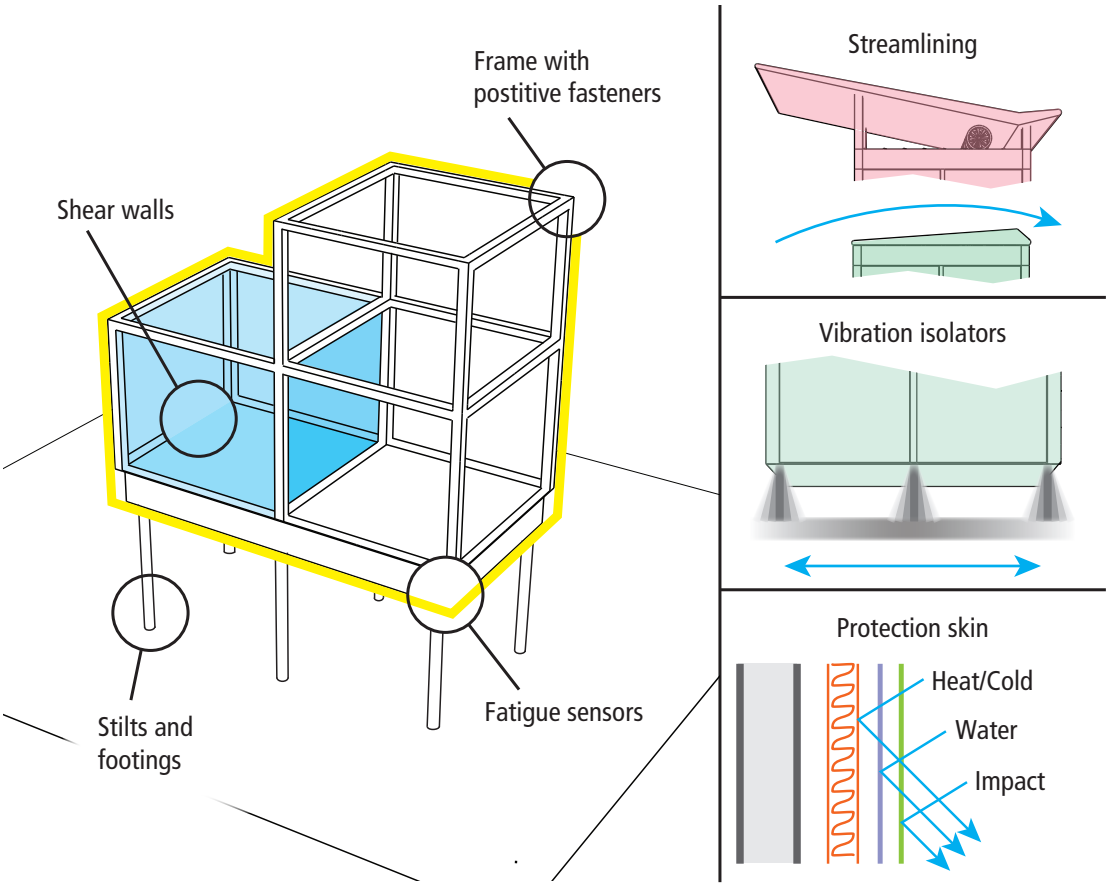
Several hours later, Lauren has returned home from the hospital with a support brace for her hip. The winds are still whipping through the area. And the rain is not letting up. At least the window is still holding up. Once the storm passes, they can have it looked at by a maintenance worker.

The **Guardian System** continues to update the family on the weather conditions. It is getting worse and worse. Still, they remain calm. They have run many simulated disaster drills, so they're familiar with the protocol that they might need to follow in case of an emergency.

The system informs them that the weather conditions have reached a level where it may not be safe for them. It is best for them to retreate to their **Safe Pod**. Lights in the house guide them and they move toward the designated section of the house that will enclose them and create a barrier from the elements.

The family stays within the **Safe Pod** for a few hours and the storm passes.





ALL WEATHER PROTECTION SYSTEM

The All Weather Protection System is an array of protective components made of special materials to fend against all natural disasters and weather conditions. The outer layer must be resistant to fire, ultraviolet radiation, projectiles, water, and must be secured to the structure to resist wind damage. An internal structure utilizing positive fastenings, shear walls, and a network of sensors will insure the structural integrity of the house. Where appropriate, flood and earthquake protection can be added to these core components. Integrating these physical components with the Guardian System allows the house to transition between protection modes depending on local conditions. While not every disaster can be prevented, the All Weather Protection System provides more than minimum protection.

PROPERTIES

- Structural frame with shear walls is rigid to protect against wind and vibration damage, and allow the house to be moved easily.
- Positive fasteners connect components to protect against structural damage.
- Dampening to isolate the structure from earthquakes.
- A system to lift the house in the case of flood.
- Footings prevent the structure from being carried away by waves or wind.
- Continuous waterproof skin.
- Fireproof exterior and internal structure.
- Continuous insulation to protect against heat and cold.
- Puncture-proof skin.
- Indestructible windows protect against theft and wind damage.
- Streamlined exterior to reduce wind resistance.
- Embedded fatigue sensors prevent catastrophic failure by detecting structural flaws.
- Integration with the Guardian System to transition the physical components during different weather conditions and disaster situations.

Discussion

While the only reasonable defenses against some disasters involves proper placement of structures, and construction of surrounding fortifications. For example, no house should be built on a slope that is vulnerable to collapse unless sufficient protection can be provided. In most other situations, the **All Weather Protection System** provides excellent protection against disasters and structural failures, which result from excess force being applied to the building, or a weakening of the structure so it cannot support the normal load. Each of these causes of structural failure will be discussed below.

Natural disasters frequently cause excessive forces to be exerted on the structure, and can be grouped into four general categories. The first are caused by motion of the earth. While each sub-type has particular behavior, earthquakes, subsidence, and erosion all cause the structure to move in abnormal ways. Unlike normal static forces, these disasters physically move the structure. In most cases, there is little that can be done to protect a structure from subsidence or erosion other than removing the structure to safety. Therefore, the **All Weather Protection System** is focused on preventing structural damage from earthquakes. This is achieved through a three-part solution. First, the frame of the home is constructed using positive fasteners, allowing forces to be transferred through the rigid frame in any direction without fasteners failing. Traditional stick frame construction can fail during earthquakes because nails used in construction have little holding strength when force is applied along the shaft. Other fastener systems like bolting and welding, do not suffer from this problem. Positive fastenings also provide some protection against damage from subsidence and erosion since the house should be salvageable despite the fall.

Secondly, the structure is isolated from earthquake vibrations using dampeners. While using a rigid frame is antithetical to some earthquake protection systems, when coupled with vibration dampeners good protection can be achieved (Earthquake Protection Systems). The rigid building will stay relatively stable above the vibrating earth, held in place by inertia, in much the same way that a car remains comfortable despite bumpy roads. This strategy can be very effective for all events that do not result in surface waves which throw objects into the air. The building will inevitably experience some motion however. To reduce the stress put on the frame, the **All Weather Protection System** employs a third strategy of evenly distributing the mass of the structure, thus evenly distributing forces. Earthquake-proofing a structure usually involves isolating masses from each other and allowing independent motion. By evenly distributing the mass of the above ground structure, the whole building vibrates as a unit, preventing failure (Ambrose). These techniques are effective measures for protecting a small building. As buildings gain height, other methods would need to be applied.

The second kind of disaster results from excessive forces applied by extreme wind. Hurricanes, typhoons, cyclones, and tornados all have the ability to destroy

homes by tearing them apart. Preventing damage from these storms requires two main protections. A strong structure, like that used to safeguard against earthquakes, and a streamlined structure. Strong winds create intense negative pressure above the roof. If the roof is unable to resist these forces and is pulled off, the structure frequently collapses. By using a strong positive connection between the roof and the foundation, instead of relying on gravity, the building will be better able to resist these forces. Where overhangs and appendages exist, there is an increased chance of damage. Wind accelerates when it swirls around these features increasing its intensity and its ability to destroy (Ambrose). The **All Weather Protection System** streamlines the structure, reducing these effects. This has beneficial downwind implications by reducing the amount of debris that could hit adjacent structures.

The third kind of disaster is the result of fire. Fires are the result of combining fuel, oxygen, and heat. Fighting fire requires breaking this triangle. To prevent damage from external fires, the placement of the home and the presence of a firebreak can have dramatic beneficial effects. Where these breaks are missing or inadequate, the **All Weather Protection System** protects the structure by reducing fuel on the skin of the building and blocking heat from entering the building. The **All Weather Protection System** utilizes a fireproof polymer skin that also provides water protection. Inside of this is a continuous insulation layer that blocks heat from damaging the structure. This system is also an effective measure against extreme cold by blocking all three kinds of heat transfer: radiation, conduction, and convection.

The fourth kind of disaster is caused by excess water. Water can cause many problems when it is allowed to infiltrate the home. Thus, the main priority is to keep water out. Water has several ways of entering the home. Floods are the most obvious, but torrential rain and ice buildup can also result in leaks, allowing water to enter. The **All Weather Protection System** uses a continuous waterproof skin to prevent small leaks. While this skin could in theory protect against floods, the water pressure created by floods is much greater than that caused by ice or rain and cannot reasonably be stopped by the building's skin. In the case of floods, the **All Weather Protection System** protects the building by lifting the building above the water. This is a good solution for small low structures, providing a ready barrier against flooding (Morphosis). Larger structures must instead be built above the flood line, since they cannot be easily moved.

The fifth kind of disaster, impact, can be the indirect result of any of the previous four disasters or it can be an isolated cause in the case of meteoroids or bullets. Regardless of what is causing the damage, the building must be able to either absorb the kinetic energy of the object or deflect the object without breaking. The strong structural frame used by the **All Weather Protection System** previously can effectively absorb the force of large impacts and it redundant enough that even where damage occurs, catastrophic failure can be avoided. To stop smaller projectiles, the **All Weather Protection System** relies on its skin. Sandwiched

FEATURES

- Prevents damage due to wind, water, motion, fire, pests, and impact.
- Monitors structure for fatigue and other structural flaws.
- Warns against sudden catastrophic failure.
- Lifts the structure above rising floodwaters.
- Adjusts fenestrations and awnings in response to weather conditions.
- Keeps the house secured in place during storms.

or integrated with the thermal and water barriers is a layer of puncture resistant material capable of stopping all but the most extreme impacts. This layer is critical since it will increase the life of the buildings skin (Fernandez).

Returning to the second cause of structural failure, the weakening of the structure, the primary means of protection is maintenance. No structure has ever been conceived which could survive indefinitely without maintenance. However, even with the means to perform maintenance, knowing when components need repair can be a challenge. Numerous structures have failed unexpectedly because they were either under engineered, or became weakened due to age and wear. To prevent sudden failure, the **All Weather Protection System** monitors structural components of the building with sensors that detect fatigue, and communicates this data to the **Guardian System** in order to provide the necessary warning. These sensor skins can pin point the exact location of the strain and alert the homeowner to the danger before failure (Loh). Even if the failure cannot be avoided, providing any advanced warning can give occupants time to evacuate.

In almost every case, the structure will not respond adequately without some assistance. Some change to the fenestration or communication must take place. While historically, the resident was responsible for these tasks, problems arose where the resident were unfamiliar with or incapable on completing the necessary tasks. For this reason, all these systems have been connected to the **Guardian System**, which will automatically make changes when necessary, or will at least guide the resident through the required steps. This system will help ease relocation by guiding residents through the new regionally specific tasks. Furthermore, as weather patterns change dramatically in the coming decades, this system will help insure that residents are prepared for the new conditions.

Together this system of elements can provide more than adequate protection against nearly all kinds of disasters. Regardless of where the building is placed on earth, it will have the basic components needed to survive and protect its inhabitants. Unlike existing structures, which gain weight as they gain durability, the **All Weather Protection System** protects this home while remaining light and materially efficient. This is important, as the structure may need to be moved during its lifetime. While some of these measures are predicated on advances in material science, like the puncture-proof skin, others, like streamlining, gracefully apply existing technology. Combining both kinds of protection measures will help insure that these structures will survive and remain useful for hundreds of years.

Scenario

September 14, 2051: There had been several days of warnings and everyone including Burt had evacuated ahead of Hurricane Owen's landfall. Safely at his family home in Georgia, Burt could only look on as Owen ravaged the coast of Florida. Using the Remote Security System, Burt got regular updates regarding his home's status. This was the first hurricane season he had experienced with his

new home, and he was very interested to see how it would fair. The included **All Weather Protection System** was supposed to be great at protecting the house.

As the storm approached, the **Guardian System** received alerts from the local authorities and began preparing the home. Storage units were secured. Furniture within the home was retracted or secured. The roof structure was retracted to streamline the structure. And the outer skin of the building was sealed, closing all the openings used for ventilation. With no one home, the **Guardian** was programmed to maximize protection. The **Guardian** could monitor and control the home for weeks with the energy reserves full.

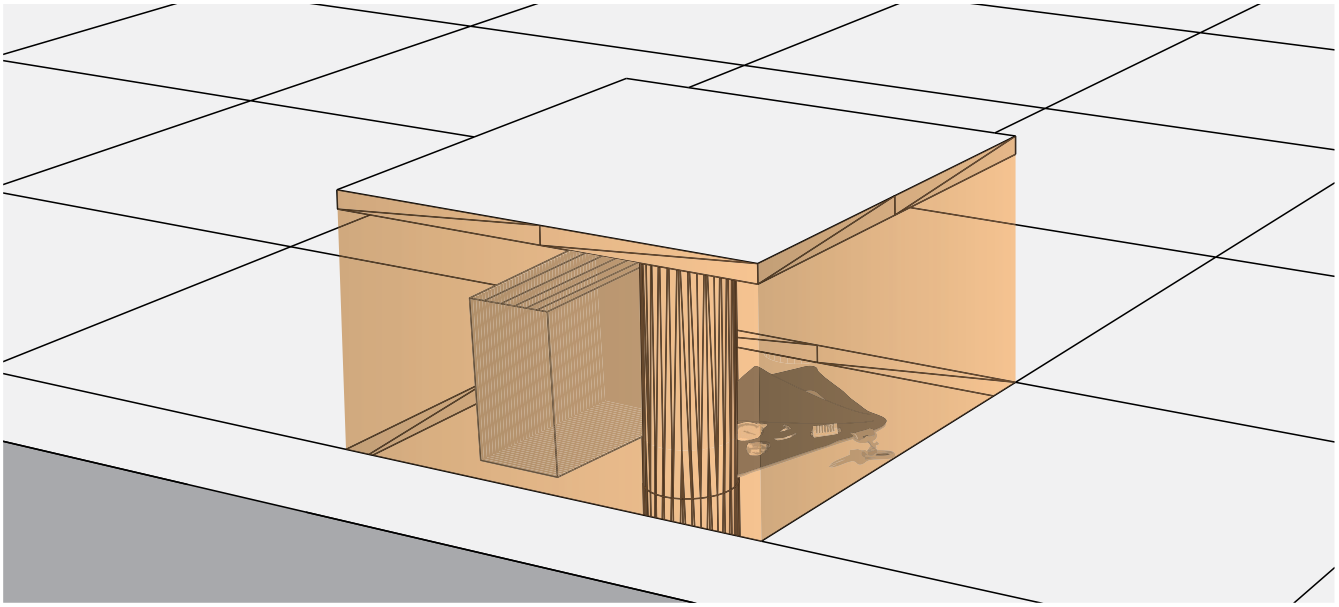
By the time Owen made landfall, the ocean had risen 5 meters and had engulfed most coastal homes. Burt received word that the **Guardian System** had deployed the stilts from the **All Weather Protection System** to lift the house above the raging water. At this point the house had essentially become a boat, riding out the storm securely attached to piers. While the house was still engulfed by waves periodically, it was spared the bulk of the wave action. The protection skin easily handled these occasional waves.

As dusk approached the storm amplified, and wind speeds were recorded in excess of 300km/h. Many neighboring houses, including those designed for hurricanes began to be ripped to shreds. Having risen above the waves, Burt's house had preserved the integrity of the walls and was thus better able to withstand the wind forces acting on the house. The **Guardian** continuously monitored the integrity on the structure using a network of sensor skins that measure strain. The negative pressure on the roof and the positive pressure on the east wall was tremendous, but Burt could easily see in the updates he received that the pressure was being well distributed and was within tolerance. The positive fasteners and shear bracing were doing their job.

