Domestically Dextrous: 
Embedded Computing For Senior Housing

by

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Bachelor of Design in Architecture
University of Nebraska, Lincoln, 2006

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Embedded Computing For Senior Housing

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Submitted to the Department of Architecture 
on January 17, 2013 in partial fulfillment of the 
requirements for the degree of 

Master of Architecture

Thesis Supervisor: J. Meejin Yoon, 
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Abstract:

This thesis proposes a new home for the aging baby boomers. The US is about to see a massive influx in 
the elderly population, and the current model of housing the elderly is woefully unprepared. The boomer 
generation has lived in single family homes for decades, and will want to continue living in one. Current 
strategies for retrofitting homes for seniors, things like wheelchair ramps, stair lifts, grab bars, are remark-
ably ill-suited to properly accommodate the needs of the elderly. Incorporating embedded computation into 
the home will allow the elderly to maintain their independence, and live in an environment which accommo-
dates their expanding and changing needs as they deteriorate both mentally and physically. The home will 
take an active role in monitoring the occupant, monitoring itself, adapting to the changing physical/mental 
dexterity of the occupants, as well as assisting with domestic activities. Given the varying degrees of com-
plexity that exist at the interface between the systems required to perform these activities and traditional 
residential stick frame construction, a new type of home which integrates electronics while also altering 
typical programmatic definitions within the domestic space.
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Thanks to a significant amount of post-war friskiness the United States saw a sudden and dramatic increase in population. That wave of resultant children, the baby boomers, are finally coming to an elderly age which means we are on the cusp of a massive increase in the amount of elderly population in the US.

Additionally, despite the doomsayers regarding how unhealthy we are as a country, thanks to modern medicine we are increasingly living longer than ever before. Meaning this influx of elderly are going to be around for a while. Before one starts to explore the significant and wide-spread impact this will have on our country, we first need to figure out where and how these people will live.
We don't really have a great system of how to deal with this influx of elderly in regards to their living situation. A person's home is one of the single most important possessions they have. They are seen as a reflection of who we are. Whether it is a statement of status or a projection of our personality, we are constantly using the home to place ourselves in society. This is especially true of the baby boomer generation, who have valued living in their detached single-family homes above almost all else.

Additionally, the home has also been seen as a financial investment. Traditionally, as one accrues more wealthy they buy larger homes with more amenities. Additionally, these homes have increased in their financial value. This leads up to the point where the retired empty-nesters buy their retirement home which has a few design considerations for their advanced age. Additionally, this is the point where one hopes they can cash out from selling their previous home, and then live off of that money for as long as possible. Unfortunately the housing bust crushed the idea of a home as a golden goose.

Not only are homes no longer the fail safe investment they once were, but as the people grow older in their retirement home, they often realize the home they love so much is starting to become more troublesome. The homes are then retrofitted to try and accommodate the changing needs of the elderly occupants with things like entry ramps, grab bars, and stair lifts. This is all in hope of stretching out the time they are capable of living independently in their home. Unfortunately, these modifications only delay the inevitable, and eventually the elderly begrudgingly are moved into an assisted living facility. This step is so often a traumatic experience for all involved. Children are trying to convince themselves there is no other option. The elderly have to come to terms that they are incapable of living the life they once did, and in all likelihood will not ever return to the home and lifestyle they have spent their lives cultivating and treasuring. It is almost universally agreed upon that avoiding this step and aging in place is the preferred scenario.
Traditionally the way in which an elderly person is able to age in their home is with the help of a caretaker. When this duty doesn't fall onto the shoulders of a child or friend, professional care takers are hired. While this arrangement is the most popular, there are a number of issues that come along. It relies solely on the professionalism and morals of a complete stranger, who is often in a position to take advantage of the elderly patient. Additionally, when emergency situations inevitably arise, (things as extreme natural disasters, or even a snow storm, or even something as mundane as a schedule conflict) the care taker is often not available.

The majority of research up to this point to replace the human caretaker has been the development of humanoid robots. Unfortunately, this line of research has not developed to where it is even remotely close to being able to be relied upon for a person's well being. The research currently is at a point where the robot being able to walk up and down a staircase is seen as a major break through. Not to mention the fact that the robots currently being produced are comically expensive.

I am proposing that the home should make use of embedded computation to allow the occupant to stay in their home and maintain their independence. I also want to stipulate that I mean making use of current technology, not a distant future scenario.
In order to look at what the home will need to be, it is useful to look at the stages of aging to start to identify their differing needs. I've defined them as "Young Old" who are the newly retired, still fully capable and functioning adults. They are often empty nesters who are looking to downsize into their retirement home, yet still want to be able to accommodate their children and grandchildren visiting.

The "Old" who are still capable of living independently, but are finding it more troublesome. Things like the upkeep and maintenance of their home starts to become an issue. Additionally, parts of their home, things like stairs, bathrooms, storage, start to become a problem physically. They start to feel increasingly isolated as traveling freely becomes more difficult. It's at this stage where the children start to think about what is next for their parents.

Then the "Old Old" who have degraded to the point where they are basically incapable of living without help. They often physically struggle with basic domestic activity. They often have limited mobility, and are incapable of traveling to the places surrounding their homes. They also mentally have degraded to the point where they struggle with essential domestic routine.
It is also necessary to identify some of the specific things that the home will need to do to accommodate the aging process. These exist in a kind of gradient between improving quality of life for the occupant to turning the home into a control mechanism protecting the owner from themselves. The first is idealized environments. The home will need to accommodate the changing shape of the occupant, as well as their changing physical dexterity. From the well known things like accessibility issues, to the relatively uncommon issue such as the changing space which is typically occupied.

