Hot Swap

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The process of computer component interchange and how it relates to the life cycle growth within residential architecture.

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Project Abstract: The current home personal computer allows for the exchange of parts so the user can easily upgrade or repair components as the users needs change. Hot Swapping, is the process of exchanging, upgrade/downgrade components within a computer while the system is fully operational. The idea of maintaining a complex computer system, while it is fully operational and certain components can be exchanged as needed, has direct applications to the construction of a modern home. Current stick-frame housing techniques for home construction do not easily allow for major changes, or updates to the system, without portions of the system rendered disabled or unusable.

Social: The current housing conditions in the United States shows homes today are oversized for the amount of occupants residing within. These conditions coincide with the life cycle of the occupants. When a family needs more square footage, many choose to move to a large home. This migration to a larger space becomes detrimental when the number of occupants in the home decreases. The remaining members of the family often stay in the residence due to comfort, yet the amount of valuable resources consumed to keep the home livable could be lessened if the occupants could remove the portions of the home.

Technology: The utilization of the Grasshopper plug-in for Rhino allows dynamic control of various constraints and components to be used with a Hot Swap system. By inputting the proper information into the model, selected inputs can be manipulated which produce multiple formal configurations. These configurations, with set constraints, can be rapidly updated to visualize future alterations. With this modeling system in place it is easy for the Hot Swap system to be visualized as it corresponds to the multiple ways it could be upgraded, downgraded, or modified to coincide with the life cycle growth of the occupants.

Assembly: By developing a component system for construction, the idea of the Hot Swapping can be implemented into the construction of a prefab home. The assembly of the Hot Swap system would resemble current SIP panel and modular home construction methods. These methods serve as a precedent for the thesis. The dissimilarity is in the connections, or how the panel connects to other components. The connections are what fulfill the Hot Swap condition. The ability to upgrade / downgrade / replace / repair panels is the driving force for how the system can be modified. Without these connections the panels would be unable to be removed for future expansion or modification. Through the initial design process of the panel, certain characteristics can be implanted so these changes can be achieved in the future.
The housing market in the United States is in a state of demise. With the increase of foreclosures due to the unstable practices on Wall St., many families have to leave their home to due the inability to pay their mortgage. This situation could be alleviated if the process of purchasing a home was similar to leasing an automobile.

When we look at the price of a home 25% of the cost is derived from the value of the land, while another 25% goes directly into the labor associated with the constructing the home. If these two areas could be redefined by using unconventional methods not normally used in residential building practices, then the saving can be put directly into the home buyers pocket.

By developing a leasing system which the home buyer purchases the land, and not the structure; the practice of moving every seven to 10 years could be dissolved. On average the first time home buyer will live in their home for seven to 10 years. This movement can be associated with the growth of the occupants as their lifestyle facilitates an increase in square footage. If the occupants stayed on their current property but upgrade their home, similar to the way one trades in a leased car for a newer model, they could essentially swap out certain components of their home for newer, more efficient components. With the ability to exchange the leased portion of the home the occupant’s lifestyle can be flexible to adapting when the situation arises.

Because the modern home has such a close relationship with the occupant’s life style, when changes occur problems may arise. This relationship typically allows updates or changes to a home when the occupants lifestyle changes. When these changes to the home are needed, certain areas of the home may be rendered disabled. Areas can become a inconvenience to the user's daily living operations while they are shutdown. By applying Hot Swap techniques used in computers, to modern home construction these inconveniences can be reduced to a simple task.

When we examine the assembled components of a personal computer, attributes with in the system lend themselves to architectural applications for prefab construction. Components are important to the composition of a personal computer and boast important roles in assisting the computer to function. While it is possible for some components to be replaced with other types or styles, the purpose of a personal computer remains fixed; function as an easily adaptable device optimized for individual tasks. Personal desktop computers currently allow for the exchange of parts or components. This exchange allows the user to easily upgrade components as their needs change, or as advancements in computer technology develop. This exchange, swapping, usually requires a computer system to be powered down so the sensitive components are not harmed during the process. There are three variations of swap: Hot Swap, Warm Swap, Cold Swap.
**Hot Swap**

An element can be replaced while the rest of the system remains completely uninterrupted. The system carries on functioning, information keeps transferring, and the hardware change is completely transparent.