At the next update, Burt got word that the house had been struck. Apparently some object, possible the neighbors roof, had smashed into the second story of the house. The facade had been damaged, but the inner protection skin had stopped the object and was still preventing wind and water from entering the home. Close call, but Burt's home will see morning.

As the sun rose, the water receded, and the **Guardian** lowered the house back to the ground but kept the other protections in place. No residents were home, and the wind was still blowing pretty hard, so the **Guardian** remained vigilant. With the water receding, a spark suddenly ignited gas from a leaking pipe and started a fire in the neighbor's home. With emergency crews busy elsewhere, there was little to stop the home from burning. **Guardian** monitored the situation, and sent Burt an update. The protection skin is flame resistant and didn't burn, but it did little to protect the rest of the house from the inferno. The heatproof insulation on the other hand, blocked the heat and protected the home.

When Burt returned home, to inspect the damage, he found that one of the Adaptive Exterior panels had been cracked by impact in the night, another had been burned, but both could be replaced easily, he had already done it when he moved in to customize the look of his house. Of course the landscaping was a wreck, but other than that the house looked great. The **All Weather Protection System** had clearly done its job well. After entering the home and disarming the **Guardian**, the house reconfigured the **All Weather Protection System** back into it normal mode. The roof extended, solar panels were uncovered, windows opened, and a fresh breeze blew into the house. The smell after a storm is so distinctive.



SECURED STORAGE

PROPERTIES

- Physical compartments
- Protective shells
- Electronic components
- Controlled climate/environment
- Encryption, passwords, biometrics

Secured Storage provides secure personal storage of individual items of value. Secured Storage compartments are integrated into the Safe Pod space and easily removed during evacuation.

Discussion

Some items in the home are stored inappropriately and are exposed to loss and misuse. In the home of the future, general security protocols for storage will be sufficient in most cases, but residents may require higher protection for more valuable items.

Secured Storage is discrete and can reside in any module in the home. Residents may choose to incorporate this into their **Safe Pod** area so that in the event of disaster or catastrophe, their valuables will remain secure.

Access to **Secured Storage** modules is controlled via biometric readings as well as passcodes and locks. These security methods can be used separately or in conjunction to create maximum impermeability.

The materials of the module will emulate that of the **Safe Pod** and the **All Weather Protection System** components in their durability and resistance to outside forces (both natural and manmade).

FEATURES

- Hidden in the home environment
- Biometrics, passwords, encryption for user
- Can be overridden by the authorities
- Can be overridden with a master key
- Protects, medicine, tools, chemicals, valuables
- Encryption of all information

Scenario

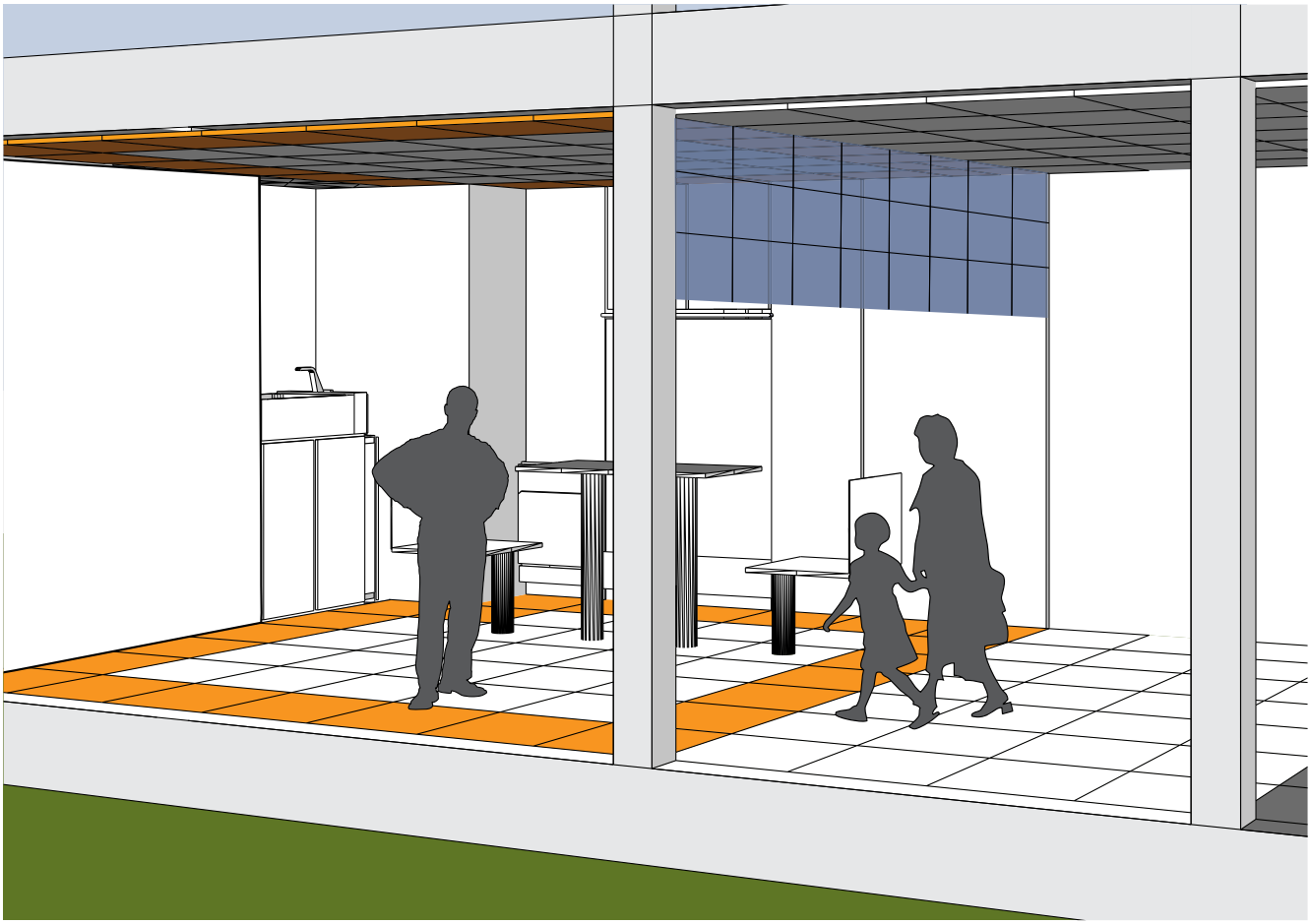
Robert is at home and receives a call from his father. His father reminisces about the days when him and his father (Robert's grandfather) used to go to the Cubs games every season throughout the majority of his childhood. Though Robert is not a baseball fan himself, he enjoys hearing his father recount the past. When Robert's grandfather passed away a few years ago, he left him his baseball card collection: one of his grandfather's most prized valuables.

Robert's father asks him if he's perused his grandfather's collection recently. He hasn't, but he ensures his father that they're safe and secure. They disconnect.

Now that it's fresh on Robert's mind, he decides to take a quick look at the collection, just to be sure it is in fact secure, and to take some time for himself to remember his grandfather.

He walks toward the area of the house that converts into the **Safe Pod** in emergency situations and locates the appropriate floor panel. His **Secured Storage** is hidden to all but him and is identical to every other floor panel. Robert lays both hands on the panel and presses lightly down. This action invokes a digital display on the panel. Robert enters a passcode on the display and vocalizes yet another passcode. Finally the panel elevates from the floor and opens up to reveal its contents.

As Robert expected, everything is exactly as he left it. His grandfather's baseball card collection sits neatly next to a handful of love letters from his wife from when they first met and a few other family heirlooms that are better suited for storage and preservation rather than display in his home.



SAFE POD

While the whole house can withstand a lot of serious damage to protect against extreme weather conditions in the future, the Safe Pod is a demarcated space within the home to ensure the whole family will survive through a major disaster. It will be outfitted with the highest caliber protective material to protect against unpredictable disasters such as fire, strong winds, heavy rains, and dust storms. The kitchen and bathroom spaces located in one of the modules will be converted into the Safe Pod space. It will function as a "house within a house", equipped with all the essential survival items - food, water, first-aid and communication devices, and select items of personal importance that can be transferred from Secured Storage. The strategy we are deploying here is to keep inhabitants in the home to wait for the storm to pass. In the most extreme cases, the Safe Pod can be detached from the mainframe of the house to be air lifted to safety.

Discussion

In the year 2050, there will be more unpredictable weather conditions requiring people to take better precautions to protect their homes and belongings from destruction. The **Safe Pod** is the space that protects inhabitants in the event of a major disaster. While the whole house has been designed to withstand a lot of serious damage to protect against extreme weather conditions (ie. the **All Weather Protection System**), the **Safe Pod** is a designated space in the home where the whole family can congregate and stay together during a storm or sudden disaster.

The kitchen and bathroom zones can be pre-built into one module of the house. This module containing the kitchen and bathroom will convert into the **Safe Pod** space because the essential survival items are already stored within this space - food, water, first-aid, communication devices, and **secured storage**. When the **Guardian System** detects a weather emergency, the floor and ceiling in the **Safe Pod** space will light up to alert inhabitants to enter the space. It will provide a visual and auditory cue to the inhabitants about the potential danger. Once the whole family enters the space, the modular floor-plates and ceiling surfaces will come together to enclose and protect the inhabitants.

Water supply, electricity, heating and air filtration will continue to function within the **Safe Pod** because the Core component, which contains all the maintenance systems, is also located within this module. If for some reason, any of the maintenance systems are cut off, the **Safe Pod** will have a minimum supply of 2 weeks worth of vacuum packed food, canned goods and water to ensure all members of the house will survive. Communication devices will also be available to contact local and global rescue networks. **Secured Storage** is also located within this module hidden in one of the floor-plates so inhabitants will not need to worry about getting their prized possessions into the space. It will already be there for the inhabitants. Other extra safety devices, such as life jackets and inflatable life rafts can also be stored here in case of flooding and the choice to evacuate the house is needed.

The **Safe Pod** will be outfitted with the highest caliber of protective materials to protect against fire, strong winds, heavy rains, and dust storms. In the future, all these materials will be stronger, lighter in weight and more protective than what we have today. Generally speaking, when disaster strikes people have a tendency to escape to a safer place and leave their home to destruction. The strategy deployed here is to keep inhabitants in the home and wait for the storm to pass.

In the most extreme cases, like what happened in 2005 with the Katrina hurricane in New Orleans, the **Safe Pod** will be able to detach from the mainframe of the house to be air lifted to safety. People will not have to lose their entire home even if the rest of the house gets destroyed. This feature of being able to air lift the module to safety will be available in certain locations where it may be needed and may not be necessarily in every house. English architect Richard Horden,

PROPERTIES

- A module containing essential services like the kitchen and bathroom.
- Stored survival items (food, water, first-aid, communication devices, and secured storage).
- Highest caliber materials to protect against fire, strong winds, heavy rains, and dust storms.
- Must contain a source to be able to grow food, filter water and generate small amounts of electricity

FEATURES

- Protects inhabitants from weather disasters, such as hurricanes, tsunamis, blizzards, tornadoes, forest fires, flash floods, and earthquakes.
- Protects against destruction due to warfare.
- Allows a household to survive without access to the global Smart Grid for up to 2 weeks.
- Contains vacuum-packed foods and water supply for at least 2 weeks minimum.
- Contains communication devices for inhabitants to connect to local and/or global rescue networks if needed.
- Contains a navigation system and survival guide.
- Certain Safe Pods may be outfitted with the ability to detach the module from the main frame of the house to allow a helicopter or rescue airplane to air lift the module to a safer location.
- Multiple Safe Pods can be assembled together to create a bigger pod to fit more people

designed a “ski haus” that could be air lifted by a helicopter to the tops of mountains for a person to stay in a cold setting for a period of time (Richardson, 2001). This concept is proof that portable structures can be designed with lightweight materials and protect against the elements, while ensuring people can survive within the structure for a period of time. The ability to air life the **Safe Pod** module to safety is an attempt to relieve the demand for more "relief housing" needed to house refugees due to catastrophic events.

Scenario

In the summer of 2050, hurricane Bob strikes the small town of Randolph, Massachusetts, located just 30 miles away from the previously famous beaches of Cape Cod. Most of the Cape Cod beaches now exists in the middle of the Atlantic Ocean 20 feet below sea level. Weather patterns have changed the land so drastically that it has caused many towns to be geographically closer to the ocean's edges.

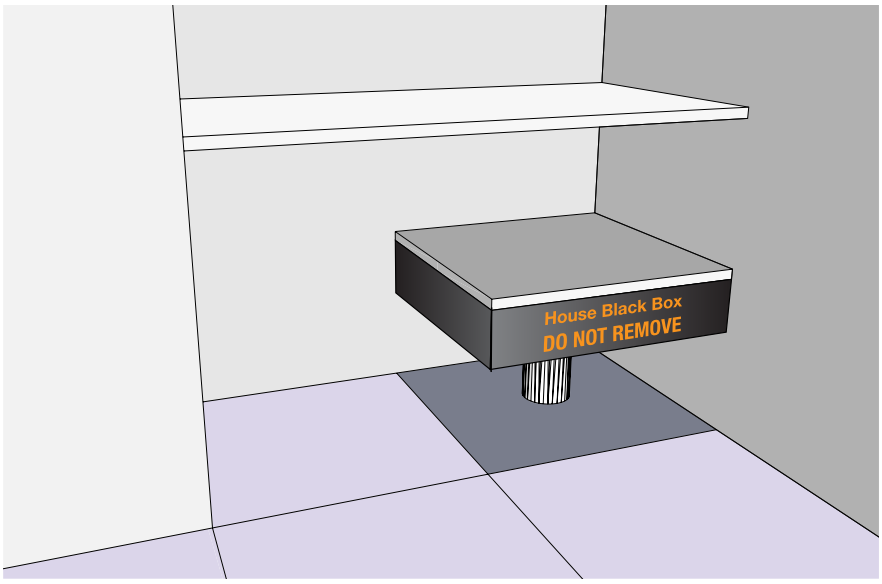
In the small town of Randolph, John Simpson lives with his wife and two kids in a small single family modular home. The house was built just a few years ago and it was outfitted with the latest disaster relief equipment, including a **Safe Pod**. Since John had decided to include the best safety precautions in his house, the homeowner's insurance company also gave him a better premium because his house will be able to withstand almost any disaster (as compared to the older houses).

Hurricane Bob was predicted to be one of the fiercest storms of the century to hit Massachusetts. John wasn't worried because his house has the **Guardian System** to warn him about weather events and he has done many drills with his family using the Practice Mode of the system. He had warned his wife and kids to stay home that day because the **Guardian** had predicted the bad weather. John and his family were all under the same roof, quietly going about their everyday rituals, when suddenly the **Guardian** sounded a warning and the floor and ceilings changed from sky blue to orange. The orange colors indicated a warning for the family to enter the **Safe Pod** as quickly as possible. John waited calmly on the first floor while his two children came down the stairs. The flashing orange lights in the kitchen alarmed his wife, Susy, but she quickly looked over at John and was assured that everything would be just fine. Emily and Sean had followed the **Guardian**'s voice and came down the stairs to join their father and mother inside the kitchen.

Everyone quickly made it into the **Safe Pod**, just in time for dinner to be put on the table. As soon as everyone was inside the **Safe Pod** zone, John swiped his hands for the protection layer to enclose everyone inside the **Safe Pod**. The whole family ate their meal and turned on the Interactive Surface to take a look outside at the storm. The winds were howling and the rain was strong, but inside the **Safe Pod**, you wouldn't be able to tell there was a storm outside until the family turned on the Interactive Surfaces to see what was going on in reality. John could still access his football on the wall screen and the kids could play their games on the floor surface. His wife lounged in the Omni-shower after dinner was done and

put away. That night, the **Guardian System** advised that it would be safer for the entire family to stay together in the **Safe Pod** until the storm passes tomorrow.

The next morning, John awoke with his family and immediately checked the Interactive Surface wall to see the damage done by hurricane Bob. He could see cars ruined and power lines criss-crossed in the streets with leaves and trash everywhere. Inside his home, the whole family watched and felt bad for the other houses, but they had slept comfortably and passed the time while the storm was happening. John swiped his hands up to open up the **Safe Pod** space to the rest of the house. He went outside to check for any damages on the outside of his house. He'll have to replace some of the photovoltaic panels that had blown away in the storm. He went back inside his house and gave a sigh of relief for the peace of mind that the **Safe Pod** had given him last night.