The home will also need to act as a kind of activity tracking system. By actually monitoring and tracking the activity of the occupant one is able to see exactly how the occupant is living, and that data can be used to determine if changes need to be made. Through the aging process this information will shift in regards to its targeted audience from the occupant, to the concerned family members, to a doctor.
The home will also need to have emergency situation awareness. It is also worth pointing out that this applies to both the occupant, and to the home itself. One of the major reasons an elderly person is incapable of living on their own is a fear of the unknown. The “I’ve fallen and I can’t get up” commercials that all kids laughed at growing up, is a very serious concern among a vast amount of the elderly population. Having emergency awareness systems provides peace of mind to all involved parties, knowing that if something is to come up, an action will be taken to remedy the problem.

The last thing the home will need to provide is domestic assistance, meaning, helping the elderly perform the everyday tasks required of a person living on their own. This can range from things like the proper administration of medicine to the procurement, storage, and access of goods. These relatively mundane and simple tasks which younger people take for granted become magnified and very serious issues for the elderly, whether due to either mental or physical limitations.
This maps some of those different requirements to various activities and programmatic spaces of a typical home.
The following examples are studying how program has been typically defined within the home. The most common method is having the space of the home broken up with simple static walls, and then whatever furniture is placed within the room determines its use.
The Rietveld Schröder House from 1924 is famous for introducing a large open space on the upper floor which made use of sliding and revolving panels to close off and subdivide the space. This introduced the idea that the same space can be dynamically redefined to provide a number of different programs.
The idea of compressing program into stacking units can be contributed to both Jones Partners and Kent Larson. Having the program unfold out of the stacking unit when needed allowed a significant amount of program to exist within an otherwise tiny footprint of space.
The Farnsworth House introduced the idea that program need not be rigidly defined, but can be more loose. The open plan allows program to bleed together and makes the space more easily reconfigured to provide more flexibility in its programmatic usage. The same space can be used for a number of different uses.
These drawings are to illustrate the discrepancy between the traditional methods of residential construction compared to the complexity involved when incorporating embedded computation and intelligent systems. Traditional stick framing 2x walls make use of unskilled labor often repeating mindless tasks ad nauseam.
Whereas a mechanical storage system requires significantly more care put into fabricating and assembling the many intricate parts and systems. This leads to the notion that it makes sense to isolate the complicated systems when possible, in order to avoid making the entire construction of the home an overly complicated mess turning it into essentially an unrealistic option.
After many preliminary strategies were explored (see appendix), I rested on making use of a large elevator that is surrounded by a structural core that houses the infrastructure as well as the complex and intelligent systems for the home. Packed into this core are various programmatic uses that are accessed by the elevator. The elevator ensures that the entire house is always accessible regardless of what physical condition the occupant may be in. Also, by stacking various programs on top of each other it dramatically decreases the overall square footage by making use of the same floor space in plan for each of the stacked programmatic functions.
Three different strategies are employed in regards to how space gets used. The first is embedding program into the intelligent core. When the elevator at the proper height the program then is usable. The second is hanging volumes of program outside of the core and elevator. This creates a private space free from exposure to the rest of the home, and also creates space which is occupiable when the elevator is not at that specific floor height. The third is making the program accessible to both the hung volume as well as the interior core. This maintains the ability to make use of the program when the elevator is not at the proper floor height. However, when the elevator is at the proper height this expands the space of that particular program into the interior as well.
The core itself is composed of nine standard sized units. A combination of these units then stack together to form the larger planes which make up the core. Standardizing the frame sizes starts to make the core feasible and systematic rather than something unruly and completely open-ended. Also, by breaking the core into smaller units it allows for their fabrication to happen in a controlled environment rather than on-site given the complexity issue previously mentioned. One can imagine these units being shipped to the site in full working condition and then simply lifted into place.
Offering a variety of heights and widths in frame sizes ensures that there is enough variety to accommodate the various programmatic size requirements. It also ensures that there is enough variety in the nesting to not make the overall composition monotonous or limited in its arrangement.
Each of these units have the exterior frame and their interior space. The interior space is where the programmatic usage gets embedded into the unit. The exterior frame is packed with all of the various systems required by the home, things like structure, plumbing, ventilation, power, electronics, etc. These then connect to the adjacent frames thus linking the systems throughout the entire core. Also, within these exterior frames are designated spaces for the intelligent systems to be placed. The space surrounding the interior serves as the interface for this specific unit while the space which faces out serves the as the interface for occupant. Essentially, this is where the various sensors, cameras, etc. which serve the elevator space will be located.
Where additional space is required outside of the elevator additional volumes will be hung from the core. These volumes are relatively simple compared to their core counterparts. The structure is a series of structural frames which align with the primary structure embedded into the core. Additionally there is some cross bracing and sheathing on top of the frames. These volumes also do not house any of the systems or infrastructure for the rest of the home so it makes their construction relatively simple and lightweight. As a result, these are conceived as being prefabricated and then attached to the exterior of the core when delivered to the site.
In most homes the program is organized from public to private, from the front door to the back of the home or the upper or lower levels. In this instance, that gradient extends from the ground level vertically. The actual program consists of the basic requirements of any home, (bedroom, living area, kitchen, bathroom, etc.) to those specific to this type of home (elevator closets, delivery box, top floor roof deck, etc.) to those specific to the elderly (intelligent medicine cabinet, food production, etc.) While the vast majority of the circulation through the home occurs with the elevator there are also a few secondary ramps that connect some of the exterior volumes. These ramps make some circulation to critical places like a bathroom accessible even if the elevator is being used at a different height.
In regards to how the occupant actually interacts with and controls the home a series of 3D tracking cameras (which are already small and cheap enough), would be deployed throughout the core to constantly monitor the occupants. A simple hand gesture would be all it would take to trigger the home into an action.
The ground level of the home of course has the entry and its closet. It also houses the majority of the systems which serve the function of the home rather than the occupant (elevator closets, mechanical areas). The thought being that in most times the elevator will be above this area thus shielding it from the occupant the vast majority of the time.
Slightly above ground floor is the area for the storage, production, and consumption of food. It should also be noted, that this height is still accessible to the ground floor via a ramp in the event of a catastrophic event in which case it is assumed the elevator would default to ground level height.
Higher up in the home is more of the “private” area. The master bedroom expands out into the elevator space which when occupied also serves to use the elevator platform to block out the rest of the home. The bathroom is accessible without the need of the elevator in the event that someone is in the master bedroom volume while the elevator is being used at a different level and needs to relieve themself.
The upper most area of the home makes use of the exterior volume below for a roof deck area. By placing the exterior space near the top of the home it makes it more private as well as more likely to have better views and solar access. This area of the home also houses a significant amount of storage with the assumption that this won’t be accessed as often as the storage areas in middle of the home.
View of kitchen level
View near top of home
Exterior view from street
APPENDIX
Preliminary Track _ pre-thesis