**Warm Swap**

The power remains on to the hardware and the operating system continues to function, but all activity must be stopped to the device connection.

**Cold Swap**

The system must be shutdown before making the swap.

A shutdown/swap/reboot operation is easy to accomplish on the personal home computer, due to the small scale of operations and information passing through on a day-to-day basis. Performing shutdown/swap/reboot operations on a large server or datacenter may not be an option due to the type of service being requested from the system. To remedy this problem, certain computer components are able to be Hot Swapped.

Hot Swapping allows certain computer system components to be changed, upgraded, downgraded, or repaired with in a system without disrupting the computational processes. Maintaining a large, fully operational, complex computer system while exchanging certain components as needed, has direct applications to the assembly and configuration of a modern prefab home. If a prefab system is constructed to facilitate ease in modification, future updates would not require areas of the home to be shutdown.

Prefab architectural components have qualities which can be compared to the components of a personal computer. These qualities stem from the way components in a computer are able to be swapped. The three variations of swap; Hot, Warm, and Cold, correlate to the architectural components by defining how the prefab system will react to the swap.

A Hot Swap operation can be achieved at the disc drive and peripheral devices of a computer because the system is not dependent on the devices. The panel of a prefab assembly is similar in that, the system can continue to function if a panel is removed. Integration of the panel into the other components is paramount for the Hot Swap system to function. The panel will allow the Hot Swap home the flexibility to be easily upgraded, downgraded, or repaired while daily operations continue throughout the home without interference.

The hard disk drive of a computer can be either a Hot Swap or a warm swap, depending on how the drive is installed. If the computer relies on important information on the drive, then the drive would require a Warm swap. This also applies to the structural frame and the module assembly, which depending on how the configuration is arranged would dictate different swap conditions. The relationship between the module and frame depends on the design of the Hot Swap home, which would dictate the proper swap to be used.

The case, motherboard, and power supply unit of a computer are cold swap components due to the total shutdown of the system. This total shutdown of the system, as it relates to the prefab architectural components, is similar to the necessary steps needed to upgrade or repair the foundation system and service core. This classification sets constraints for the way the architectural assembly will be constructed.

Certain components once set within the system will require complete shutdown to be modified.
The case provides a body, housing, or structure to place components in, and serves to protect the various components from harm. While various styles of cases exist on today’s market all have the same purpose, just different ways to store the various components. Some cases are designed to optimize the removal of heat generated from the electronic components. Others are designed to facilitate optimal use of space, reduction of noise which ultimately is consumer preference of the design of their system.

Since the case houses all the necessary components it makes it virtually impracticable to keep a system running safely outside of the case. For this reason the case produces conditions which are not suitable for swapping while the system is operational.
The motherboard is the docking platform for all components within the system. All information from the components is routed through the various channels within the motherboard, without the motherboard this information would not pass through. On the motherboard resides a location for specific components.

The Central Processing Unit (CPU) is the brain of the computer, processing and routing necessary information to run the system. The CPU draws its processing power from the Random Access Memory (RAM), which aids in running the configuration at high speeds. This information is produced in the visual form through the Graphic Processing Unit (GPU).

All of these components reside in specific locations on the motherboard, and these components must remain in their fixed location for the computer to function properly. Removal of the motherboard is only possible if all electrical current to the system is stopped and the previous components are removed. In this instance the motherboard is unable to facilitate a swappable condition without rendering the system unusable.
The Power Supply Unit (PSU) provides the computer with the necessary electrical current to power the system. Without the PSU the computer would be a collection of components without a function. PSU’s are multi-faceted controllers which power all necessary components with specific amounts of voltage. Cable end connectors are site specific to certain locations on different components within the computer. If the PSU is removed from the system, all operations would cease to exist. For this reason the PSU produces conditions which are not suitable for swapping while the system is operational.
The Hard Disk Drive (HDD) allows the computer to store and retain data so it may function according to the user’s specifications. Without a HDD the computer would be deficient in the ability to store data to run the components, along with an assortment of applications.