BLACK BOX

In the event of a catastrophe, the Black Box is a device that remains in the house to record data about the catastrophic event. The Guardian System is the main security system in the home that records and monitors security data. The Guardian will constantly send information to the Black Box to ensure that data is kept in case disaster strikes. The Black Box will be made out of indestructible materials to ensure that residents will be able to retrieve the data after the incident. If a disaster happens and the house is destroyed, people can return to the house to retrieve the data from the Black Box and reconstruct what happened during the incident.

PROPERTIES

- Data storage.
- Indestructible materials ensure the data within will remain intact for retrieval.
- Data connectivity to permit the Guardian to store data and for later data retrieval.
- Located within the home in a safe storage space.
- Contains GPS or other tracking mechanisms for easy location.
- Password protection solely granting access to residents and their proxies.

FEATURES

- Records security data about the home.
- Allows a resident to retrieve stored data.
- Information is stored up to 96 hours and will automatically over-write to ensure enough memory space is available.
- Allow people to reconstruct multiple points of view about the disaster incident by connecting multiple black boxes from different houses.

Discussion

In the event of a catastrophe, the **Black Box** is a device that remains in the house to record data about the catastrophic event. The **Guardian System** is the main security system in the home that records and monitors security data for the home. The **Guardian** will constantly send information to the **Black Box** to ensure that data is kept in case disaster strikes. If weather or warfare has caused the house to be destroyed, the **Black Box** is the data device that will provide evidence about what happened during the incident. The inhabitants will be able to survive within the **Safe Pod**, but the rest of the house may not be able to withstand the catastrophe. There will at least be a way for residents to find an answer to why the house fell apart, so they may be able to improve the protection system in the future.

The **Black Box** will be made out of indestructible materials to ensure that residents will be able to retrieve the data after the incident. The data storage will allow up to 96 hours of data to be kept at a minimum. The data will automatically overwrite data every 96 hours to ensure enough memory space is available. In the future, if data storage becomes cost efficient and the data limitation is insignificant, then the **Black Box** might be able to store longer hours than indicated here.

The **Black Box** is stored underneath the storage spaces in one of the modular floor surfaces in the home. If a disaster happens and the house is destroyed, people can return to the house to retrieve the data from the **Black Box** and reconstruct what happened during the incident. People would then be able to use the information to improve the protection system. This idea is similar to the **Black Box** contained in aircrafts to reconstruct scenarios when planes have failed. One example of this has been done by Exosphere, which is software that aggregates data from multiple sources to recreate a plane failure scenario using a 3D software tool (“Exosphere,” 2009).

Scenario

The following year, John's house was nearly destroyed when a bizarre earthquake shattered small town of Randolph, Massachusetts. His family survived in the **Safe Pod** for almost a week before the national rescue team came to save them. A month after the incident, he returned to see his home in shambles with only the frame of the house structure still standing and parts of the floor surfaces still intact. He quickly dug through the rubble with his **Black Box** navigator that located the whereabouts of the **Black Box**. When he finally found the box, he could not activate the automatic mechanism that lifted the box from the floor plates. He took an old screwdriver and hammer and rammed his way into the floor plate to retrieve the **Black Box**.

He pried the box away from the floor and stepped a few steps back into the yard to look over the house. He didn't understand why the cambers had failed during the earthquake. Perhaps, they were not built strong enough for this sudden

earthquake. He was only speculating at this point and nothing was assured until he could see the evidence.

As he walked through the neighborhood, he spoke to a few people who were able to retrieve their **Black Box**es. They all huddled together back at the rescue camp in front of old personal computers that they had not seen in twenty years. They were able to connect the boxes together and reconstruct the incident on the old computers to see what happened during the earthquake. It was eye-opening to get a glimpse of Mother Nature in her rage against man. From that day forward, the community began devising new plans to rebuild and protect their new homes better than the ones before.

SYSTEM ELEMENTS

SOCIAL DEVELOPMENT

Community

COMMUNITY KUPAH

Kupah literally means "cash box" in Hebrew. A cash register in Israel is referred to as the kupah. But kupah has a colloquial meaning, as a communal or shared "kitty" where people share their finances. It is common on kibbutzim which a re communal farms, and on Moshavim, which are privately owned shared farms. (the differences are that on a kibbutz, all of the property is communally owned while on a moshav property is privately owned with certain functions like marketing, packaging and shipping are shared.) The Community Kupah takes its inspiration to this form of sharing.

Discussion

In the **Community Kupah**, a number of adjacent households form a sharing cooperative. The **Kupah** is used to pool common tools and facilities (like a lawnmower or power-washer); Make group purchases of bulk items common to all households (like fertilizer, toilet paper, meat, vegetables and paper towels) and store items in long term storage, like seasonal items, sporting goods and occasional furniture (lawn chairs, folding chairs, etc.).

Participation in the Kupah

The **Kupah** is independent and administered by its members. Governance is democratic and depending on the size of the **Kupah**, governance might be representative, like a board of directors. There would generally be one administrator, and a committee responsible for stocking the **Kupah** (a purchasing committee) and a committee responsible for maintaining the **Kupah** (maintenance committee), including making sure tools are in good repair and safe and they have been properly returned from those who have borrowed them.

In urban areas it is not inconceivable that there would be companies that would manage and administer a **Community Kupah** for a group of households, for a nominal fee from each household. Governance of the **Kupah** including the decisions of the scale and facilities of the **Kupah** would be by the members themselves. There are many models that could be adopted in the governance of the **Kupah**, but one model might be a "round-robin" where each quarter a different household administers the **Kupah**. Monthly meetings would allow residents to have input, make new requests and participate in the decisions of the **Kupah**

The **Kupah** is a social institution but also has a physical presence in the form of a shared structure.

PROPERTIES

- Independent structure located adjacent to but separate from homes
- Shared access from multiple families
- Storage and workspace
- Garden on the roof with stairway access
- Wide doors to the workshop to allow for large items to be worked on
- Facility to share and store outdoor robots
- Smart storage spaces that can identify when items are removed and by whom
- Entry keypad/biometric scanner that logs users into the building/system
- Glass doors that are selectively transparent
- Accessible by robots
- Cold storage facilities, one per household
- RFID sensors embedded in fenestrations

FEATURES

- Membership is voluntary but membership entry and exit is on a periodic basis (to avoid a revolving door effect)
- Allows for safe storage of staples and dry goods
- Communal walk-in refrigerator freezer with individual member spaces for long-term food storage
- Restricted access by members only
- System tracks usage by household (not individual)
- System reports on usage and consumption for planning, assessment and budgeting purposes
- System communicates Kupah status and inventory to all members
- Inventory presets can trigger alerts when stocks run low to allow member to replenish supplies
- Administrators can send messages to all Kupah households
- System tracks location of shared tools and items
- System allows reservation, check in check out by members of shared items
- System allows users to set borrowing terms for shared items
- System sends borrowers reminders to return items
- System can schedule maintenance and purchasing trips

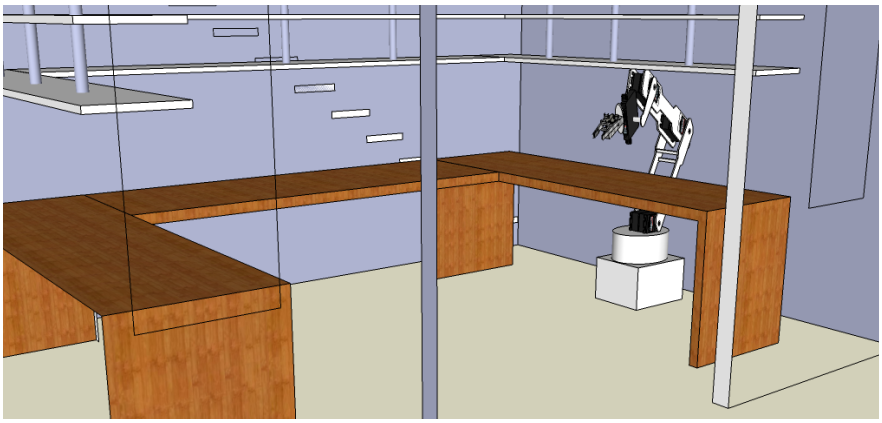
Physical structure

The **Kupah** has a physical component in that it is a repository of shared items, but structure would be governed by the needs of the **Kupah**. Some Kupot (plural of **Kupah**) might include shared refrigeration space so staples like meat and other foods can be frozen and stored long-term without requiring additional storage space in each house). Some might be just a shared shed for gardening equipment. The design of the **Kupah** will be determined by the needs of the group.

A stairway leads up to the roof, which can support gardening, or the installation of solar or wind generation equipment. The roof could also be reinforced to hold a stationary lap swimming pool or whirlpool spa. The **Kupah** structure consists of two sections: a shared workspace or **Workshop**, and a **Storage Facility**.

The Workshop

The Shop is equipped with bench space and storage in overhead bins and underneath the bench for tools. A corridor behind the bench can accommodate a robotic assistant who can provide a “third hand,” and put away tools as needed.



The **Workshop** is flexible and can be configured to meet nearly any need. For example the **Workshop** could alternatively be converted to a whirlpool spa or an exercise room.

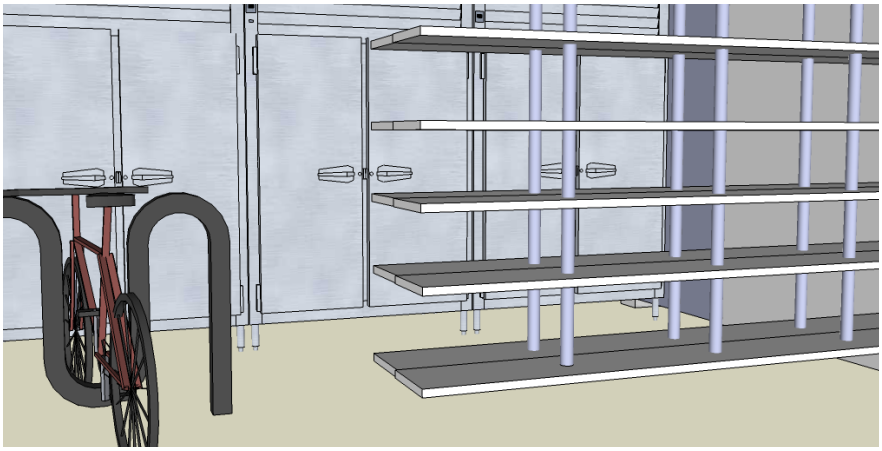
FEATURES (Continued)

- System has a financial accounting system to track spending of staples and group purchases

The Storage Facility

The **Storage Facility** has smart shelves that hold items and track inventory as items are removed and returned. There is room to store bicycles and other sporting equipment. Cold storage units with both a refrigerator and freezer are along the back wall, typically one per household. Garden tools can be hung on walls.

The shelves are aware of items placed on it. Awareness is through RFID tags embedded in the tools themselves and an awareness of the exact weight of the item. If the item is checked in and is appreciable under or overweight, the system generates an alert that the tool or item might require maintenance.



Borrowing tools and sharing resources

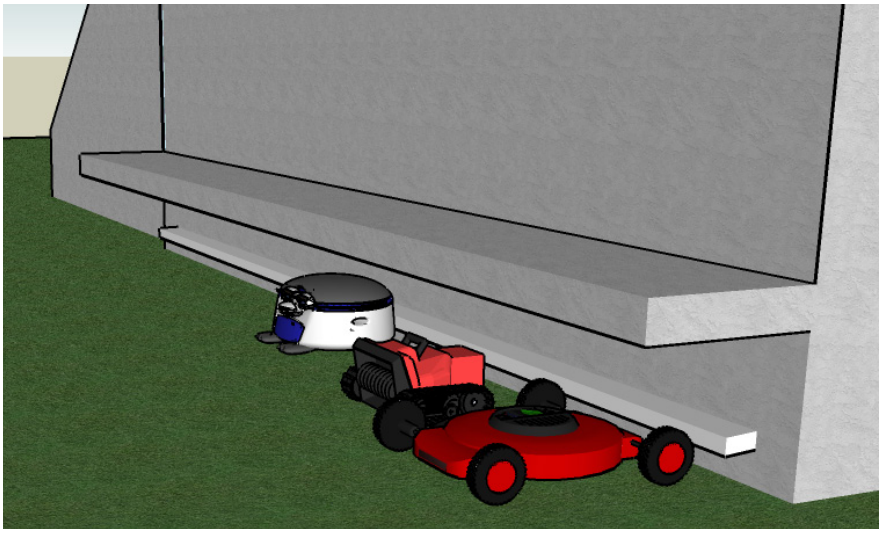
There are technologies that will be common to all kupot structures regardless of size or shape. A coded entry lock will allow members of the household to enter the **Kupah**. Upon successful entry of the code the visitor is “logged in” and identified as a member of a particular household.

Items that are shared are identified by RFID and consumption can be tracked and known by the group. Each time an item (like a hammer) is removed from the **Kupah**, the system notes time and household. The idea to provide enough information to track usage for budgeting and planning purposes, not to accrue charges or bill on a per usage basis. If one household is using a disproportionate share of **Kupah** resources, that household might be asked to contribute more to the upkeep of the **Kupah**. The family would simply get a usage report with a request for funds periodically. Details would be discussed in periodic meetings of the **Community Kupah**

RFID tags would be placed on tools and other shared items and a tracker would allow members to track where a particular item was located. A software based system would allow administrators to create reports, manage membership and receive requests and communications.

Occasional Robots

There are several tools that are used only occasionally and could be easily shared among several families. This makes them suitable for inclusion in the **Community Kupah**. For example, not every family requires a lawnmower. A robotic mower could be shared among five families relatively easily. To accommodate this, The **Kupah** is equipped with a **BotBay** on the rear of the **Kupah** structure. The **BotBay** consists of a flexible rail system that hold modular adapters that provide power and/or data to each robotic appliance. The adapters can be clipped/unclipped from the The **BotBay** also has an overhang which helps protect it from the elements.



Scenario

Julie is beginning preparations for her husband's birthday dinner. She will be hosting a small gathering of about 4 couples. She'll need to pull some meat from the freezer and begin defrosting it. Jim's favorite is beef tenderloin and while it is dreadfully expensive, the sting is lessened by the fact that the families in her **Kupah** purchased an entire cow together. They do it every spring and fall and it gives them real meat throughout most of the year. It winds up being half the cost of purchasing meat at the local market, and thanks to the **Kupah**, she not only has the opportunity to buy at this scale, but she has a place to store them.

Julie goes out to the **Kupah**, places her hand on the bioscan pad and the door to the **Kupah** suddenly turns transparent, indicating that the **Kupah** is now unlocked. She pulls on the glass door and enters the **Kupah** storage room. She walks toward

the cold storage unit, opens it up and unseals the vacuum chamber. The cold storage units have a vacuum chamber that keeps the meat protected from Freezer burn and makes the refrigerator more efficient.

With a hiss the door opens and Julie reaches in and after some sorting pulls out a yummy-looking tenderloin that is frozen. She carefully closes the vacuum chamber and hears the pump kick in pumping the air out. She then closes the fridge door and turns to leave when she notices the stackable chairs in the corner and realizes that she'll need to borrow the chairs for the dinner party.

She'll also need the mixer for Mike's cake. She notices the mixer on the shelf and also notices that the wisk is attached. She places the meat on the shelf and reaches for the mixer to remove the wisk and replace it with the mixing blade. "Damn," she curses, when she realizes the wisk is stuck.

Picking up the meat, she walks back to the house, places the tenderloin into the oven and begins a slow defrosting cycle. She then calls upstairs: "Jiiiiiiiiim!" Her teenage son Jim emerges from his room.

"Yeah Ma?"

I need to you to the **Kupah**, get the mixer and try to get that wisk unstuck. I need it to make Dad's cake.

"Huh? Can't Zizzy do it?" Jim replies referring to the domestic robot assistant.

"No, Jim I need you to go and fix it for me. The wisk attachment is stuck on."

Jim bounds downstairs and out the door. First he goes to the **Kupah** and opens up the storage room. He picks up the mixer, inspects it and leaves the storage room. The **Kupah** silently makes note of the fact that Jim has removed the mixer and mixer blade from the shelf and from the **Kupah**.