As part of the pre-Thesis semester I produced the following document which was a culmination of my research and ideas up to that point. The following is the document in full. Much of it ended up on the cutting room floor as I proceeded through the actual thesis period, but this is essentially the genesis of where the thesis started.
It is my stance that the next widespread innovation in the field of architecture will be the introduction of computation into the built environment via the microcontroller. I plan on exploring this new architecture which is personalized, responsive, adaptable, and capable of new experiential affects within the everyday mundane spaces we occupy in our daily lives, the home and the office.
One of the inventions with the largest impact of the past century, the computer, has had a minimal impact on the built environment. Whether this is a result of architects being busy exploring ways in which the computer can be used to design a space rather than looking at ways in which a space can make use of a computer isn’t exactly clear. What is clear is that we have an architecture which is seemingly indistinguishable from that of something built several decades ago. Making use of computation in the built environment will change this. Embedding architecture with computation allows the built environment to autonomously adapt to its surroundings or inhabitants. No longer must architecture be a static construct, generalized to merely satisfy as many as possible. We can use computation to make architecture capable of being personalized to each individual and their varying needs and desires. Additionally this new architecture is capable of adapting itself to meet changing needs over time. While speculation about these types of “intelligent” or “smart” spaces have been rampant, we are at a point where they no longer need to exist as murky projections futurists develop. The technology exists for the actual design and implementation of these technologies, and its impact on the field of architecture will be dramatic.
Micro-controllers are essentially tiny computers which are capable of being embedded in the materials which make up our built environment. Rather than using a keyboard and mouse to interact with these tiny computers, we are able to directly interact with the physical space through the use of sensors, or inputs. These sensors come in a wide variety and are capable of reading anything from air quality to acceleration and degrees of rotation. The data collected from the sensors is sent to the micro-controller to process. If necessary, the micro-controllers then trigger actuators, or outputs, resulting in whatever response was deemed appropriate.

New components are constantly being invented and brought to market. The existing components are continually getting smaller, cheaper, more accurate, and more powerful. The result is that we increasingly are able to incorporate them into our proposed environments.

The scale at which these technologies are applicable varies dramatically. From the localized individual block with a specific task such as lighting up in the dark, all the way to a networked system the scale of a city providing real-time data about how the city is being occupied. The potential applications vary in an equally sizable range. The limitations are more in actually imagining the potential usage scenarios rather than any physical limitations.
This idea of a responsive environment can be traced back to the work of Gordon Pask and the field of cybernetics. He developed the idea of information environments, which placed the human and the environment in a loop constantly reacting to one another, altering the behaviour of each as seen fit. He demonstrated this train of thought through his device called the Musicolour in the early 1950's. It was a keyboard on which a user played music which was processed and had a corresponding light show. Additionally, the control loops would continually change during the course of the performance forcing the musician to continually be adapting and trying new things, lest the machine get bored and turn itself off.

Pask explored these ideas through an architectural lens in his collaborations with Cedric Price in projects like the Fun Palace. The Fun Palace was designed to frequently be reconfigured by bringing in new programs in response to its inhabitants resulting in new and different experiences for the users. The result was an architecture which was flexible and impermanent. This started the idea of an indeterminate architecture, or an “anti-building”, one that is capable of changing to meet future needs.
Later on in the 90's some of these ideas were picked up again by people like Robert Kronenburg and Chuck Hoberman who were calling for a kinetic architecture. They thought that ridding themselves of the static solution would result in a more optimized and flexible architecture. They saw an architecture capable of spatial optimization, contextual adaptability, and mobility, all while being multifunctional. Unfortunately they got an architecture which was often overly simplistic in its operations and failed to make an impact on society in any sort of significant way.
Eventually actual computation was able to be implemented in the built environment. However, initial implementations were mostly market driven, meaning they were designed to save people money. The result was looking for ways to optimize the performance of the building's energy usage. This displayed that computation is great for engineering feats of brute force efficiency. Unfortunately, some of the more interesting things architecture is capable of, questions of culture, meaning, or larger implications on society, were being utterly ignored.
Then came the people who were enamored by the idea of data collection. They treated the built environment like a science laboratory, collecting vast amounts of information regarding how one occupies a space. Satisfied with collecting the data and making it available, they failed to take any sort of critical approach in regards to how the information gathered could then be used to create a better architecture. Ultimately, knowing how many times a person opened a cabinet maybe isn’t taking full advantage of the technology available.


