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OPEN SOURCE BUILDING



Left Post occupancy,
ad-hoc personalisation of
mass housing in Taipei.

Text by Kent Larson.

The individual design of living space today involves much more than the mere selection of furniture and fittings. Modern interfaces between client, architect and manufacturer allow the customer himself to be the architect of his own idea of how to live. In the following article, Kent Larson from the Massachusetts Institute of Technology in Cambridge, USA, describes a new approach to mass customization in the construction industry.

THE MASS-HOUSING blocks of Taipei, as conceived by their architects, are dreary and monotonous. These banal buildings, however, become the backdrop for extraordinary creative expression. In an ad-hoc and probably illegal manner, windows become bays, bridges are added, and balconies are infilled with an endless variety of forms, materials, and systems. Some show a meticulous attention to detail while others look like death traps. But the whole reveals, at the scale of the city, a powerful desire of individuals to create personal and unique places of living.

While not expressed in the façades of U.S. and European buildings, this desire is revealed in the hundreds of books, magazines, and television programs devoted to home design. Companies like Ikea, Home Depot, and Lowe's exist largely to tap this do-it-yourself market. The housing industry, however, has not found a workable strategy for meaningful customization.

Other industries are rapidly adapting their products and processes to respond to the market demand for customization. Car websites encourage visitors to 'build and price your car'; Dell has become the most successful PC manufacturer by producing tailored computers for individuals; the New York Times allows online members to 'create a customized news alert'; Nokia offers interchangeable faceplates to personalize mobile phones; and clothing and shoe companies can scan your body to create personalized products. Many of these companies are, in effect, integrators who form business relationships with a network of strategic partners and suppliers to offer 'batch quantities of one' personalized products. They provide consumers with increasingly sophisticated configuration and decision-making tools for customization. Speaking at a National Association of Home Builders conference in 2002, William Novelli, Executive Director and CEO of AARP, said the following about baby boomers and housing, "They love choice: set up the smörgåsbord and let them help themselves. They will. They want information – and the more sources the better because they are not afraid to make decisions – but only on their own clock and on their own terms."

The existing process and fee structure of housing development, however, makes it largely impossible to address the unique design problems of individual residents. Architects typically focus on planning and the exterior envelope, while

creating generic living spaces. But the idea for architectural customization is certainly not new. Mies van der Rohe suggested in 1927 that "if one limits only the kitchen and bath as standardized rooms, and the remaining living area with movable walls, I believe that any justified living requirements can be met." Walter Gropius, founder of the Bauhaus, wrote in 1910 that industrialized construction processes could "meet the public's desire for individuality and offer the client the pleasure of personal choice."

Today, the need for meaningful personalization goes well beyond the satisfaction of desire. The home is rapidly becoming a center for proactive health care, distributed energy production, work, commerce, entertainment and learning. Homes in the future will likely contain the most complex activities of any building type. It can be argued that many of the looming societal problems due to demographic pressures and energy shortages must be addressed by finding a new model for the cost-effective tailoring of the form, technologies, and services to meet the needs and values of individuals.

OPEN SOURCE BUILDING

We believe that it is now possible to increase the quality, responsiveness, cost-effectiveness, and formal richness of residential architecture by taking advantage of the new tools of our epoch: inexpensive computation, powerful algorithms, almost-free electronics, the internet, high-performance materials, and new design, fabrication, and supply-chain technologies. We propose a new model for design and construction, called Open Source Building model, with six underlying concepts:

- 1 Integrators partner with developers to offer branded, tailored solutions to individuals
- 2 Buildings are disentangled layers of integrated assemblies
- 3 Manufacturers agree on interface standards and become tier-one suppliers of components
- 4 Builders become assemblers
- 5 Architects design design-engines to efficiently create thousands of unique environments
- 6 Customers (home-buyers) become 'innovators' at the center of the process by receiving personalized information about design, products, and services at the point of decision.



RENDERING BY LARSON 2003. SCALE MODEL MCL EBS1/2003

In this chapter, we summarize the work of the MIT House_n Research Consortium to prototype and test selected design, decision-making, and construction systems that support this new model.

CHASSIS AND INTEGRATED INTERIOR INFILL (I3)

GM's well-publicized HyWire concept car is conceived as a standard chassis common across their entire product line, with highly customized 'infill' (the body parts, finishes, electronics, etc.) often provided by 'Tier-1' suppliers. Personal computers are built with a similar strategy. No comparable approach, however, can be found in the design and construction of buildings.

The MIT House_n Group has developed prototypes to separate a building into a 'chassis' (the standardized structure, power, data, and plumbing of a building) and 'infill' (apartment interior fitout that are customized at the point of sale by the individual and connect in standard ways to the chassis).

A variation of the chassis/infill strategy was used to create an apartment-scale research environment to study the interactions of people with new technologies. The PlaceLab, an MIT House_n plus TIAX LLC initiative, consists largely of prefabricated, customized cabinetry components with accessible connections to the building 'chassis'. These components house sensing, communication media, lighting and control systems.

We envision a future where individuals could tailor their physical and computational environment according to their needs and values via customized Integrated Interior Infill (I3) components, each with pre-installed, tailored technologies.