Jim walks next door to the **Workshop**, opening it up by placing his hand on the bioscan. He enters the shop and announces "hello Bizzy!" Bizzy is his name for the robotic assistant in the **Workshop**. Zizzy and Bizzy. He named the robots when he was 9.

"Hello Jim" the **Workshop** replies.

Jim places the mixer on the bench and realizes that the retaining screw has been over-tightenened.

"Bizzy, can you get me a Powerplier?"

"Certainly sir. Small or large?"

"Small should be fine," Jim replies.

The robot quickly retrieves the pliers and hands them across the bench to Jim. Jim quickly makes use of it and manages to loosen the retaining bolt. He slides the wisk off, installs the blade and as soon as he leaves the **Kupah**, the robotic assistant puts the pliers away, slinks back into its corner and places itself into power-saving mode.

As Jim is leaving he notices the Poopbot on its way back from cleaning up the Furlagers' lawn. The Bot turns sharply to the left, heads for the vegetable garden and docks itself over the composter and deposits the pet waste now treated with degrading enzymes into the composter. "Turning crap into gold" Jim thinks, mentally replaying his father's joke when they bought the Poopbot for the **Kupah**.

NEIGHBORHOOD MICRO GRID

PROPERTIES

- A system of distributed energy resource units (DER)—micro turbines, fuel cells, pv systems, and traditional internal combustion engines
- Peer-to-peer—a master controller or central storage unit must not be required for its operation
- Owned and operated by the local community
- Responsive to the needs of the community

The Neighborhood Micro Grid is a local power utility owned and operated by the community it serves. It supports responsible resource use by carefully managing demand and supply—at the local level.

There are two key benefits of the Neighborhood Micro Grid: it ensures the reliability and safety of electrical power for the local community, and because it is owned and operated by members of the community, it is highly responsive to local needs.

Discussion

At the beginning of the 21st century, much of the developed world still distributes electricity via power grids that are not much different than the system Thomas Edison devised at the turn of the 20th century. Huge, filthy coal-fired power plants—or nuclear generators—generate massive amounts of electricity which is transmitted over long distances via power lines to its far-flung communities and individual households.

What's so wrong with that?

For one thing, these utility grids are aging, and their resulting inefficiencies and instability add to the external stress brought on by increasing demand. Experts estimate that up to 10 percent of electricity generated, is lost as it travels over long distance transmission lines. Waste occurs also in the centralized generation of power itself. According to Tim Healy, cofounder of EnerNOC (explain who this is) 10 percent of all U.S. generating capacity is deployed just to meet the last 1 percent of demand, essentially generating excess energy that sits on the side-

lines, just waiting to be tapped during periods of extreme demand. But perhaps the most distressing feature of the centralized utililty grid is its vulnerability to massive blackouts — the August 14, 2003 blackout left over 50 million people in Canada and the Northeast and Midwest U.S. without power when more than 508 generating units at 265 power plants shut down during the outage. (wikipedia)

The global grid is also inflexible, which is to say, one-way. Not only are there no incentives or mechanisms for incorporating energy from sources other than large, industrial generators, it is also incapable of coping with the inconsistencies that plague renewable energy sources (water, wind and solar). The sun doesn't always shine, the wind doesn't always blow.

Finally, the existing grid simply cannot keep up with demand. It is true that existing worldwide network of electrical grids is immense—but it is still too small to accommodate demand for all the electricity we will need in the future. Experts expect worldwide electricity demand to rise from about 12.5 terra watts (trillion watts, or TW) today, to 16.9 TW of power by 2030.

Clearly, our aging, inflexible, and insufficient utility grid must be re-imagined for the future. In 2003, the U.S. Department of Energy outlined the following vision for a revitalized utility grid:

"Change of this magnitude requires unprecedented levels of cooperation among the electric power industry's many stakeholders. Hundreds of billions of dollars of investment will be needed over the coming decades to accomplish modernization of the electric system. National leadership is needed to create a shared vision of the future and to build effective public-private partnerships for getting there.

Imagine the possibilities: electricity and information flowing together in real time, near-zero economic losses from outages and power quality disturbances, a wider array of customized energy choices, suppliers competing in open markets to provide the world's best electric services, and all of this supported by a new energy infrastructure built on superconductivity, distributed intelligence and resources, clean power, and the hydrogen economy."

The answer is the **Neighborhood Micro Grid**, a utility platform designed to optimize the generation, conservation, and local distribution of electricity for individual and common good.

It works like a conventional utility grid in that its fundamental function is to get electricity to where it is need. But this is where the similarity ends.

Unlike a conventional utility grid, the **Neighborhood Micro Grid** is designed for two-way transmission of electricity. Households on the grid generate their own electricity via some combination of renewable technology—wind, water or solar, and converts that energy via a home-based inverter. Only after each household

FEATURES

- Distribute energy generation and delivery widely within the community
- Place a DER at any point within the micro grid without requiring re-engneering of controls
- Balance supply and demand
- Automatically isolate itself from the global smart grid at any time
- Store excess electricity in a backup battery
- Draw electricity from battery when needed
- Sell excess electricity to the industrial grid at peak prices
- Replenish backup batteries with energy from industrial grid at off-peak prices
- Mitigate the impact of a black-out in the industrial grid
- Manage household electricity use at the device level

meets their own immediate electricity needs, and stores a reasonable amount of energy as backup, does the excess flow into the grid.

Failure Modes

While there are four very real potential failure modes (regulatory schemes, investment incentives, power technology, or battery technology fail to advance), sustained advancements in battery technology may be the most challenging obstacle.

How do we get there from here?

Lithium-ion batteries hold the most promise for future development because they offer more power per kilogram than either nickel-metal hydride or lead-acid batteries—currently more than twice the power of a nickel-metal hydride battery, and six times the power of lead-acid. The most advanced lithium-ion battery commercially available today provides16kWh in a pack that is six feet long and 375 lbs. It is important to note that many of the negative features of lithium-ion batteries—including cost—can be attributed to the fact that it is a relatively new technology.

Researchers at MIT have recently developed a new surface structure for lithium-ion phosphate batteries that enables them to charge and discharge in seconds, rather than hours—effectively doubling the capacity of the battery. It could be commercially available within two or three years.

Lets imagine what how the self-sufficient house would store energy using technology available now. The most recent (2007) estimates of household energy use in the U.S. suggests the average house uses 234kWh of electricity per week.

Doing the math, if we use the most advanced lithium-ion battery available today, we would need 14.6 batteries to power a house for a week under a worst-case scenario where no solar or wind power could be generated. In three years, when the new MIT battery is available, we could cut that number in half—to 7.3 batteries. Given the intense research pressure that will be put on the energy storage industries, a reasonable projection of battery power improvement suggests that our self-sufficient house would need only 3.6 batteries to provide a week's worth of emergency power in 2050.

Scenario

On any given day, energy demand peaks during daylight hours. During these peak load times, the **Neighborhood Micro Grid** isolates itself from the larger grid, and each house or commercial building generates its own energy.

If demand exceeds supply, the system supplements with energy from battery storage.

If a surplus of energy generated, the **Neighborhood Micro Grid** reconnects with the larger grid and sells the excess power back—at peak prices.

During off-peak hours, the Neighborhood Micro-Grid can purchase energy from the larger grid—at lower prices. In addition, battery stores can be replenished during off-peak—at lower cost—for use during the day.

If a blackout occurs, the Neighborhood Micro-Grid isolates itself from the larger grid. Power is supplied by batteries until renewable power generation can resume.

Inside the house, power to non-critical devices — TVs, cook tops, washing machines and refrigerators — is automatically discontinued, ensuring the continued operation of critical functions like communications and transportation.

Once power is restored, power to devices resumes, and normal operating status resumes.

SPECIALIST VOLUNTEER NETWORK

The Specialist Volunteer Network helps coordinate and connect community members, matching their skills with the needs of other members. The system tracks the reputation and specialty of each member. In times of need, the system will recommend the appropriate member, rendering help to other individuals within the community.

PROPERTIES

- Customizable to user-preferred level of intrusiveness
- Customizable to user-prefered level of involvement
- Programmable to adapt to new response sequence
- Sensitive to degree of intervention required and alert appropriate response party

Discussion

The **Specialist Volunteer Network** helps the community be more self-sufficient by enabling members within the community to help each other.

The Reputation Monitor help build trust in the community. Members of the system can endorse each other based on pre-defined criteria. Members gets points for participating in community events and points for feedback.

Since inclusion in the **Specialist Volunteer Network** is voluntary, members can set their desired level of participation on the Involvement Manager

Base on the skill sets, interest, reputation and preferred level of involvement, the Assistance Matcher will suggest possible tasks that other members require help in. These tasks could be requested by either the members themselves or they could be necessary interventions coordinate by the house.

FEATURES

- Establish user preference
- Establish response protocol
- Determine level of urgency and required degree of intervention
- Select relevant and effective response sequence (house or neighbor, which neighbor)
- Evaluate effectiveness of response and reassess needs
- Track the speciality and reputation of members in the community

The **Activity Planner** also brings members with similar interest and skills together to plan for large-scaled or long termed community events and activities.

Scenario

Tom is a volunteer emergency liaison with his local fire station. Since his children have left for college, he has more free time for volunteer work and has indicated that through the Involvement Manager.

One afternoon, Tom receives a job alert via the Assistance Matcher. It informs him that Cindy, an elderly lady in her 70s who lives alone, has accidentally left her stove on. Though no harm is done, it would be advisable for him to drop by for a quick check to make sure everything is in order for Cindy.

Cindy is appreciative for Tom's concern and expresses her gratitude by endorsing Tom on the Reputation Manager. Tom offers Cindy an alternative to cooking her own meals as his wife, Stephanie, is an enthusiastic cook, and could easily help her out.

From Tom's suggestion, Stephanie began helping Cindy. She has also through the Assistance Matcher offered to help several other members, providing dinner to members who are sick or elderly, lessening their burden of preparing a meal.

Through the **Activity Planner**, Stephanie has, found several others that has also taken up similar volunteering tasks. They decided to consolidate their resources and start a community-based service to provide dinners to those in need. The **Activity Planner** gathers more support from the community and the Assistance Matcher, which tracks other members needs, is used to offer Stephanie's service.

NEIGHBORHOOD WATCH PLUS

Neighborhood watch plus is an area-wide monitoring system that sense and detect threats within the community, coupled with an intra-community alert network. This enables the members of the community to look out for each other and care for weaker members of the community in a personal, non-intrusive manner. It helps the community come together to deal with different situations - from everyday needs to emergencies.

Discussion

Neighborhood Watch Plus maintains vigilance over the community by 1) monitoring individual households and 2) having alert protocols that involves multiple household in the community.

Within the home, the **Guardian System** establishes the baseline, depending on the internal environment and the inhabitant's routines, and dynamically track the rate of change in the environment to sense and detect abnormalities. Local external data about the neighborhood is also fed into the system, updating the baseline periodically.

Working alongside Fast Track Change and Restore is Smart Appliances which can be controlled remotely. The smart feature detects if the outcome is intended and will override the user-control if it is not. (e.g. if food is about to be over-cooked.) Each member of the community also has Designated Neighbors, another members of the community that they know and trust, and can assign roles and tasks to, in times of need.

Connecting the inhabitant to the community network is the **Alert Commander** which will determine the most relevant party to alert - selecting between alerting the authorities, neighbor, or next of kin, or the neighboring intra community home system. Channel Hop complements the **Alert Commander** by selecting the best channel for communicating information - through a phone call, text massage, or email, etc. Depending of the level of urgency, the amount of detail transmitted and the alert interface used is also optimized for clarity.

All homes in the community is also linked by the Whole-home Anticipatory Response Network (WARN) system. This allows homes to warn each other about approaching threats to provide needed seconds of readiness.

Scenario

Recently, there has been an increased number of break-ins the in Cindy's neighborhood. The **Guardian System** detects the need to step up security. Cindy is in her 70s and living alone and the system determines that though the situation is not of immediate urgency, but it would be good for someone to come by to check on her, to remind her to secure her place in the night, and to check that she is not overly worried. This reassures her that there are others looking out for her.

The **Alert Commander** determines that the best party to alert is Diba, her 16 year old next door neighbor. Cindy had selected Diba as her Designated Neighbor in these situations as she and Diba are close and she has watched her grow up.

Channel Hop determines that since Diba is in school and it is not an emergency situation, it alerts Diba via a text message to suggest going by Cindy's place when she can. Diba drops by after school to chat with elderly lady to remind her to increase security.

As Cindy is elderly and stays alone, she requires her home to have extra precautionary measures to ensure her own safety, as well as the safety of her community.

PROPERTIES

- **For monitoring:**
- Customizable to user-prefered level of privacy
- Programmable to recognize new threats
- Allow user to control appliance within the house remotely but over-ride controls if safety is threatened
- Monitor in a non intrusive manner
- Determine level of threat and react accordingly
- **For alerting:**
- Communicate via most effective channel
- Alert most relevant party - person or home system (authorities, neighbor, next of kin, etc) depending on situation
- Communication channels independent of infrastructure

FEATURES

For monitoring:

- Establish baseline and dynamically track the rate of change in the environment to sense and detect abnormalities
- Evaluate and chart plan of action to restore baseline when change is detected
- Enable remote control of appliances within safety limits

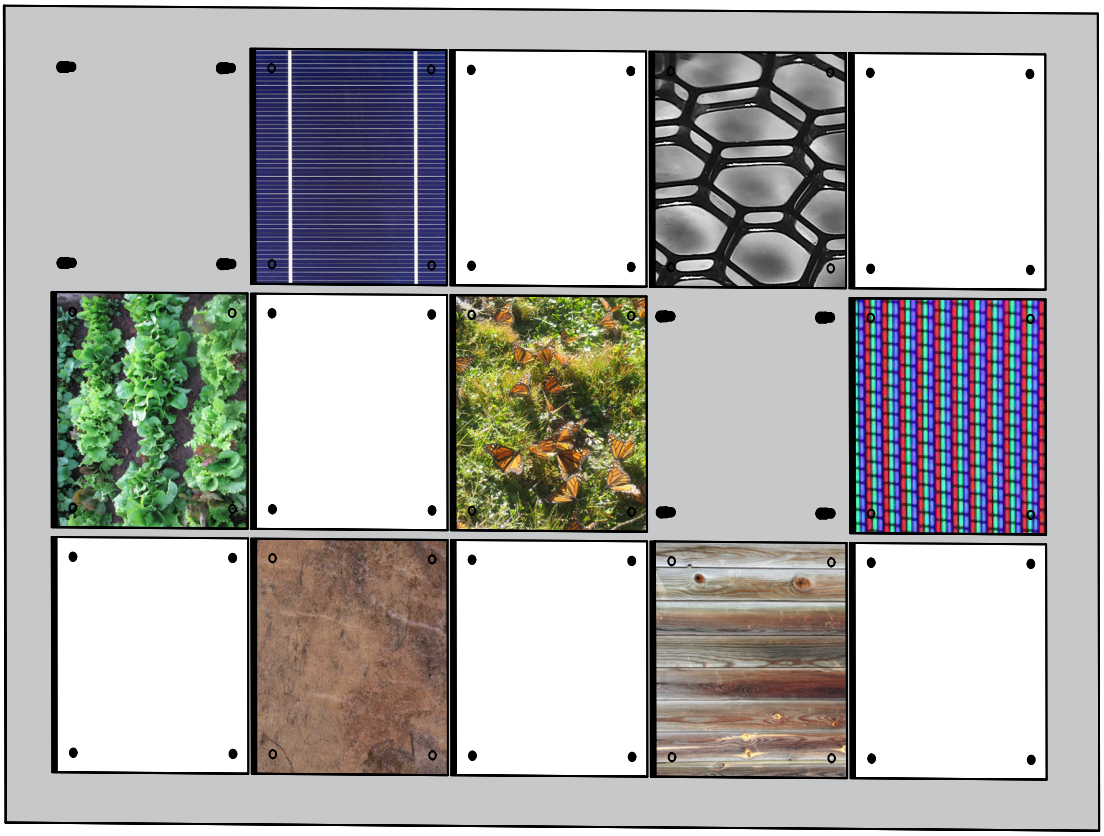
For alerting:

- Execute plan of action by selecting the most effective channel of communication - phone, text, email, etc
  - amount of detail and mode selected will depend of level of urgency (FYI, Respond now, Life-threatening)
- Select most relevant party to alert - person or home system (authorities, neighbor, next of kin, etc)
- Rely on decentralized P2P networks
- Evaluate effectiveness of alert and reassess situation
- Reports situation to relevant members of community

For instance, when Cindy forgets to turn the stove off. The **Guardian System** detects that and the Smart Appliance automatically switches the stove off, and alerts Cindy of that.