Larson / MIT, Kent, and Richard Topping / TIA. PlaceLab. 11 Nov 2003. PDF.
It seems like artists were the ones who initially started to utilize these technologies in more interesting ways. They demonstrated how computation can be utilized to alter our perceptions of existing environments. They also created new types of environments in which the interactions between the user and their surroundings were experientially engaging enough to impact the user in meaningful ways. The artists have been doing what we as architects strive for.
That isn’t to say that all architects have been ignoring these advances and opportunities. Some are slowly introducing computation as a way to achieve the types of environments they imagine. This has resulted in buildings of atmosphere or special effect with new forms of social interaction, more sophisticated versions of the architecture the kineticists were hinting at, or the creation of synthetic spaces previously unavailable. As we imagine the new types of environments made possible or imagine how we can better modify existing ones it seems we are at the tipping point for the widespread use and development of these technologies.


It seems that as a society we are somewhat reluctant to embrace technology. A quick study of how the notions of computation is portrayed in media is startlingly dystopian. Whether it is the fear of computers becoming too intelligent rather than acquiescent, the notion of people becoming reliant on technology not easily understood by the masses, or the distancing of things which supposedly define and give meaning to our existence as humans, we seem to continually proceed with caution.
Corb famously and fanatically called for a new architecture which embraced the latest technologies, which at the time was industrialization. The resulting machine architectures were mass produced and cost very little relative to the crafted and labor intensive architectures of before. The resultant environments were seen as a large step in the evolution and progress of architecture.

Yet technology has advanced to the point that we can take another critical look at the architecture being produced. As Corb once killed his predecessors, it has come time us to kill Corb. No longer must we be satisfied with the seemingly standardized environments the mechanical revolution resulted in. The introduction of the microcontroller to the industrialized processes opens a new path for architectural environments. What was a simple machine for living may become something more of a responsive robot providing new ways of living.

"The mechanical revolution is a new cause - immense phenomenon in the history of mankind. Where are the new effects? A hundred years of new materials and new methods have made no change whatsoever in your architectural viewpoint."

The microcontroller is a new cause - immense phenomenon in the history of mankind. Where are the new effects? Over 40 years of computation and new methods have made no change whatsoever in your architectural viewpoint.
Examining the role of the architect within the implementation of these technologies in regards to practice seems pertinent. We are guided to avoid taking on any more legal responsibility than necessary by clearly separating ourselves from the various parties involved in the process of designing and building. As a result, we have distanced ourselves from the processes of production, which has limited our potential impact in shaping our projects. In conjunction, comes the role of the architect in how these technologies will become an industry. Will we let the product manufacturers develop them continuing the kind of productization or the catalogization of architecture? I argue that the recent advances in our design capabilities as well as direct manufacturing industries has opened the door for us, the architects, to be the ones to design and develop these systems.
A person's home is one of the single most important possessions a person has. Owning a home is often the single largest investment a person makes. The importance of a home in its occupants' lives is undisputed, yet the occupants are often left underserved. The majority of homes we live in are built by developers emphasizing their bottom line rather than the future home owners. The result is the plethora of similar homes we see everyday. They are designed to appeal to the largest range of people, with little regard for individual tastes, preferences, or lifestyles. Individual preferences are most often met by simply shopping around and looking for something slightly different. Even when a person has a home designed and built they often fall into the generic context of the field. The home has often been explored as a problem of merely providing shelter rather than exploring the impact on its occupants. Despite the rapid and vast changes society has gone through, the changes within a home are most often seen in the easily replaceable material selections. Shag carpeting to oak hardwood to bamboo floors. Patterned wallpaper to solid colored paint. The noticeable changes in our homes are more in having to do keeping up aesthetic styles rather than changing anything to do with the way we actually live or occupy the space.
The office is where we spend a significant amount of our waking hours at least five days each week. For something so ubiquitous, the way in which we inhabit or use the space of an office is rarely looked at critically. As we progress towards a post-industrial state the need for office space seemingly will only increase. The range of work performed varies dramatically, while the vast majority of office space can be housed in anonymous office parks full of lowest-common-denominator architectural infrastructure. Within each company surprisingly little is done to make each space cater to its employees needs. The design of the space itself is often given from the upper most management, those most removed from the actual work performed, and unless there are dramatic changes made to the company little is done to change the design of the office over time. The adjustments made to the chairs ergonomic settings and the angle of the monitor are often the extent of how the office space responds to the individual preferences of its employees. Each personal possession brought in serves a purpose to distance the employee from their given work environment. A family picture serves as a reminder of their private life. A visual reminder of both the reason they need to leave work (in order to spend more time with those most important), but also the reason to continue to work longer (in order to financially support). A desk plant serves as a reminder of vitality, a portal to the world outside full of life. A favorite pen brought from home serves as a personal intervention on the homogenized environment which surrounds us, a statement of defiance to the given.

Arrive at work, 0819
Chat with receptionist, 0821
Read email, 0829
Ask coworker question, 0934
Meet with boss, 1017
Work at desk, 1049
Prepare lunch, 1201
Eat and chat with coworker, 1209
Work at desk, 1255
Go to restroom, 1419
Make copies, 1432
Work at desk, 1435
Browse internet, 1645
Work at desk, 1703
Leave for home, 1807
Villa Savoye
1931 - Corbusier
The clear representation of Corb's "five points," this home is also a prominent example of his idea of a home as a machine for living. He famously called for a new type of architecture which took advantage of modern technologies to change the way one occupies a home.