The HDD pulls all the components together by providing a location to store information before it is passed to the required locations within the system. HDD’s are one of the few mechanical parts within a computer, which makes it susceptible to failure due to wear and tear of the drive. Also, since the HDD receives and stores data it is possible for corrupt data to infiltrate the system and render the system unusable.

If multiple HDD’s are installed in a specific configuration, it is possible for a HDD to be removed from the system while it is fully operational. Yet, there are some instances where is not possible such as the HDD storing the operating system running the computer.
The disc drive is a mechanical device which reads data from and writes data onto a disk. This provides a gateway for information to be loaded and unloaded from the system. It is possible for a computer to not have a disc drive, but this would make certain operations difficult. Disc drives are often located within the case, but there are options available to have an external device if one so chooses. Since disc drives are a peripheral component, it is possible to remove them from the computer system while the system is fully operational. This allows the disc drive to be swapped if needed.
Peripheral devices are attached to a computer but are considered not part of the system, due to its primary functionality being dependent upon the system. Therefore, they can be considered as expanding the computer's capabilities, while not forming part of the system.

Peripheral Devices

These devices are often powered by the computer, or require an external power source. Mice, flash drives, external hard drives, disc drives, and printers are all peripheral devices, and can be swapped easily since the system is not reliant on the device to function.
The Loblolly House, by Kieran and Timberlake, complied the 40,000 parts that make up the average home and collapsed into five integrated construction elements, Site, Scaffold, Floor / Ceiling Cartridges, Block, and Wall. The components were assembled using only wrenches made possible by the file-to-factory design system in place.
The Loblolly House developed a system of assembly which was unique to the modern prefab home. By using BIM to efficiently document and plan the assembly of the Loblolly house, the project exploited the design and fabrication techniques which minimized errors in the field.
In January 1947, the Lustron Corporation announced that it had received a 40 million dollar Reconstruction Finance Corporation loan to manufacture mass-produced prefabricated homes. The homes were to be constructed from steel, which at the time was thought to be a cheaper alternative to the wooden mass-produced homes.
The Lustron home was composed of a steel skeletal frame, which was clad in 2’ square porcelain enameled panels, significant due to the durability and ease of cleaning. The assembly of a Lustron home took approximately eight days to complete. The Lustron Corp. constructed just fewer than 2,500 Lustron homes between 1948 and 1950. In 1950 Lustron Corp. filed for bankruptcy.
The weeHouse is a modular system which can be customized to serve as a home, office, addition or rooftop structure. The flexibility of the design is developed from a base modular size. This module, when scaled and repeated, develops multiple configurations which construct larger modular units.
The customizable modular unit allows flexibility in all aspects of design. Utilization of sustainable products aids in producing a smarter, efficient prefab home. The modular unit is 15 - 20 % cheaper than a home with similar square footage.
From 1908 to 1940 over 100,000 kit homes were sold through the Modern Homes mail order catalogue. Over 447 different designs were developed by Sears's designers. Characteristics of the homes were diverse, ranging from straightforward one-room structures to intricate multi-family multistory units. These designs were not groundbreaking, yet they fulfilled the needs of the consumer; focusing on hardware, appliances, finishes, and furnishing sets. The diversity in clients allowed for Sears to develop three different levels of home lines relative to their quality: Honor-Bilt, Standard Built, and Simplex Sectional. The Sears homes were innovative for the time period through the use of drywall and asphalt shingles, and for introducing central heating for residential use. By utilizing the railroad to transport the materials to the consumer resulted in a majority of the homes can be found near the rail lines.
[Cold Swap]
The total shutdown of a computer system, as it relates to the prefab architectural components, is similar to the necessary steps needed to upgrade or repair a structural column grid, foundation system or service core. This classification sets constraints for the way the architectural assembly will be constructed. Certain components once set within the system will require complete shutdown to be modified.