The **Alert Commander** determines that the situation is under control but might be dangerous and informs local authorities. Channel Hop calls the local fire station who sends Tom, a volunteer firefighter with the **Specialist Volunteer Network**.

The Whole-home Anticipatory Response Network (WARN) also alert other homes in the immediate vicinity to scan for any environmental abnormalities in the home.



ADAPTABLE HOUSING SKINS

Adaptable Housing Skins systems consist of a grid of standoffs that are securely attached on the exterior solid walls of the house. Using the standoffs, residents can snap-on thin, modular, square panels so that the exterior walls are covered by the panels. Panels can be made of a variety of materials or perform specific functions that residents need.

Discussion

Adaptable Housing Skins are a response to standardization in housing design and aim to nurture the sense of belonging that is derived from shared architectural themes and from the experience of being immersed in a particular geographic place. Culture and personal creativity are expressed through the look and feel of living spaces that people choose to construct for themselves.

Mechanically the system is straightforward but the flexibility inherent in the system is derived from the fact that the standard panels can be made of any suitable material. Otherwise the only constraints are that panels should be lightweight for easy

PROPERTIES

- Matrix of simple metal stand-offs affixed on exterior walls.
- Durable square panels with latching mechanisms that mate with standoffs.
- Lightweight and compact for ease of use and storage.
- Strong and secure to withstand extreme weather.
- Standardized size.
- Pre-manufactured or hand-made by homeowners.

FEATURES

- Panels must be able to be constructed from a variety of materials.
- Incorporates natural and technological materials.
- Enable display of cultural artifacts and other visual type communications.
- Be a medium for creative expression.
- Help a standardized home fit in with established local architectural traditions.

installation and replacement, they should be sized appropriately to fit well in the houses storage spaces, and they should lend themselves to reuse and sharing between households. The material used in making the panels or the functions that they can perform ultimately will dictate their propensity for being shared.

The choices of panel material and function are potentially endless. The most immediately relevant possibilities in the community building context are to use panels to display cultural artifacts or unique local materials. When housing structures are pre-manufactured, as the Future Living design necessarily will be, architectural variety will need to be sacrificed in the name of low cost and process efficiency. By incorporating earthen or organic natural materials into panel form, almost any architectural tradition can be adapted to the new house by covering the structural core with a panel array.

The other probable use for adaptable skins are to introduce technological components onto the house in a way that has rarely happened on residential structures. Digital displays could be placed on the house to create dynamic or interactive surfaces similar to the way that interactive surfaces were used inside the house. With a more visceral example of convenience one could imagine the use of such displays as a communication medium to neighbors and passersby. The job of decorating the house for the holidays could be relieved of the need to stand on a ladder and hang strings of incandescent light bulbs from the eaves. Instead, a display of colorful light could be programmed from inside the home. The same opportunity exists for communications of other types whether showing a political campaign poster or a written message that scrolls across the front of the house announcing a marriage or the arrival of a newborn.

The generation of electricity and other forms of energy is also covered in this system. Photovoltaic panels could very simply be integrated into the standard skin panel form factor and placed on the exterior of the home as needed if household demand temporarily exceeds the established supply. Modular and standard panels could help homeowners adapt to gradual changes in energy technology. Considering that labor is a large part of the cost of outfitting a home with energy generating hardware, the panels could facilitate rapid replacement of parts and upgrades to the latest and most efficient technologies. Available technologies in 2050 may not resemble PV at all, however. Solar assisted fuels, such as that now produced by Sundrop Energy, or solar concentrating methods could prevail. This demands and also introduces the possibility that the adaptable skin panels need not even be flat.

A third possible function for the panel system is to allow the house to assume proactive roles in the natural environment. Inside the home we prefer our interior environment to be closely controlled in terms of temperature, sanitation, and the presence of wildlife. But on the outside of the home there are ecosystems that exist in spite of the presence of our houses. Imagine installing panels that provide a way for the house to become a contributing part of ecosystems. This

could happen through supporting biodiversity, sheltering, nourishing, or assisting reproduction of sensitive wildlife. Exterior walls could become vertical gardens, growing food or native plants at times when growing conditions permit.

A final possibility is that the home could take an active role in filtering the environment of toxins or pollution. Using nanotechnology or advanced filters the massive amounts of air or water that come into contact with the house could be stripped of contaminants by micropores or on the surface of panels. Alternatively, panels holding live colonies of bioengineered algae could actively metabolize particles of pollution out of the air. In general this is a compelling function for coatings on future structures of all kinds because ultimately the world will still be a polluted place even after we've stopped polluting it.

LOCAL DATA FILTER

A supporting feature of the house aimed at defending the notion of local identity and community is the Local Data Filter. This is a data filter that is local and more importantly it's a filter for local data. This system element consists of software which operates within the computing systems of the house. It works behind the scenes to intervene in the delivery of digital media to which you are involuntarily exposed. With the Local Data Filter you'll be more likely to read headlines about local news, see advertisements from local businesses, or be influenced by the opinions of people who live close by.

PROPERTIES

- Embedded software feature for the home.
- Invisible to residents/users.
- Context and geographically aware.

FEATURES

- Qualify and modulate residents involuntary exposure to electronic data and media.
- Prioritize data of local origin.
- Fortify and reinforce unique community identities.
- Redirect intellectual contributions made in a digital environment back to the geographically local community.

Discussion

In a house where computing and digital environments will be pervasive this system element aims to consider what effect the increasingly digital lifestyles will have on our socialization behaviors. The results of neurological studies in the last decade have suggested that the new patterns of media consumption enabled by the internet may actually be changing human brain chemistry. We are what we eat and our capacity for thought could ultimately be influenced by ideas and content to which we are exposed. This hypothesis, coupled with observations of people today suggest that our communities and human relationships could suffer in some form in the future. In digital environments today, such as the internet and television, we are exposed to an enormous amount data that unnecessarily distracts and leads us to social disengagement. Considering that community will likely be more important in the future than it is now, this is a cause for concern.

The **Local Data Filter** supposes that digital media consumption can be complementary to actual human relationships when the two share more in common. When the virtual and physical contexts of our daily experience begin to look and feel more alike.

Scenario

Imagine that in the home of the future the residents still like to read news, watch television, and surf the internet. When they search for a video on YouTube the results that will be returned could number in the thousands and as the amount of digital content available online increases with time, so will the amount of data that will be considered "relevant" by algorithmic search engines. The **Local Data Filter** helps the resident by adding an additional layer of qualification to online activities. The most relevant search results from YouTube will be geographically relevant as well as topically relevant. In fact the goal of this system is to reevaluate what it means for data to be relevant to people.

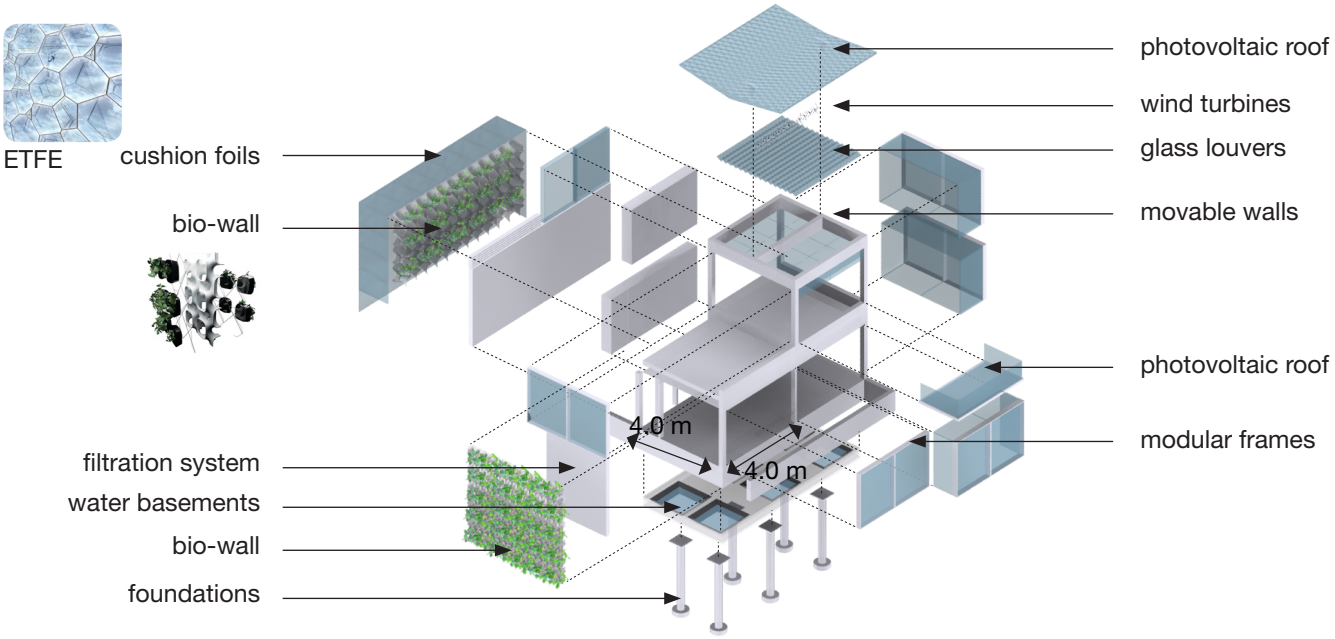
The resident might not like to be cut off from the depth of the world wide web, or its future equivalent, and so the **Local Data Filter** would not restrict access to anything. Unique content will still be there if the user goes looking for it or knows how to find it. Similarly, users still might value anonymity in virtual environments which could still be preserved if such a concept as anonymity exists in 40 years time.

The system would need to be told what data qualifies as "local". As a measure of proximity media could be tagged with geographic coordinates and not necessarily with the names of people. The **Local Data Filter** would then operate by defining an aperture from which it would prioritize "local" data. The aperture would be centered around the real time location of the user at home or on a mobile device. The radius of the filter aperture could similarly be customized but smaller is probably better. Looking historically at the sizes of functional and productive cities or civilizations, an area that includes about 20 to 50 thousand people is the range.

ARCHITECTURAL DEMONSTRATION

Institute of Design, Illinois Institute of Technology

Future Living: Blending Human Aspirations with Environmental Realities

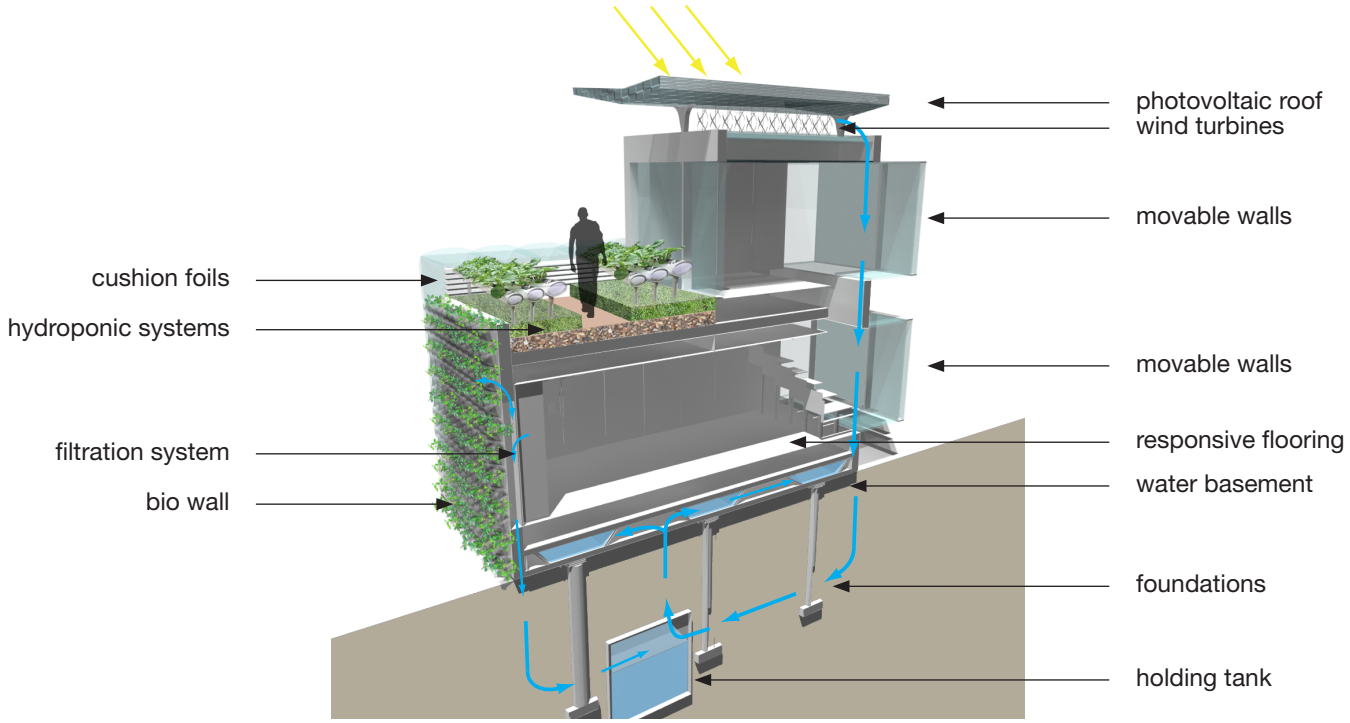


Exploded view of the house

The house has been designed from a basic module of 4X4 meters, further broken down into segments of 1X1 meter. This house has 3 such modules giving you a total area of 48 sq m. (approximately 500 sq ft.).

It is a modular design with construction on a standard post beam structure. It is a kit of parts that is manufactured and fabricated in the factory under controlled environments and shipped to the site for assembly.

Part of the house will be built and customized at the location in conjunction with the residents using the local material available. For example, the double glass wall panels can be replaced with either brick, bamboo or other locally available materials.



Sectional perspective: 1

This cross section shows the co-relation and interaction between the various components of the house.

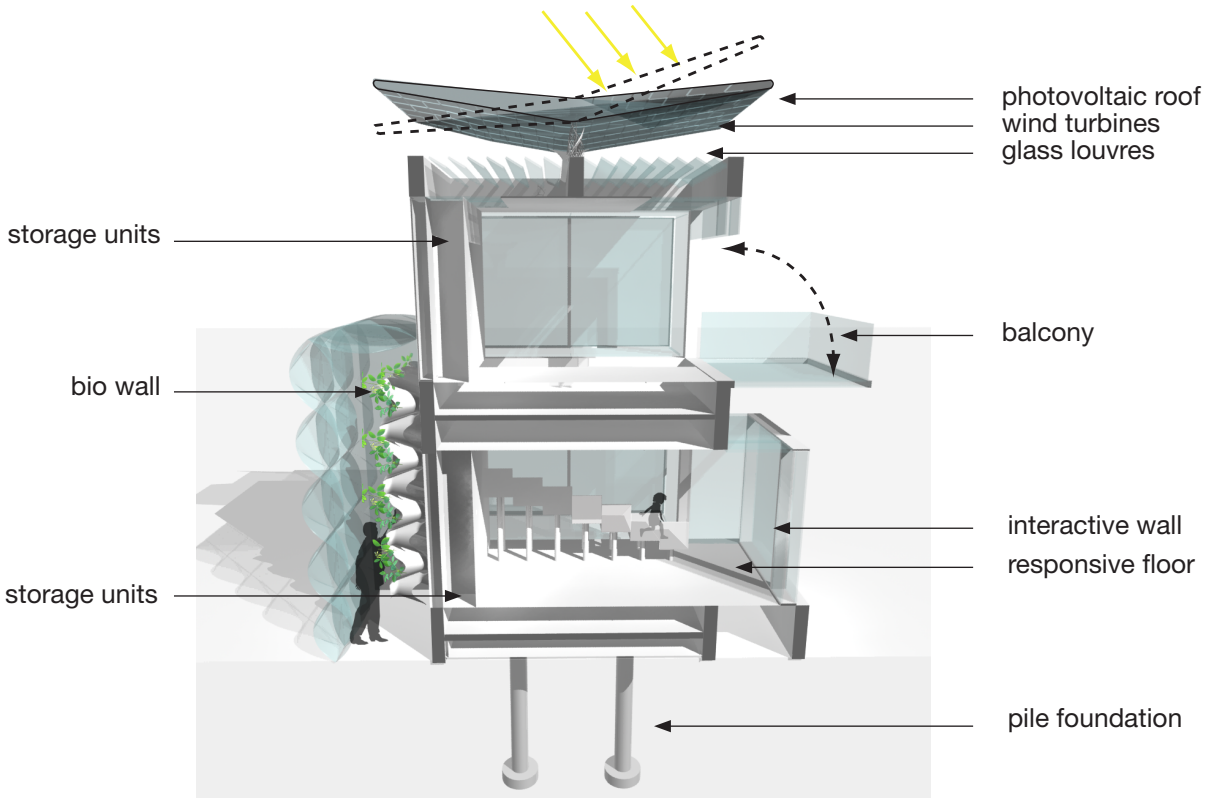
Holding Tank: The holding tank located at an appropriate depth below ground has enough capacity to provide residents with water during the dry season, with varying sizes depending on the location. Being at a considerable depth below ground helps to naturally cool the water. In places where it rains, the water is collected from the roof, walls and the ground, and stored in the tank. It is then pumped to the water basements for immediate use.