Case Study Home #8
1949 Eames
Constructed using exclusively off-the-shelf parts, the house was intended to be a display of a comfortable and functional alternative to typical single family homes. The home eventually became more famous for its very specific and prolific collection of curated objects the Eames acquired and displayed.

Farnsworth
1951 - Mies
A home which made use of floor to ceiling glass around all four sides connecting the interior of the home to its surrounding environment as much as possible. Additionally the home was designed as a single room with the spaces flowing into each other.
Taylorism:
early 1900's

Frederick Winslow Taylor invented scientific management. He approached the work place like a scientist, looking to maximize efficiency. He had four main principles:
1. Eliminate rule of thumb with actual calculated values.
2. Select, train, and develop each employee rather than letting them figure it out.
3. Provide detailed instruction and supervision of workers.
4. Separate management from workers so that workers don’t have to think about what they’re doing in a larger context, but can just work on their specific task.

The architectural result was rows and rows of workers desks with a clear distinction between management.

Office Landscape:
1950's

Developed by the Quickborner Team in Germany as a rebuttal to Taylorisms “dehumanizing” approach, everyone sat together in a large open and undivided plan. Conventional furniture was arranged in whatever organization was desired, and it was seen as a more collaborative and humane environment. When privacy was needed, screens or plants were conveniently located to provide a semblance of separation.
Dymaxion House
1945 Fuller
Designed to be a low cost, mass produced, and easily transportable home which made use of the industrial construction processes. The home was also designed to be heated and cooled naturally with minimal need for cleaning or upkeep.

House of the Future
1956 Smithsons
A series of unique sized spaces revolving around a central courtyard, the home was to be made of a single plastic structure. It also incorporated a number of 'futuristic' appliances like its self-cleaning bath, a shower which also dried its occupant, and a table which adjusted its height based on need.

Monsanto House of the Future
1957 Richard Hamilton, Marvin Goody, Albert Dietz
Using the phrase “Better Living through Chemistry” the prototype home was designed using a new structural plastic composite system. It also included a number of 'futuristic' appliances like sinks which adjusted their heights, video and hands free phones, and an ultra-sonic dishwasher.


Action Offices:
1968
The business furniture system developed by Herman Miller was originally designed to meet a variety of work related tasks the traditional desk failed at. Multiple working surfaces allowed for a variety of tasks to be performed in their ideal conditions. As businesses started looking for ways to fit more employees in smaller footprints, while maintaining the flexibility that traditional walls don’t offer, this eventually turned into the infamous cubicle. The cubicle was developed over time to satisfy a number of office related needs, such as: varying levels of privacy, variety of work and storage surfaces, variety of sizes or layout options via modularity, embedded systems (electrical, lighting, networking, etc).

Remote Offices:
1990's
The advent of telecommunication and networking technology allowed people to perform work related tasks remotely. Companies didn’t have to provide the architectural infrastructure for as many people. Employees were free to live where they wanted with less regard to proximity to their office, and no worries of time spent commuting. Over time this strategy has seen mixed reviews. Some enjoy the perceived “freedom” of escaping the traditional office environment, while others, sitting in their unused bedroom turned into an “office” miss the social aspects that come along with working side-by-side with coworkers or complain of inefficient communications compared to face-to-face interaction.
T.R.O.N. Intelligent House
1989 Ken Sakamura
The house was designed as a showcase for computation being integrated into a home. It incorporated 380 connected computers into its design, and had a plethora of future appliances or design features such as: a hidden mechanical storage system, temperature controlled windows, kitchenette which helped cooking by displaying proper ways of preparing the food while performing some tasks such as mixing proper amounts of spices, and even a toilet which analyzed the waste for health concerns which could then contact a doctor if necessary.

Adaptable House
1997 Michael Mozer
The house incorporates a number of sensors and computers which control its lighting and temperature systems. The house learns occupants patterns and preferences over time automating these tasks as much as possible while. It also provided feedback regarding the occupants preferences, displaying a dollar value relating to an increase or decrease in desired temperature.

PlaceLab
2004 House_n + TIAX Initiative
The home makes use of a large amount of sensors to study and gather information on how people occupy the space, producing large data sets which can be analyzed to better understand human behavior.

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Open Prototype Initiative Webcast. 13 Nov. 2008. PDF.
Larson / MIT, Kent, and Richard Topping / TIAX. PlaceLab. 11 Nov. 2003. PDF.
Virtual Offices: 1994
Housed in a sparkling new building designed by Gehry, TBWA/Chiat/Day tried to eliminate the idea of employees "owning" their own office space. Employees were given lockers in which they could store their possessions, but otherwise had all sense of personal space removed. They were allowed to check out laptops, told to work paperless despite their reluctance, and given the freedom to sit or work wherever they wanted. The thought was that by freeing employees from a single defined space they could choose their working environment based on their changing needs. The concept initially drew heavy interest in its radical departure from the norm, yet they were forced to eventually admit failure when productivity nose-dived.

Employee Friendly: 1990s
Trying to escape some of the perceived baggage of office spaces, companies tried to make their offices more "employee friendly". Whether it was a way to draw and retain better employees, or hoping that happier employees result in increased productivity, or companies simply trying to incorporate some of their culture and ideals reflected into the design of their office there have been a number of justifications developed.
For something that is a reflection of the needs/wants/lifestyle choices of the owner, the spaces which comprise a home are surprisingly generic. Dictated seemingly by cultural conventions, the home is comprised of a set of standard spaces: the bedroom, bathroom, living, kitchen, dining, etc. This is exemplified by the fact that homes are often classified merely by the number of bedrooms and bathrooms and square footage. Any additional type of space beyond the standards is seen as a bonus and worth calling attention towards.