[Warm Swap]
The structural frame and the module assembly, which depending on how the configuration is arranged dictate which different swap conditions would apply.
Hot Swap

The panel of a prefab assembly is similar in that, system can continue to function if a panel is removed. Integration of the panel into the other components is paramount for the Hot Swap system to function.

The panel will allow the Hot Swap home the flexibility to be easily upgraded, downgraded, or repaired while daily operations continue throughout the home without interference.
Pre Fab Assembly Types

The **integrated system** is a panel assembly. The panel fulfills the function of the framework and enclosure. Since this panel contains structure, removal of this panel may provide difficult if it is used as a load bearing. A panel by itself is obsolete; once multiple panels are introduced it is possible to develop spatial arrangements.

The **separate system** is a structural frame and panel assembly. The panels can be attached and removed from the structural frame without disrupting the system. With panels removed, it is possible to access the frame. The separate assembly can develop spatial arrangements through the linking of multiple assemblies.

The **module system** is an factory assembled component comprised of panels. This application is useful when specific spatial configurations can be pre-assembled. Due to the nature of installing a module, the system may be interrupted for a short period of time. If the module is an addition then the downtime may not exist.
Current trends in consumer customization show the application of a base being modified by the consumer; cars, clothing, computers, electronic gadgets, architectural building components, and residential homes give the consumer multiple options to apply to a base model.

These personal specifications are inputted into the system and calculated accordingly. The end result is the a personalized product; the consumer feels the satisfaction of designing a product suited to his/ her style. This application of personal input into a base model allows a variety of individualized products to be created.
base product + personal specification = individualized product

Configuration & Customization

HOT SWAP
The average household size was approximately 3.38 occupants per home. This results in approximately 874.5 square feet per person.

The average household size was approximately 2.63 occupants per home. This results in approximately 724.3 square feet per person.

The average household size was approximately 3.11 occupants per home. This results in approximately 482.3 square feet per person.

The average household size was approximately 2.38 occupants per home. This results in approximately 874.5 square feet per person.
The family life cycle is in direct correlation with the progression of square footage as it relates to American housing. An increase in family size leads to an increase in square footage needed to live comfortably.

To gain this needed space two options exist: move to a larger home or update the current residence. If it was possible to upgrade or downgrade as the occupants lifestyle required, would the problem of wasted space within the larger family until home disappear?
The utilization of the Grasshopper plug-in for Rhino allows dynamic control of various constraints and components to be used with a Hot Swap system. By inputting the proper information into the model, selected inputs can be manipulated which produce multiple formal configurations. These configurations, with set constraints, can be rapidly updated to visualize future alterations. With this modeling system in place, it is easy for the Hot Swap system to be visualized as it corresponds to the multiple ways it could be upgraded, downgraded, or modified as the users needs change.
Grasshopper Integration

Dynamic Formal Configuration Control: Structural Grid

Dynamic Formal Configuration Control: Site
Dynamic Formal Configuration Control: Growth and Postion
Once a site is selected, the dimensional parameters can be entered into the Grasshopper inputs. These dimensions are based on the parcel lot size dictated by the development. The structural grid point field can then be overlaid. The structural grid point field is spaced at 16' increments. This dimension is flexible to a degree; multiples of four are needed to comply with the panel size.

With the structural grid point field set, inputting the proper site setback information is necessary to comply with city zoning regulations for residential construction. After the setback information is entered, the buildable site is developed. This area can be manipulated to develop multiple configurations, which can be used to forecast future development when changes in the user's lifestyle permits.
The division of the structural grid point field is arranged to allow flexibility. The system permits change by setting parameters to divide the space between the grid points.

This example above is currently arranged to accept a 4' panel, but could be configured to accept a 8', or 16' panel. This space will allow for the system to either adopt large sections of panel assemblies, or single panels.