Water Basements: These water basements sit within the structural system of the house. They are supported on cambers to reduce the friction and dampen the lateral movement during an earthquake.

Foundation: The type of foundation will depend primarily on the soil conditions in different locations. In a location where it is feasible and economical, the pile foundations will have hydraulic pistons in them to lift the entire house off the ground in case of floods.

Filtration system: This system is sandwiched between the bio-wall and the toilet components. It filters the water from the toilet, and the excess water from the bio-wall, into the holding tank.

Walls: The walls are mainly constructed using a modular framework. This frame permits the residents to use locally available materials to be incorporated within the frame. These walls move in and out of the main structural system allowing for more floor space as desired by the resident.



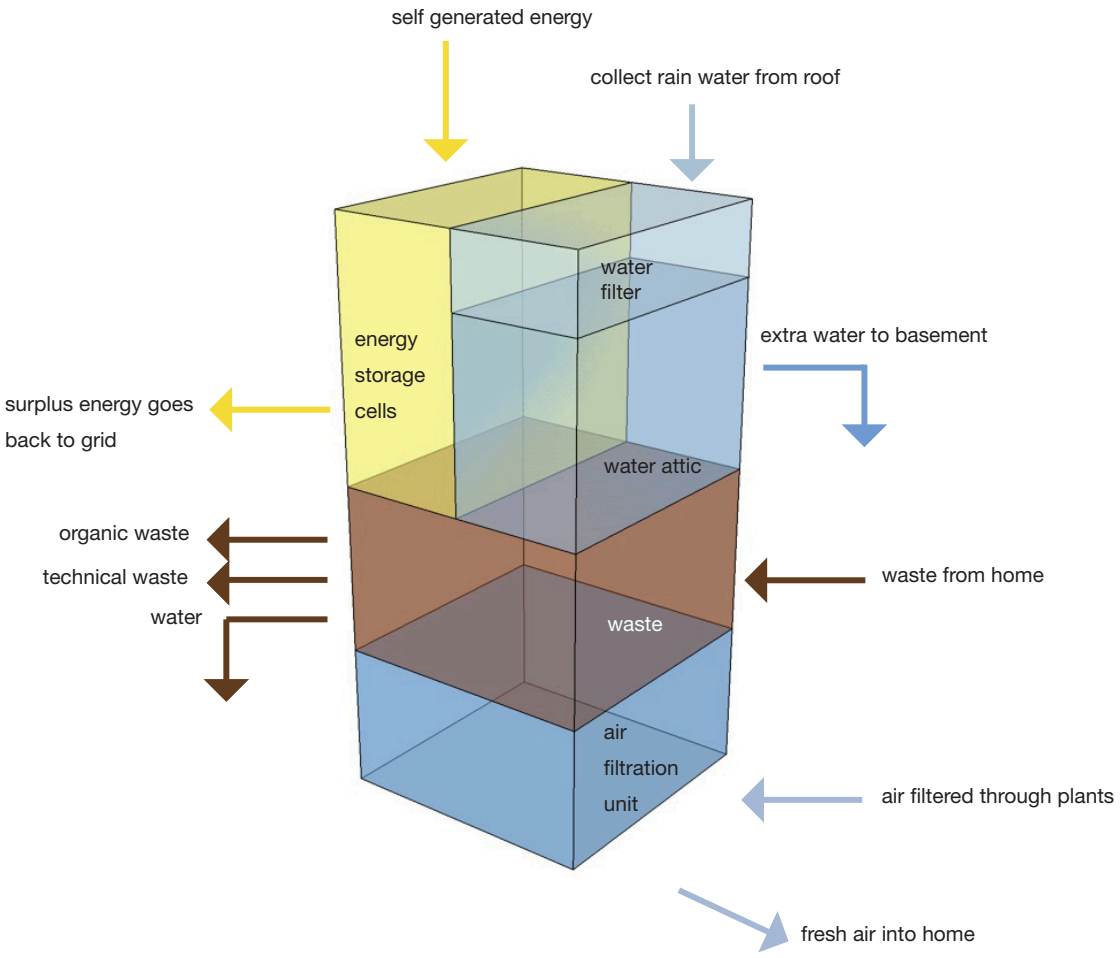
Sectional perspective: 2

North-south cross section of the house.

North Facade: The north side is glazed and has fenestrations to allow for ample north light inside the house. The balcony at the upper level automatically opens and closes as desired by the residents. The walls at the lower level are movable and transform into the main entrance to the house.

South Facade: The south side contains a bio-wall along the entire length. This is the wall used to produce necessary food and it is covered with ETFE foil (more commonly known as vector foil or cushion foils) along the entire bio-wall. This space acts like a green house, allowing residents to produce food all year long during summer and winter. This wall also acts as insulation and prevents the house from heating up too much from the south facing sun.

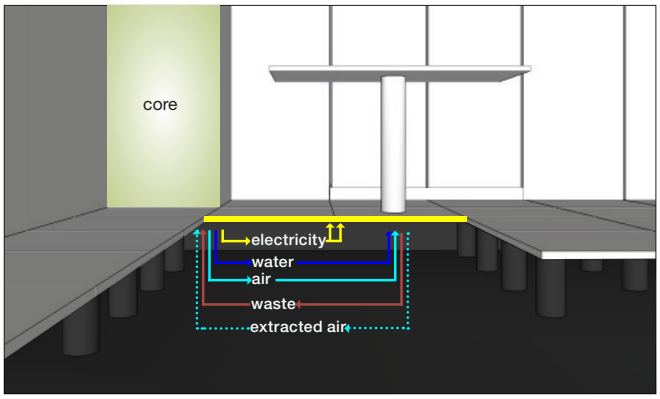
Roof: The roof has integrated photovoltaic cells. It automatically adjusts the angle based on the sun's path to maximize the solar gain. The opening between the ceiling and the roof edge automatically adjusts to create a negative pressure on the leeward side to draw air currents across the wind turbines on the roof.

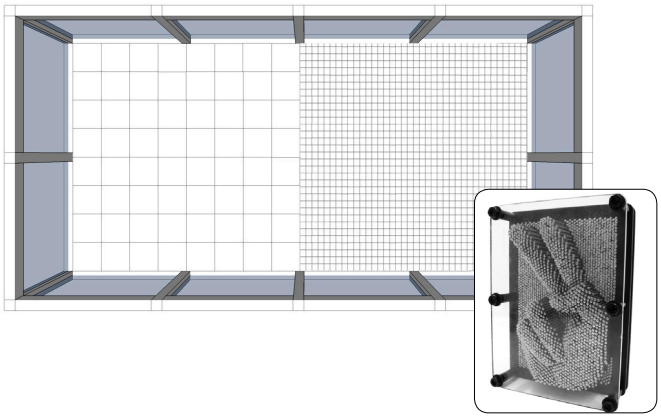


Core

The home's basic energy, water, air supply and the waste system is packaged in a core unit that becomes the life-giving and regulating spine of the home.

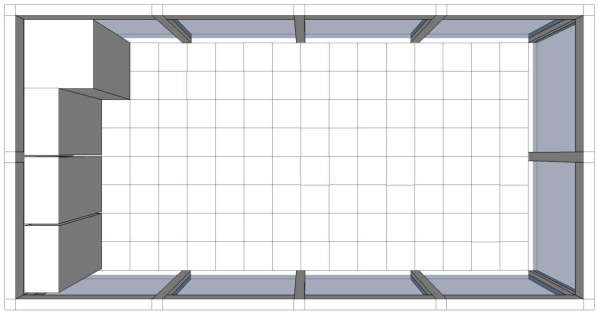
From the core, these services are distributed underneath the floor. Instead of terminating at one point in the home (ie. the kitchen sink), there are multiple termination points in each of the modular floor-plates. This enables the user to do any type of task anywhere in the home. The top surface is self-healing, self-cleaning and contains the electricity and access to water/waste/air. Furthermore, the height is adjustable from a low coffee table to a bar counter and changed as desired by the residents.





Responsive floors

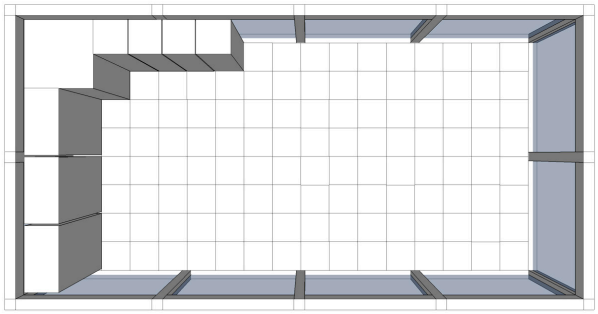
In response to furniture needs, a pixel-like floor was created, taking its cue from pin art. It is especially useful should the inhabitant want to quickly change the furniture configuration within the space. The floor is gestured up with a hand motion to create sitting and resting surfaces that contour to the shape of the body, much the way pin art contours to the shape of a hand. Using nanomaterial, the surface material has the ability to change from hard (when the “pins” are at floor level) to soft, when they are in use as furniture.



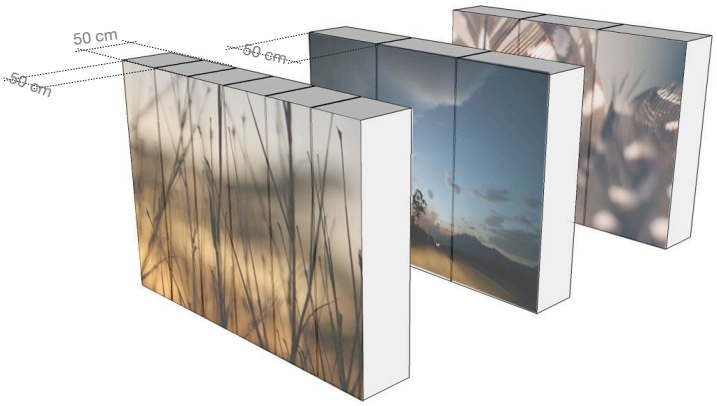
1. core + bath components

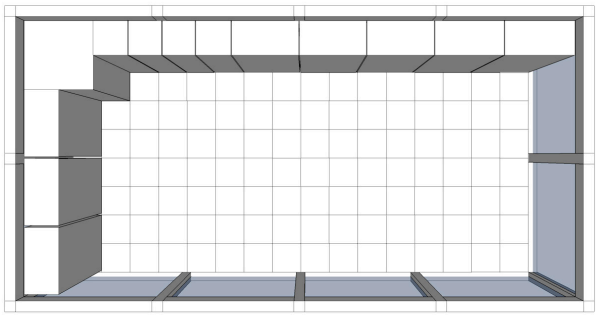
Interior components

The house can be re-configurable and packaged in modularized components that all fit perfectly into the home’s grid pattern. This enables the homeowner to select the specific system elements and give the homeowner flexibility to choose the components that works best.



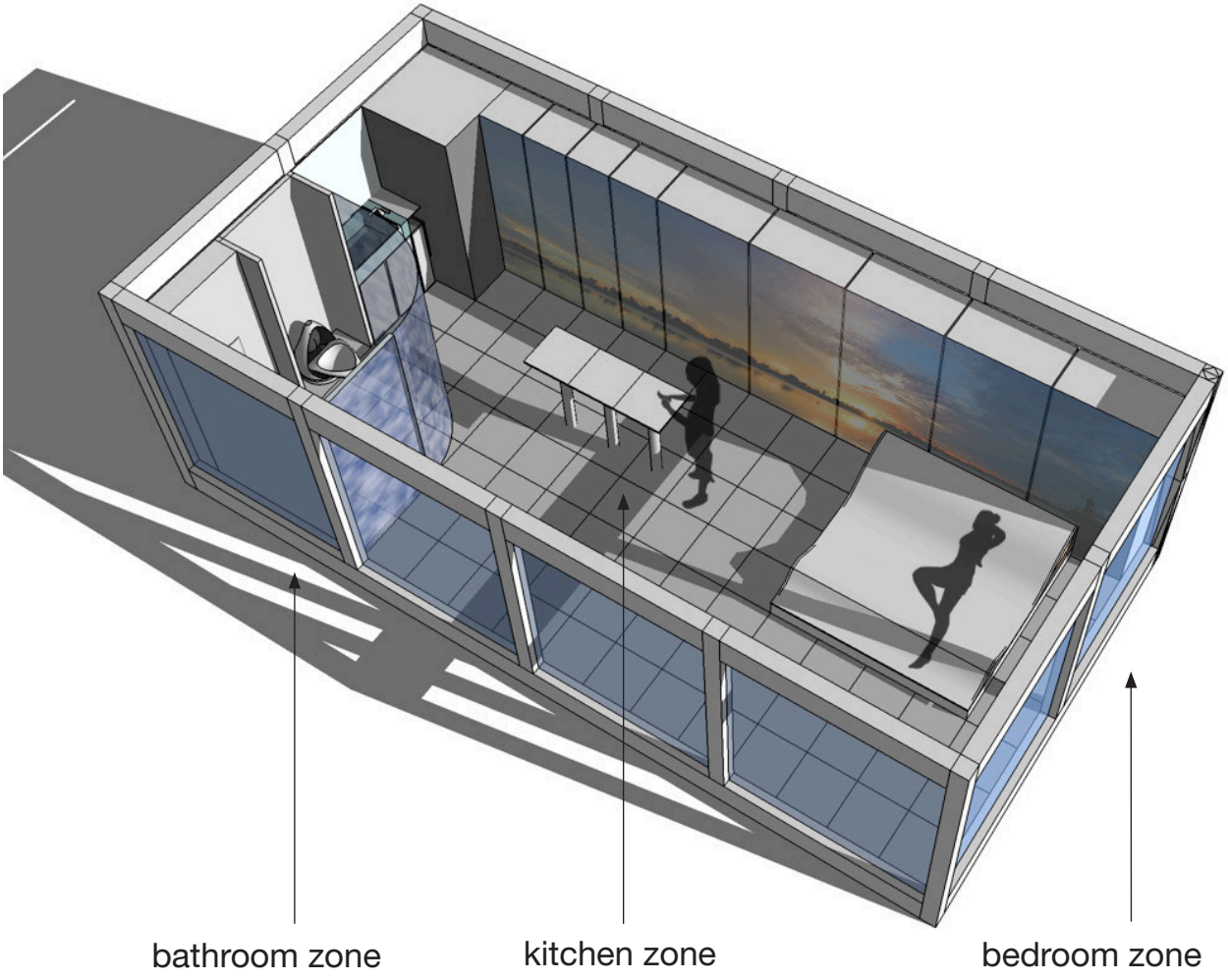
2. core + bath + kitchen components





3. core + bath + kitchen + storage components

The elements will be wrapped in a smart-panels system element that can change it’s surface appearance as needed.