The office space is comprised of spaces of production and those which service the production space, with a few grey areas doing both. The production spaces vary in size, amenities, and desirable characteristics. The service spaces exist to support the production spaces, whether directly such as utilities or circulation, or spaces seemingly to make the production spaces more comfortable such as a lounge, yet really exist to increase moral and thus productivity.
The home is about self-identity and personalization. Our homes are seen as a reflection of who we are. Whether it is statement of status or a projection of our personality, we are constantly using the home to place ourselves in society. This entails the continual process of personalizing our homes to make sure they meet our individual tastes. However, there is an inherent predicament. While the homeowner and their needs/wants are constantly changing and evolving, the production of architecture is seen as an event to last for significantly longer periods of time, many years or decades. As a result, the modifications and personalizations currently exist more in the realm of the housewares we accumulate and display for all (including ourselves) to see rather than the architecture itself.


The office space can be seen as a kind of white collar factory with its desire for the utmost efficiency. Housed within the generic shell building lie the endless grid of drop ceilings with optimal light distribution, fields of cubicles sized and furnished for optimal working conditions, all swimming in a sea of artificial white noise to drown out the sounds of the fellow coworker to avoid any unwanted distractions. New products and technologies are routinely brought forward promising less input and more output. Workflows are streamlined, logistics are sped up, communication is made faster and more efficient. The collective office environment continues its surge forward, increasing productivity while using less time, effort, and energy.
The home has also developed under the striving for the automation of domesticity. Long ago families just had more kids who were put to work around the house. The role of the home in the process of domestic life has been that of a vessel. It is separate from the actual domestic activities. Owners fill the home with more and more products which were invented to make tasks easier or more convenient. We are constantly looking for new ways to make our daily domestic life easier, to free up more time to do the things we want to do.


Another aspect of the office environment is its overbearing portrayal of hierarchy. Top floor versus the ones below. The highly sought corner office, the private office with a window versus the one without, the lowly cubicle, or even worse, the shared cubicle. Rare is such distinction made abundantly clear, especially when equivalent measures such as salaries are routinely held top secret. Even when not physically delineated, hierarchy is still present. It is evident in both movement and communication. The spaces and their organization which make up an office are the physical manifestation of the proverbial ladder everyone is trying to climb.

<table>
<thead>
<tr>
<th>Function</th>
<th>Area in sq ft (Sq m in parenthesis)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top executive</td>
<td>500 (47)</td>
</tr>
<tr>
<td>Executive</td>
<td>400 (37)</td>
</tr>
<tr>
<td>Junior executive</td>
<td>250 (24)</td>
</tr>
<tr>
<td>Middle management</td>
<td>150 (14)</td>
</tr>
<tr>
<td>Secretarial/clerical</td>
<td>100 (9.5)</td>
</tr>
<tr>
<td>Minimum work station</td>
<td>50 (4.7)</td>
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</tbody>
</table>
I am interested in exploring these typologies within the generic environments of everyday life, specifically within their suburban contexts. Thus I am looking west to the shining example of our suburban metropolis, Los Angeles. With its overwhelming suburban characteristics and its rich architectural history it seems like a relevant location for exploration.

It is far from the idealistic plot of land. It doesn't have the dramatic sweeping views of LA which Julius Shulman made famous. Nor is it remotely located to seemingly escape the city and connect itself to nature. It is not even located in the expensive part of the neighborhood. It does however have some desirable characteristics. The area is known as an up-and-coming part of LA, and contains a large amount of culturally enriching elements. (a significant amount of architecturally interesting homes by the likes of Nuetra or Jones Partners and many others, a number of well regarded retail outlets and restaurants, and galleries such as Materials & Applications) It is in close proximity to transportation arteries such as the 101, the 5, and the Glendale Freeway. It also is just a few blocks from a focal point of the area, the Silver Lake Reservoir.

The site I have selected exists as a compromise. It is a reflection on the home owner's personal weighing of the needs/wants/lifestyle choices versus their available means.

The site for the office building is located on the periphery of downtown Pasadena. Nearby are a few anonymous office buildings and a number of commercial establishments which support these types of office buildings (restaurants capable of accommodating the lower waged employees as well as the higher ups, gas stations, etc.). The site is a kind of a leftover space, not quite a part of the romanticized and picturesque fabric of The City of Roses. Its strongest characteristic is its relation and proximity to the interchange between the 210 and Ventura Boulevard. It seems more akin with the space Ballard characterizes in Concrete Island, a leftover, forgotten about piece of the city one drives past without second thought.

These types of spaces within the city may take an increasingly important role in the urban fabric. If communication technologies advance to the point that physical location and proximity is increasingly devalued, as has been widely speculated, there may be a shift in the location and needs of future office spaces. These enclaves of vast amounts of private space may be broken down and distributed. No longer does an office need to tie into the urban centers, leaving them largely overwhelmed during business hours and desolate otherwise. The sites for an office may transition into something else. The central business districts found so often may start to become less relevant, while other parts of cities become activated.
To explore this topic I intend to take a dual pronged approach. The first is to explore ways of grafting this technology onto the existing notions of the home and the office. To understand how to do this I intend to first explore what it is that defines each of these typologies. This will involve understanding how each of these typologies have changed over time and how they developed to the point at which they exist today. This will entail documenting the types of spaces which typically make up both of these typologies, and understanding what is required of these spaces. This will involve documenting the types of activities which take place in these spaces, in addition to the physical properties. Another aspect of these spaces I want to be sure to document is the relationship between the owner and their reason for including this type of space in their home or office, so the documenting the sociological properties of the spaces. Once I understand what the various pressures are for each the home and office I intend to explore various avenues in which the use of embedded computation via micro controllers can take on some of these issues. This process will involve the design and prototyping of these some of these systems to prove their validity and to better understand what the process entails.
The second prong is to look at ways in which these technologies can alter or create a new type of home and office. This process will first entail documenting the various components and understanding what they are capable of doing. Then a number of these components will be assembled to develop a variety of actions or performances. This will involve the design and prototyping of these pieces. Analyzing these will involve understanding what benefit or hindrance the systems provide. These then will be explored in regards to how they may start to create a new type of home and office or alter how one inhabits that space.
Usage Scenario