This flexible configuration aids the overall composition of the system by providing the ability to remove individual sections of panels as needed.
The divisions from the structural grid spacing allow for the panel configuration to be extruded from these exact locations. The amount of extrusion is a flexible parameter which can easily be modified to a specific height. This extruded height can be developed to situate a structure which is composed of only one floor, thus providing a base for a roof system. An additional configuration exists by allowing the extrusion height to act as structure support for a second floor.
The second floor configuration is semi-dependent on the first floor configuration. The arrangement can be manipulated to develop a separate assembly which can be arranged within in the boundary of the first floor configuration. Within this configuration the arrangement can be displayed in a variety of different designs. It may also be developed on its own merit. This is possible by using the structural grid point field as indication points to where structural supports will be needed.
1st Semester Iterations
Panel Break-down
Structure Break-down
Assemblage
Panel Swap Process
Growth of the Home
Final Designs
1st Semester Iterations

connection to column

connection to floor plate
connection to column [detail]

panel types

initial panel configuration
The Hot Swap panel plays the key role in developing a home which can be upgraded/downgrade or repaired. Without the panel the Hot Swap system is non-existent, and the system is reverted back to a strictly module based system.

For the Hot Swap panel succeed it need to accomplish these goals; be easy to install and have the flexibility to attain multiple configurations.

1 ease of install

The Hot Swap panel has two components which secure the panel from movement and prevent environmental elements from penetrating, the locking gasket and the locking mechanism. The locking gasket forms a tight seal between connections from a panel to panel, or a panel to column. This gasket would be replaced and renewed each time a panel is swapped. The locking mechanism is located on the upper most portion of the panel, and only accessible from the interior portion of the home. This is to prevent would be thieves from removing portions of the home.
Leasing Options
With the Hot Swap system the homeowner never owns the panels. The panels are leased to the consumer. This is so that the Hot Swap panel can always be upgraded to the most efficient materials on the market. With the leasing structure in place consumers can always guarantee that the materials used in their home are the most energy efficient and environmentally friendly. Leasing also provided the consumer the option of removing portions of their home and trading it in during tough financial times.

multiple configuration
The Hot Swap panel has been designed so that multiple configurations can be achieved, which results in a variety of architectural possibilities. The panel can be developed to achieve any particular type of opening one might want.
Structure Break-down

The structural system for the Hot Swap system is composed of HSS steel columns and W-shaped steel for beams. The connection type between the two structural members needs to be bolted connection. This is so the system can be easily installed into the structural foundation points. Also the system needs have the capability of disassembly in the event the home owner wishes to upgrade or downgrade their home.
The core within the Hot Swap system provides a fixed centralized location for services to enter the residence. The nature of the core allows the system to still be flexible in the event of a system change. The core supplies all necessary HVAC, plumbing and electrical services to the residence through the floor panels.
The Hot Swap home system is displayed here as a collection of parts. Homes constructed today are composed of over 40,000 pieces. Displayed above is a Hot Swap system home, which is composed of only 224 parts. This collection of components can be assembled into a 1600 square foot home.
Typical Hot Swap module
[exploded for clarity]

floor panel
beam
panel A.4
panel A.2
footing
panel B
panel A.6
panel A.3
Panel Swap Process
Swap Steps

1. Unlock panel from inside house.
2. Remove locking gasket from the exterior side of the panel.
3. Tip out and remove panel.
4. Return panel to Panel store for credit.
5 & 6. Lift new panel into place.
7. Tip panel up into previous location.
8. Install new locking gaskets.
9. Lock panel from inside the home.

Detail of locking to beam

1. Locking assembly shown with the locking mechanism in the locked position.
2. Locking assembly shown with locking mechanism in the unlocked position.
Growth of the home

- 768 sq. ft.
- 1280 sq. ft.
- 1536 sq. ft.
- 1792 sq. ft.
- 2048 sq. ft.
- 2304 sq. ft.
- 2304 sq. ft.
- 2816 sq. ft.
- 3072 sq. ft.
Final Designs
second floor
scale = 1/8" = 1'

first floor
scale = 1/8" = 1'
Final Designs
Final Designs
Final Designs
Bibliography

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