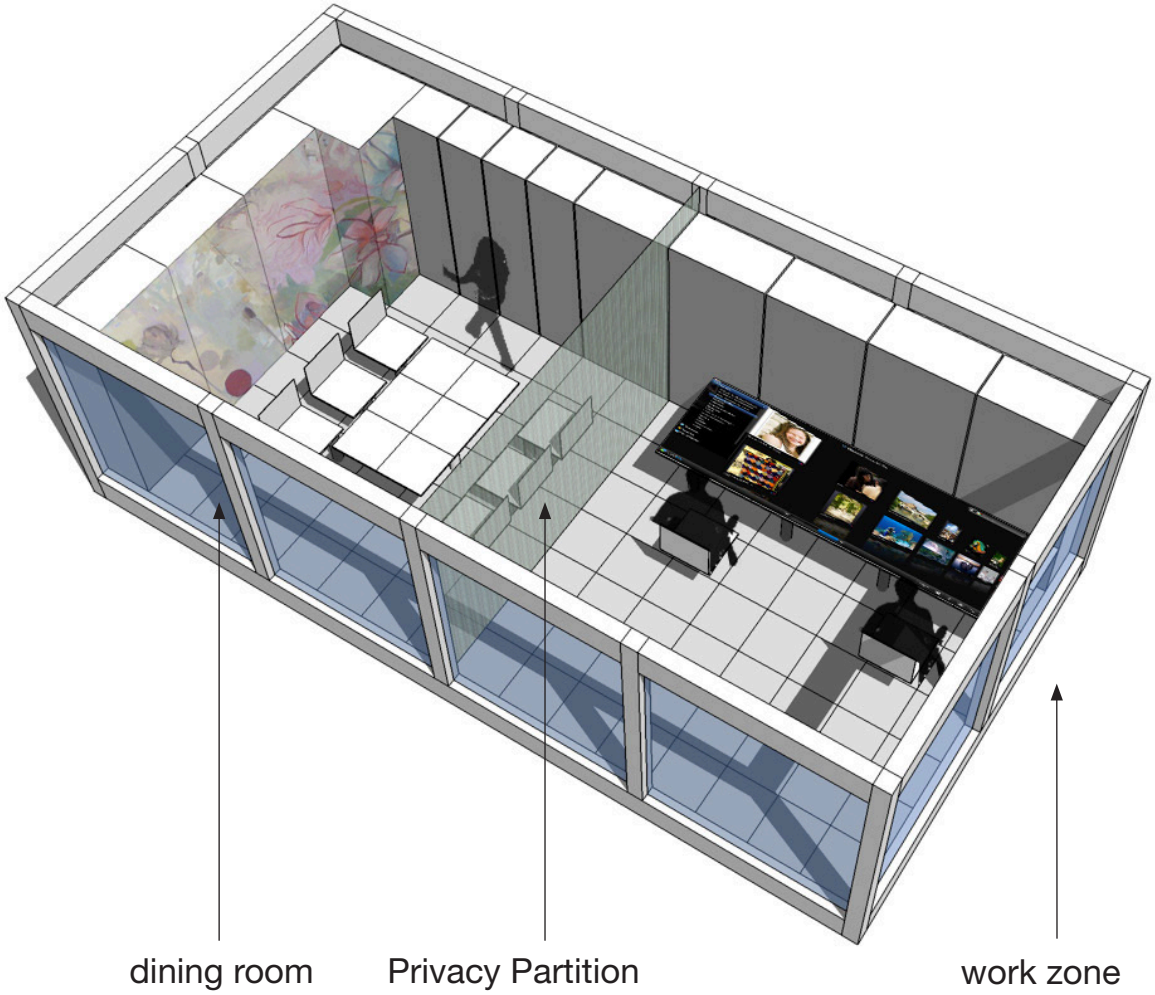


Interior zones: 1

The following set of images shows how the home can be used in various parts of the day in a household with two people.

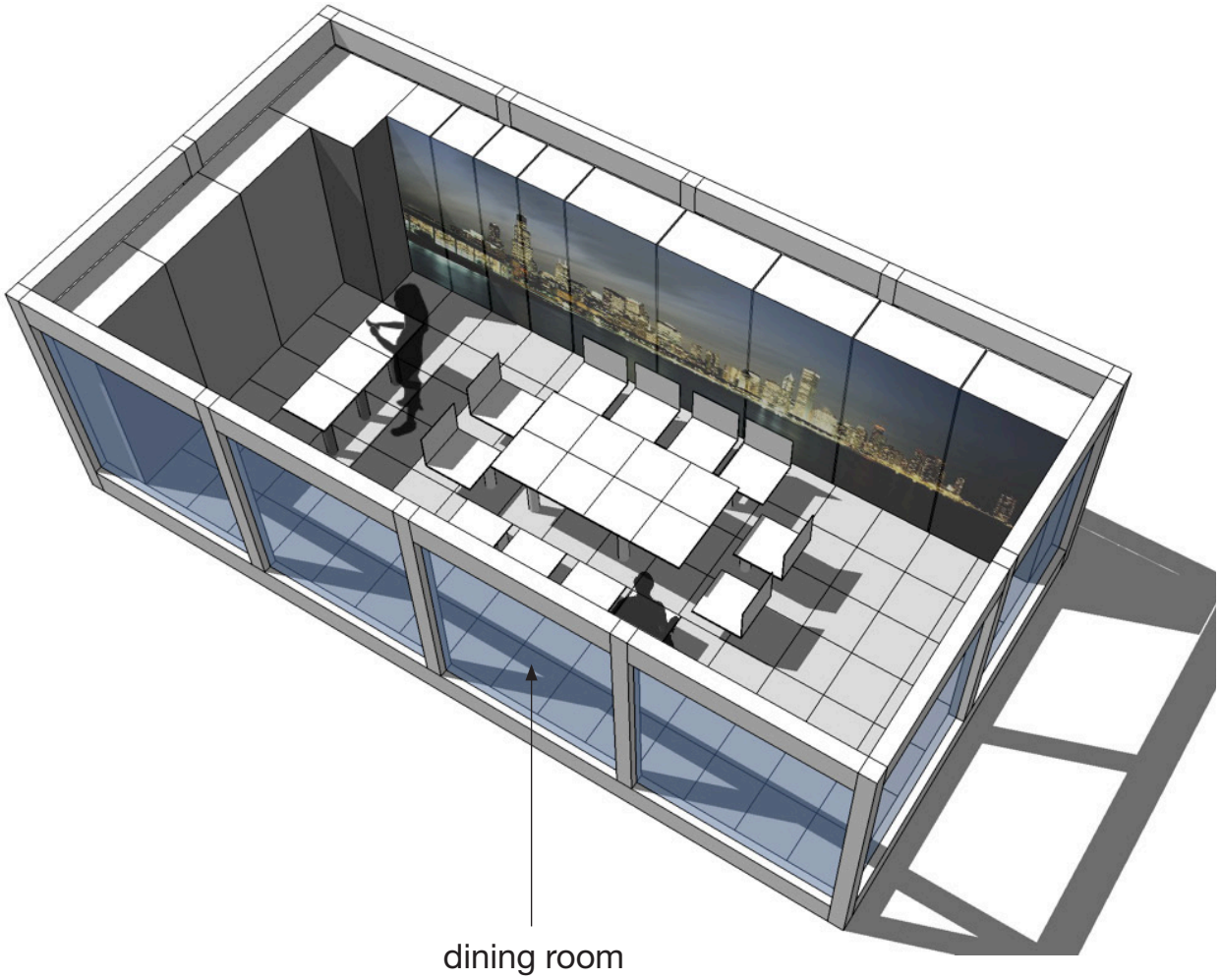
This illustration shows the bathroom zone, kitchen zone and the bedroom zone.

It is early morning, the bathroom privacy screen has been turned on creating a private bathroom. Coffee is brewing on the kitchen counter while the other inhabitant is still in bed.



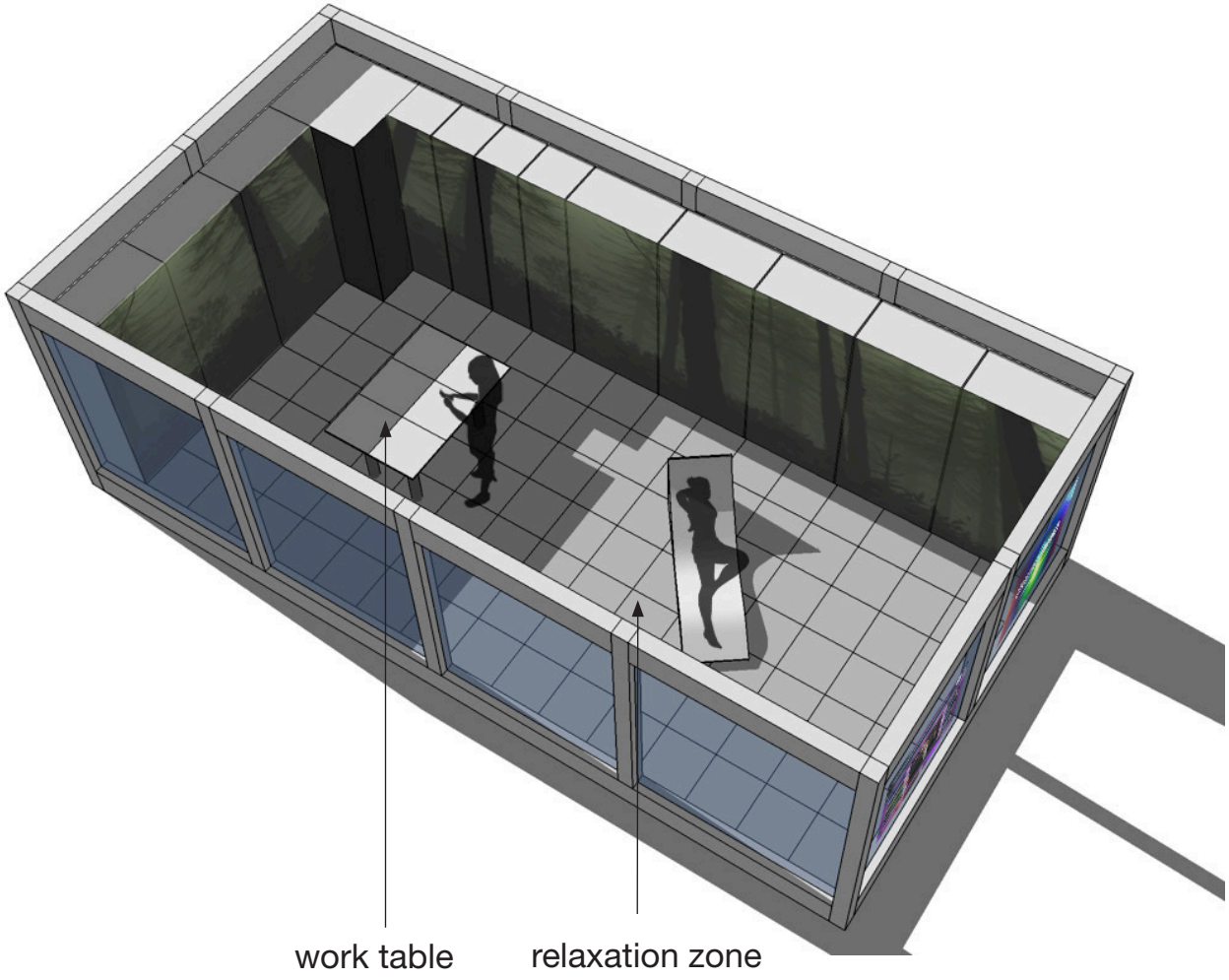
Interior zones: 2

This illustration shows the work zone and dining room, partitioned by a privacy partition with a sound-proof curtain. One person is having a lunch time conference meeting and the other is working on a project in the work zone.



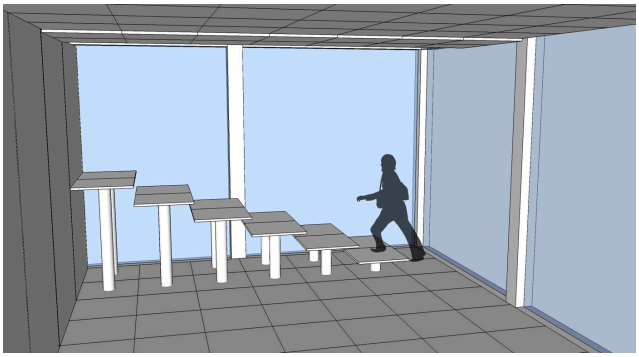
Interior zones: 3

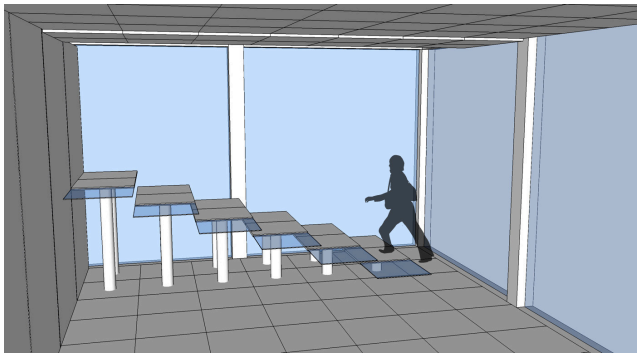
The space transforms itself into a dining room to accommodate a dinner party for 12 guests and a small bar. The scenery on the wall behind can be changed to create an ambient mood and achieve a cohesive look and feel for the interior environment.

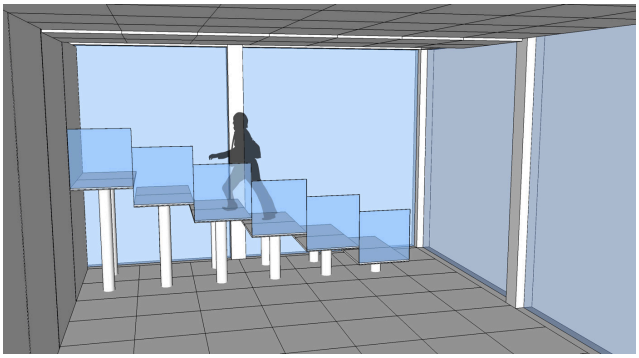


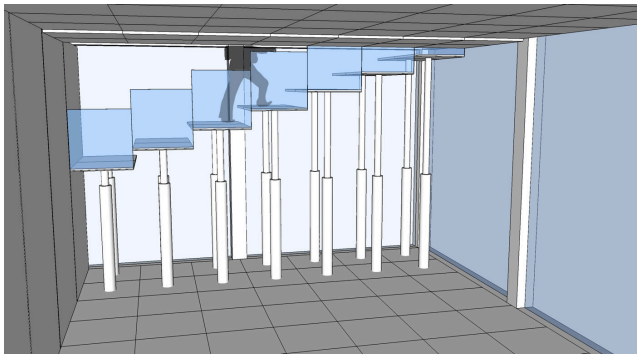
Interior zones: 4

The space is modified into a relaxation space for one person who is watching a DVD on the wall. The other half of the space is turned into a workshop space for the other person doing a craft project.



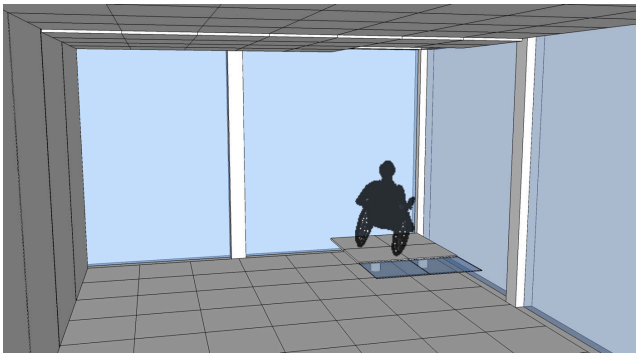


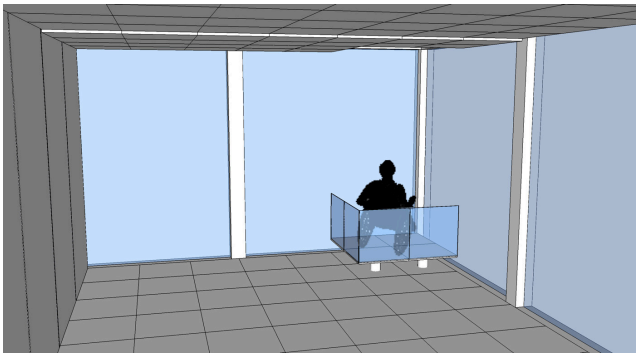


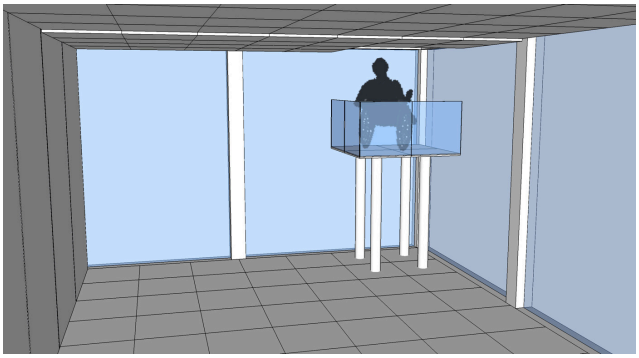


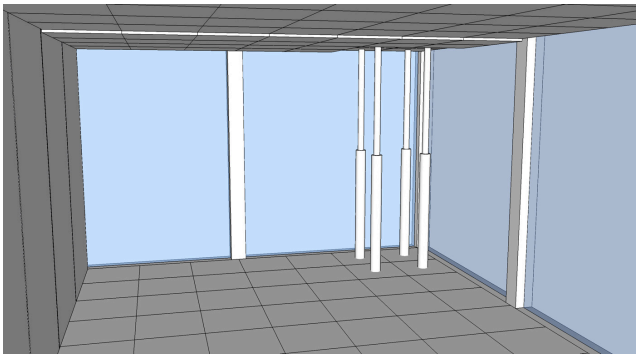
Vertical transportation: Stairs

The treads for the staircase are raised up from the floor by the hydraulic pistons. The glass panels slide out from underneath the treads to form the railing. The ceiling slab slides inward to allow for enough headroom.