Within the allotted window of time before owner must be awake the resistance sensor between the mattress and the box spring is indicated he is not in a REM cycle because of the amount of movement it reads. As a soft alarm the shades are drawn letting in the natural light gently awakening ownerA. He hasn’t felt the shock and then sickening sound of his old alarm clock in weeks.

As ownerA gets dressed the RGB led light in the closet glows blue hinting at the forecasted temperature for the day, preventing ownerA from being underdressed.

OwnerB routinely has trouble falling asleep, and as a result often reads in bed. The dimmed spot light embedded above the bed casts a narrow beam only above ownerB while ownerA sleeps undisturbed. When ownerB eventually falls asleep, book in hand, the motion sensors lack of input eventually turns off the light.
"I hate having our bedroom on the first floor and close to the sidewalk/street. The fact that the blinds are always down and the bedroom is always dark when waking up is one of the things I dislike the most about our place. Leaving them open at night is simply not an option, I am not nearly a large enough exhibitionist for that. If only our shades would be open when light out and closed when dark..."
Development Track _ Project History

The following is some of the work / thoughts that I produced throughout the thesis semester.

Step 01

I initially proposed a scenario that as 3d printers become more and more ubiquitous, architects will look to start designing objects which make use of the technology for actual built products. The thought was that home owners will go to architects to design a number of smaller units which nest together to form large furniture scale constructs. All that would need to be exchanged is the digital file given to the client, and the production could occur directly within the client's home itself, rather than involving other industries or trades. These furniture or wall scale constructs then could also be taken apart and recycled back into raw product to be reprinted into whatever new piece the owner wanted/needed. The thought was that this allows the potential for people to regularly remake their domestic environment, rather than being stuck with the static conditions which most homes seem to be.
The following are a few examples of the large furniture scaled objects would the owner would print out. This hints at the mass customization allowed with the system, resulting in having a domestic environment more suited to your specific needs and tastes. This also points out where some of the embedded computation would be deployed. The thinking was that as 3d printers continue to develop they will be able to directly embed the systems into the unit. How it works has already been demonstrated with pick and place machines, thus it's not difficult to imagine this being a viable solution within a few years.
To take full advantage of this proposed system, homes would generally be large open spaces. These printed objects then would be deployed within the home to define program and divide space, with the intention that they are able to be reconfigured throughout the home. Select spaces would have been static (kitchens, bathrooms, mechanical, etc.) because of infrastructural limitations. This allows for the home to accommodate significantly more of the occupants needs, but doesn’t have to conform to those situations which occur infrequently. Things like having a large entertaining space or having a guest room for the visiting in-laws. By making the home more flexible, one is able to live in a more optimized arrangement.
Step 02

This is a potential scenario in which homes may need to change their overall size rather than just their interior layout. Many of the typical reasons for people wanting or needing to move to a different house could be eliminated if the house is able to easier adapt to the lives and needs of its occupants. The resultant scenario would also have some significant impact on how we value homes. Rather than focusing on things like the number of bedrooms occupants would focus on aspects that they were not able to change, things like site / surroundings / etc.
The parents think that by increasing the size of their house and increasing the distance between them may reduce their fighting in front of their children. A bitter divorce results in the ex-wife moving in and the husband coveting.

Year 4

A new child results in a new addition. Jealous of his neighbor's new new tuber addition results in a reconfiguration.

Year 5

The house is again expanded in opposite directions, a clear representation of the owners strained relationship.
This is looking at how the shell of a home would be able to more quickly change, and in this instance the foundations. Traditional cast in place concrete foundations, while very strong, are extremely limiting in regards to accommodating change. Any type of addition or subtraction to a home requires significant amounts of labor and time. This proposed system utilizes a few steel beams slightly embedded in the ground which a space frame then connects to. This frame would then be easy to expand, contract, or rearrange by connecting to the beams which are already in place.
This proposed floor system makes use of modular units with embedded connection features. This would allow the floor to be more easily assembled and disassembled because of the relatively smaller size of the pieces and the fact that the pieces are self-aligning. These floor units also would have built-in space for the required infrastructures to run throughout the floor. The overall system would consist primarily of a standard unit, and then a number of custom units to accommodate the varying geometrical configurations required.
Floor frame units

Variance in edge

Variance in slope
The proposed wall system is composed of prefabricated wall panels which incorporate connection features to easily connect to each other, but also the floor and roof systems. This allows for the wall panels to be reused rather than stripped down to each individual material as is typical in stick framing. Also, this breaks the wall into a number of smaller units more easily handled by a person or two.
Variance in geometry

Connection to roof with openings for systems

Embedded connections for walls

Connection to floor with openings for systems

Variance in geometry

Openings
Step 03

This was an exercise in looking at large furniture scale objects which have program embedded into them. These were all one directional thinking they would serve the space in front of the object. Some of the embedded computation systems are called out as a way to start to dive into what types of systems will be required. Additionally, a potential back and forth scenario between the occupant and the unit is listed for each unit, which hints at some of the specific scenarios that the house might be reading and reacting to.
**Exercise**