RETHINKING THE DESIGN PROCESS FOR RESPONSIVE PLACES OF LIVING

The customization of homes is significantly more challenging than the mass-customization of individual products since the users of the system have a wide range of age, interests, skills, and cognitive ability. The resulting home is a complex mix of many products, some standard and some customized, that exist in the complex context of architectural form, light, and materials. Since it is not feasible for an individual designer to work closely with each resident of a large housing development, a design interface that provides individual non-expert designers



PHOTOS BY KENT LARSON

with the means to effectively make informed decisions without becoming overwhelmed by the process is essential. This involves much more than simply offering choice since, as Joe Pine writes, "Customers do not want choice. They want what they want (and generally now)."

A good designer has the ability to keep many variables at play simultaneously until converging on an integrated solution – simultaneously solving many problems, from formal to functional. We believe that home-buyers, using sophisticated decision making tools, can become 'innovators' at the center of the process by receiving carefully tailored personalized information about design, products, and services at the point of decision. In our model of design, experts create systems that capture their design knowledge and values. They are used to guide non-expert designers through complex design and decision-making problems – without requiring that one think like an expert. This approach to design decision-making for non-expert designers involves four integrated components:

PREFERENCE ENGINE

A preference engine takes people through a series of exercises or games to uncover needs, preferences, values, and reasonable tradeoffs – what might be called the architectural program. The preference engine builds a user profile that includes family size, budget, aesthetic values, and range of activities. To prototype and test various strategies, we built a digital table that projects images and data from below onto a luminous surface, and uses sensing to recognize gestures and optically tagged architectural component scale models.

DESIGN ENGINE

The design engine is a computational algorithm that makes use of the preference engine data to create a starting point design that the 'designer' (i.e. the future homeowner) then refines.

We envision many design engines, each capturing the unique values of a particular architect. We have experimented with several strategies, ranging from a simple decision that finds a best-fit among a series of pre-developed solutions, to a more complex and unconstrained design system.

Opposite (far left) Scale study model of the building exterior.

Opposite (top right) PlaceLab interior, showing Integrated Interior Infill (I3) fit-out. Each of the 22 interior components contains a micro-controller, sensor bus, and a variety of state change sensors, environmental sensors, and communication devices.

Opposite (bottom right) PlaceLab interior testing one aspect of Open Source Building: Integrated Interior Infill (I3) components with sensing and addressable lighting infrastructure. Shown are hinged, accessible sensor bus raceways. All cabinets use the same embedded connections and technologies, simplifying installation and increasing flexibility. The facility contains hundreds of modular sensors.



PHOTO BY KENT LARSON

Left View from above of digital table showing plan, information display, tagged physical components, and continuously updated feedback about design.

DESIGN ITERATION INTERFACE

Using one of many possible design iteration interfaces, customers can experiment with design alternatives, and evaluate a complex mix of elements including form, finishes, lighting, health technologies, appliances, comfort systems, and services.

House_n researcher T.J. McLeish developed a design interface prototype where the users have various tools to help them understand the design and its implications:

- Conceptual views: diagrammatic floor plans showing the relationship of spaces and elements.
- Tangible objects: optically tagged scale physical objects placed on the plan. These objects provide the means to move architectural elements and furniture to study alternate arrangements. By physically moving or replacing scale objects, the displayed views and information is continuously updated. The views of the design are updated by moving a physical scale figure.
- Perceptual views: as the physical objects are moved, a ten foot-high projected perspective rendering showing form, light and materials is updated in real time. This presents the solutions as perceived by an individual standing at a particular spot at a particular time of the day.
- Data: the alternatives can be evaluated according to cost, performance, durability, etc., including data provided directly from the manufacturers.

COMPUTATIONAL CRITICS

While iteratively exploring a design solution, most non-expert designers will require feedback from experts related to best practices, building codes, and design integrity. Since face-to-face interaction between a skilled architect and client is typically not feasible for housing developments, we envision a system where architects provide software 'plug-ins' that non-expert designers can use to get real-time feedback as they make changes to their designs. While code requirements can be rule-based, capturing the more subjective values of a designer may require a more open-ended approach. Computational critics can provide feedback to the user as incremental changes are made to the design. House_n researcher Reid Williams implemented a prototype of a computational critic system that runs with the design iteration interface described above.

Once the design is set, specifications for standard products can be sent directly to the manufacturer, and machine data can be sent directly to millwork fabricators, for example, for the production of customized or mass-customized components.

STANDARDS

Widely available, highly customized places of living will only be possible if the design and construction industry collectively agrees on standards for how building components and systems connect. This would involve standardized interfaces for power, data, plumbing, and mechanical attachments as is common in the electronics industry. It would allow interoperable assemblies with sufficient economies of scale to increase quality and reduce costs. This approach may transform how homes are created over the next 10–15 years, and create new pathways into this \$300-billion-per-year-market for companies producing materials, products, and services for the home. It could create the ultimate mass-customized product: highly personalized living environments comprised of a complex integration of customized, mass-customized, and standard integrated assemblies.

Kent Larson is principal research scientist at MIT's School of Architecture and Planning. He is director of the Changing Places research group and the MIT Open Source Building Alliance. Larson has practiced architecture since 1981: in partnership with Peter L. Gluck from 1981 to 1995 in New York City, and as Kent Larson Architects, PC from 1995 to present. *Architectural Digest* selected his firm as one of the 100 architects for residential design, and his designs have won numerous awards.