Vertical transportation: Stairs

The four corner floor panels can be raised to the upper level, forming a lift and providing easy vertical transportation to the handicapped and the elderly.

FUTURE HOMES

Four locations were chosen to consider for our future homes. These locations were chosen, partly based on cultural knowledge within the architectural team. One example of the application of this knowledge was the number of people that typically live in a home. More significantly, we chose these locations because their different climates pushed the team to consider the possibilities of self-sufficiency.

To figure out how to design the house we took a global average of food, water, and energy needs. To feed one person for a year, 50 sq m of growth space is required. One person required an average of 50 liters of water per day, and 39.5 kWh each year. Between the photovoltaic, wind turbines, bio- wall and water basement, the house should be close to self sufficient, although it is still attached to the grid in extreme circumstances.

One person...

Needs:
50 sqm of space to grow enough food to live on for 1 year

Uses:
50 litres of water / day

Uses:
.2156 kwh / day

CHICAGO, USA

Occupancy : 2

Number of Modules : 3

48 sq m living space / 516 sq ft

Growth space required : 100 sq m / yr

Food Production:
3 walls / 48 sqm / Harvest 2 x per year

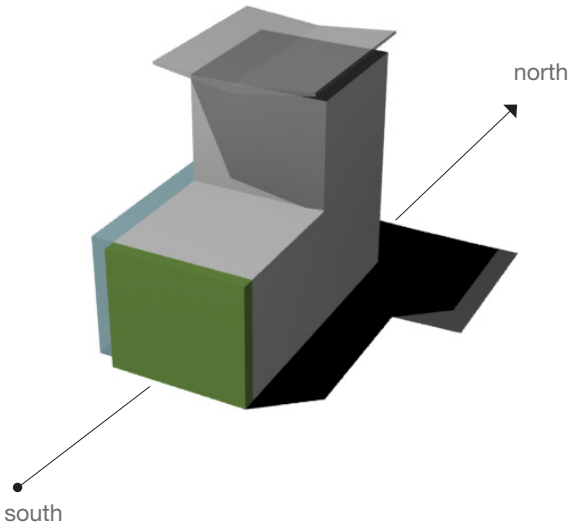
Water required : 100 L / day

Water Basement Capacity : 35,000 L

10 x

Energy used : 158 kwh/year

Sources of energy



50 sq m / yr

50 L / day

0.03 Kwh /day

The first place chosen was Chicago. The climate in Chicago consists of hot summers and cold, snowy winters. The Chicago home utilizes three modules, with 48 sq m or 516 sq feet. For a couple living in Chicago, the house will need 100 sq meters for food production per year. If they use three outer walls for vertical food production, the Chicago couple will only need to harvest once each year. The inhabitants of the home would make the best use of their growing spaces by incorporating a diet heavy in fresh fruit and vegetables.

If they use 100 liters of water each day, the water basement will hold enough water to use for 350 days, given that it rains enough. Due to the windy climate in Chicago, the house will produce more energy through wind turbines than photovoltaics.

SHANGHAI, CHINA

Occupancy : 4

Number of Modules : 4

64 sqm living space / 689 sq ft

Growth space required : 200 sq m / yr

Food Production:
3 walls / 48 sqm / Harvest 4 x per year

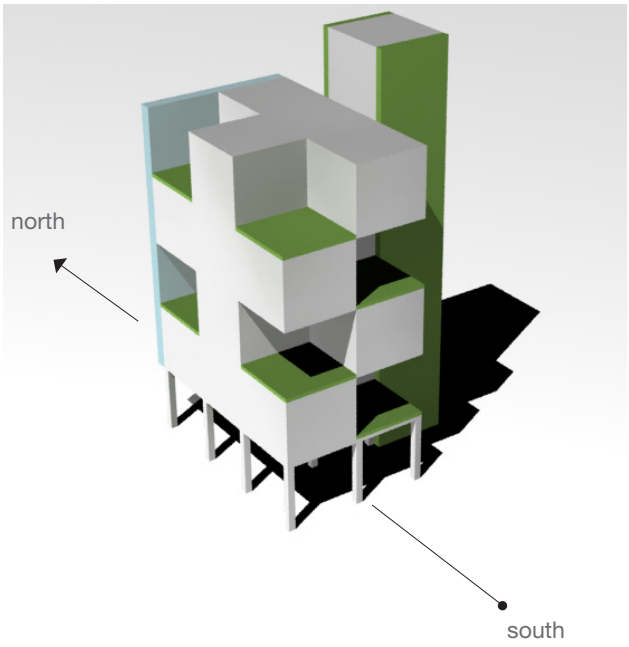
Water required : 200 L / day

Water Basement Capacity : 35,000 L

35 x

Energy used : 158 kwh/year

Sources of energy



50 sq m / yr

50 L / day

0.03 Kwh /day

The second location is Shanghai, China. The climate in Shanghai is humid and subtropical, with four distinct seasons. Another relevant quality of Shanghai to be considered is it's dense population. For this reason, the modules were stacked vertically. This is an example of what could be an apartment complex. This home was designed for a family of four, with the family using 64 sq meters of living space, or 689 sq ft.

If they use three walls for food production, they will have to harvest about 4 times per year. This also means that intensive small plant agriculture will have to see a few more rounds of development in the area of acceleration before this is possible. In many cases, food will need to be produced and shared within the community. Because there is a strong possibility for floods and hurricanes, pile foundations are integrated into this home.

YADZ, IRAN

Occupancy : 6

Number of Modules : 4

80 sqm living space / 861 sq ft

Growth space required : 250 sq m / yr

Food Production:
5 walls / 80 sqm / Harvest 3 x per year

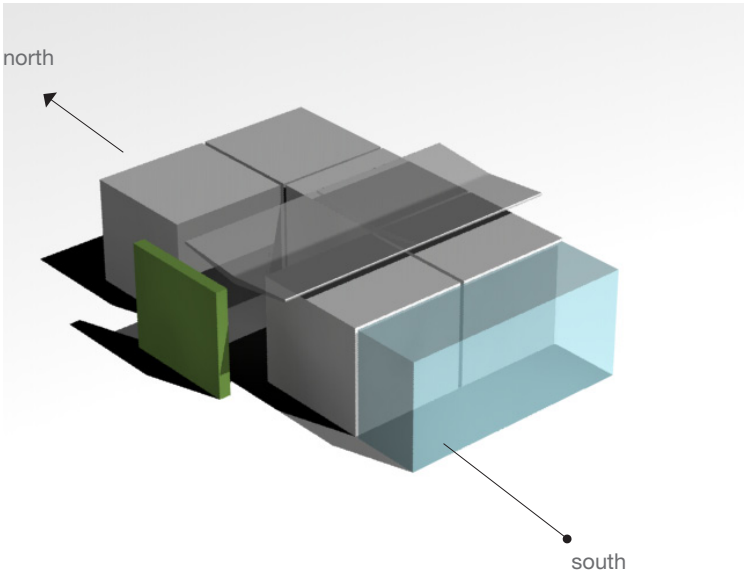
Water required : 300 L / day

Water Basement Capacity : 25,000 L

25 x

Energy used : 196 kwh/year

Sources of energy



50 sq m

50 L / day

0.03 Kwh /day

The third location is in Yadz, Iran where the climate is hot and dry. The house, built for a family of six, covers 80 sq meters (861 sq ft) of living space. They require 250 sq m / year to grow enough food for the family. This means that if they cover 5 exterior walls of food production space, the family will need to harvest 3 times per year.

Iran has a very dry climate, therefore the house will still need to depend on the grid for water. The grid in Iran is called “Ghanats” which runs through the entire country.

JOHANNESBURG, SOUTH AFRICA

Occupancy : 10

Number of Modules : 6

128 sqm living space / 1378 sq ft

Growth space required : 500 sq m / yr

Food Production:
8 walls / 128 sqm / Harvest 4 x per year

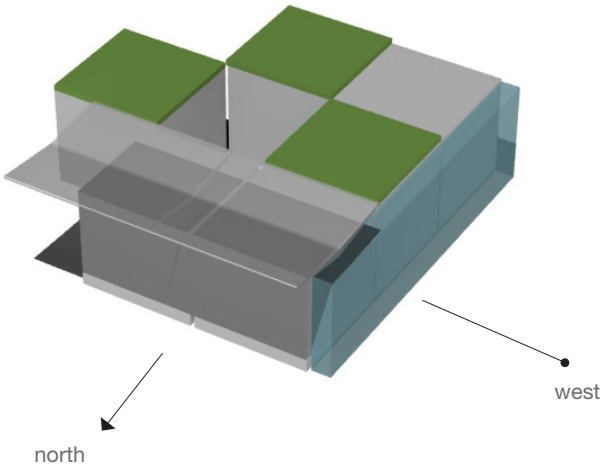
Water required : 500 L / day

Water Basement Capacity : 25,000 L

30 x

Energy used : 393 kwh/year

Sources of energy



50 sq m / yr 50 L / day 0.03 Kwh /day

The fourth location is Johannesburg, South Africa, where a family of ten lives in a six-module house. They will require 128 sq meters (1378 sq ft) of living space and 128 sq meters of bio-wall space. This means that if they use 8 walls for food production, the family will need to harvest 4 times each year. Most of the energy produced will come from photovoltaics.

SUMMARY/ CONCLUSIONS

The Design Challenge

In the developed world, housing—like so many other aspects of modern living—has become an object of consumption. As middle classes have raised their standards of living, excess earnings have been used to buy larger, more luxurious homes and to outfit them with space-filling objects of consumption. Wasteful living now consumes a sizeable portion of our resources, a condition that has been tolerable if not desirable, but cannot continue. The forces of population growth, climate change and resource depletion will make it necessary for all—those living in developed and developing nations alike—to reduce human impact on the Earth's resources. The alternative is not conceivable.

In this project, housing was examined as a means for contributing to a reduced impact. If the average number of people per household stabilizes at five (with some families caring for three generations), there will be 1.8 billion households worldwide by 2050. Reducing household demand for water, food and energy obviously will have impact on those primary resources. Changing a culture of consumption to one of conservation will have similar impact on the wide range of other resources used to produce the artifacts of daily living. A ready example is information, a serious competitor for storage space in the home where it is the paper associated with purchases, correspondence, books, periodicals, records and the like. Today's information technology already has the ability to preserve all of this as digital data, complete with high resolution graphics and color. In the near future, that capability will become routine service. For a household with even a moderate amount of these paper forms of information, the space saving will be remarkable, and information technology has much more to offer for reducing consumption and managing operations.

Information technology is only one of the emerging new technologies that will affect the home in a positive way. Robotics promises to provide complex forms of assistance formerly only available from human providers. Biotechnology, through genetic engineering, will specialize crops to be grown in the home, extending growth cycles from seasonal to perennial and multiplying yields for space-saving, high-density production. Finally, nanotechnology offers the widest range of technological benefits: materials that can change their properties, self-healing and self-cleaning surfaces, see-through solids, shape changing forms, selectively permeable filters

and much more made possible by design and construction at the molecular level.

Speculating on their use in the home allows us to see beyond the limitations of today's technology. The result is a liberating change in the way we can visualize living at mid-century. Critics will object to the speculative use of technologies only beginning to imagine their own potential, but this project intentionally is set in a time frame far enough advanced to expect capabilities as yet uninvented. To get the best from the design, engineering and architecture communities, we need to set distant targets. A system described with technical features as yet only imagined presents a goal that can stimulate the development to achieve it.

A Housing System

The house here described for Future Living is not a house, per se, but a housing system, a system of components that can create many houses. Dwellings created with the system and previewed here are far more than shelters. They are support systems outfitted to help their inhabitants to grow as individuals, physically, mentally and emotionally, and to mature as members of society in the community and larger associations.

Dwellings created with the system are smaller than conventional houses of today. The generic home described for a two-person household has only 48 square meters of enclosed space. It is made from modules four meters square that are assembled in a pattern of choice. Using a bolt-together (or similar connect/disconnect) construction process, a post and beam structure is assembled of members made of ultra-strong nano-materials able to resist the forces of expected mid-century storms. Houses can be small at initial purchase, but can then be enlarged with additional modules—and later reduced in size as desired by the removal of modules. It will no longer be necessary for families to shed their homes as hermit crabs do when they outgrow their shells.

Because dwellings are small does not mean they provide less. Future living should seek improved quality of life, and the availability of advanced technologies coupled with a philosophy of interchangeable space allows any dwelling to become what its inhabitants need without resort to single-function spaces unused except for the single function. With the traditional Japanese house as a historical model, the system house extracts maximum use of its space through the incorporation of surfaces including walls, ceilings and floors that can be reconfigured.

Beyond its physical borders, a dwelling can borrow space by using its nanotechnology endowed walls to project the view outside—or a view from a distance, for example, a real-time scene from the national parks. To the viewer inside, the wall is as glass; to an external viewer, the wall is opaque and unchanged. Views are not limited to existing settings. Exploration with holographic reality will be possible in virtual worlds at levels of abstraction created as desired.

By mid-century, people will be living longer and more will require the kinds of care now usually available only in specialized assisted living institutions. No one likes to be forced to leave their home, and no one should have to if means for assisted living can be brought into the home. Robotics will provide assistance, not only for the elderly, but for children and anyone needing it. Sometimes, the assistance is the help that makes a complicated task more easily accomplished. Often, it is just the small difference that a helping hand can provide. Together with vertical lift stairways that eliminate the need for climbing stairs, the robotic help will make multi-generational living the pleasure it can be—for eldercare, childcare and the care of anyone who needs it!

A primary goal of the system is self-sufficiency. The goal in this case remains partially a goal because there are many forms of uncertainty that constrain the production of energy and food and the conservation of water. The goal will be well served if self-sufficiency can be attained for some of the three resources in some geographical areas. For all three resources, dwellings will remain connected to the grid. If a dwelling's alternative energy sources are not functioning (dark days, no wind, etc.), energy can be obtained from the dwelling's own energy storage—or the grid. If energy production is greater than needed, excess can be returned to the grid. Water mains need to be two-way, allowing similar supply in times of drought, but accepting surplus in times of intense precipitation events. Food production is least likely to meet the full demands of the household, especially if families are large. Excess produce of one kind will be traded at community markets for other kinds produced in excess by neighbors, encouraging community interaction, But food stuffs

will continue to be marketed commercially, and home production probably will be more supplement than principal source.

Food, water and energy self-sufficiency, rather than isolating households, will help to support community. In times of need, neighbors are likely to be able to help with others' needs. Natural disasters as well as local problems will be less destabilizing in an environment in which help may be only as far away as a neighbor.

As the system has evolved, three major areas of concern have emerged: system performance, personal development and social development. System performance covered the workings of systems to be incorporated; personal development concerned the may ways that the system could support personal growth from standpoints of physical, mental and emotional development; and social development brought connection to community and the growth of individuals as social beings prepared to work together for common goals. In sum, they provide a strong base from which to challenge a generation of architects, engineers and designers.

Over the next forty years, many homes will be replaced and many more will be built to house the additional three billion people who will join our societies. If, in our planning, we reach for the stars, there is every chance we will achieve a great deal, and what we achieve may make a very great difference for those to follow in generations to come.