- Lightly stretch before workout
- Confirm target workout
- Video chat friend to socialize
- Start to get flushed
- Get distracted by husband's loud music
- Conclude workout

**Home**

- Scan range of motion and compare to target goal
- Lower treadmill into functional position
- Suggest distance and pace based on doctor's prescribed routine
- Skype contact
- Turn on fan
- Increase oxygen levels through fan, slow pace to more moderate
- Note increased audio levels and play white noise
- Indicate target goal met
- Log workout and email to caretaker daughter, noting light headedness
- Play reminder to take post workout vitamin
- Initiate kitchen to prepare prescribed protein shake

**Kitchen**

- Offer a number of meals, with preference to food that will expire soon
- Collect ingredients from mechanized pantry, note low inventory of egg noodle and place online order for replacement
- Offer instructions on proper cooking techniques
- Read increasing temperature sensor
- Alert homeowner to situation, exhaust fumes
- Reach them of doctor's strict warning, lock cabinet restricting access
- Offer alternative, approved snack
- Read remaining weight of food left on plate, log amount of food eaten
Step 04

This was exploring a scenario where simply rearranging large furniture scale units would accommodate the needs of an elderly couple as their lives change over time. The first setup is thinking that the newly empty nest couple is excited to have their own space which doesn’t accommodate their children who they finally managed to get to live on their own. The second arrangement is setup to easily accommodate having their new grand children visit and sleep over night.
The third is arranged to allow for the couple who for all intents and purposes would prefer to live independently but for various reasons decide to continue living together without one having more or less of their own private space. The fourth is setup for after one of the couple is deceased, thus things like privacy between the bedroom and the living room is no longer a concern. The last arrangement is setup for when the occupant starts to slip mentally and may require having another private bedroom for a caretaker.
Step 05

Here I was looking at embedding the vast majority of the intelligent systems into a central spine which ran throughout the home. This spine divides space and defines program. The systems incapable of being embedded (things like lighting, temperature regulation, window controls, etc) connect to and are controlled by the central spine. The spine would consist of a number of smaller units, each their own program or use, which fit together to form the larger whole. The central spine would then serve as the interface hub between the occupants and the home itself.
Step 06

This scheme was looking at focusing the intelligent systems into an aggregation of smaller units that are independent of the shell. Each of these individual units would have built into them the required infrastructures to accommodate expansion/contraction as well as replacing the types of units required. The thought is that this will simplify the process of adapting the home to account for the changing needs of the occupant over time. This aggregation would also then be a transportable and unique condition which is specific to the occupant. This hints at changing the notion of home ownership, where the idea of one's home is tied more to this hub than the space itself. If this hub is capable of being transplanted into a new space, this also hints at significantly diminishing the foreign feeling one has when moving into a new home.
Step 07

This is an idea of expanding the space of the intelligent systems into a number of nodes or volumes located throughout the home. These volumes then start to divide the space of the home, but more importantly are capable of accommodating program underneath or within as well as to their sides. This scenario was looking at a way in which these systems could be deployed into an existing home rather than having to always start with new construction. One can imagine this being deployed in only smaller areas of a home where a significantly smaller scope of retrofitting would need to occur.
Step 08

This idea was focusing the intelligent systems into the ceiling which snaked its way through the home. Where the space of the home needed to be divided, the ceiling would extend either partially or fully to the floor, creating either visual or physical separation. The intelligent ceiling also was continuous from the front to the back of the house with the intention that this ceiling is its own complete and independent system not entirely dependent on the occupant to move things into place.
Step 09

This exploration focused the intelligent systems to one wall that traversed the entire height of the home. This touches on the intelligent systems having access to all areas of the home. Also, placing elevators along this wall enables the occupant to have access to the full height of the wall, not just the space easily accessed from the height of a standing person or from a wheel chair.
Step 10

This scheme was looking at hanging a number of volumes which house the various programmatic functions of the home from a central space. The central space serves a large elevator shaft, moving the living room vertically through the home. The elevator also was subdivided into two elevators allowing the different levels to be simultaneously occupied.
This scheme was exploring the idea of wrapping the central elevator volume with a continuous space. This was a way to start to explore how the home can be navigated and occupied by multiple people simultaneously.
Step 11

This explored the creation of rooms/spaces only accessible via specific elevators. These spaces when occupied would then be enclosed by the elevator separating them from the rest of the house creating private spaces in an otherwise entirely open and accessible home.
Step 12

This scheme looked at embedding the intelligent systems into the core between the hung volumes and the central elevator. This also explored the notion of having the core be made of a system of smaller units rather than as a poche.
Step 13

This was the first of a few iterations which explored different sizes, hung volume/program configurations, and roof scenarios. This one was more stout with a roof that incorporated a skylight in one corner.
This iteration explored the idea of including intermediate floors within the central volume that when the elevator would align with would extend the floor area of the elevator. This also created more of a constant connection between the space above and below the elevator platform, which otherwise is entirely divided by the platform.
This iteration slimmed up the central volume to its thinnest point without making the space unusable. This forced the relationship between the central elevator, the core, and the external volumes to be more co-dependent than before.
Parallel Track _ Machine Building

During the course of the thesis semester during the time I wasn’t directly working on my thesis work, I was also building my own 3d printer as a means to explore some of the various sensors/mechanics that would be implemented into the type of home I proposed, in addition to exploring ways in which one is able to design and create parts to easily house all of these various intelligent systems.
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Bibliography

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