USER PARTICIPATION AND MASS CUSTOMIZATION AS KEY FACTORS IN THE FUTURE RESIDENTIAL BUILDING

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Abstract The adoption of mass customization concepts, new manufacturing technologies together with the user participation, can open up an opportunity to the future residential buildings to achieve both a status of art and commodity, breaking the typical dichotonomy in architecture and meeting the individual needs and values of the future clients .The paper emphasizes on the concept of introducing the design as critical selling point where the customers can make their choices and changes through an interactive Web site exploring how mass customization and co-design will affect the architectural design / construction process of the residential multi-storey buildings**.**

1. Introduction

The information age has created opportunities never before available, connecting information, people, products and tools in a comprehensive, open source format. Information and technology made it increasingly possible to 'mass-customize' and to rapidly respond to the consumers with customized products at mass-production prices, where the design becomes a client centric process.

New ways of design and construction are being developed to meet the individual needs and values where mass customization and new manufacturing technologies are opening up an opportunity to change the image of the fantasy vision of the manufactured residence which has a poor artistic taste and cheap construction and still remains a sterile and technologically inept product that pales in comparison to other fields of investigation (Figure 1)

The CAD/CAM technologies are streamlining the process of manufacture, changing the model from mass produced similar products to

mass produced dissimilar objects, with the same cost of similar objects. The residential architecture industry is moving in the direction of On- Demand manufacturing, rapid prototyping, visualization tools and direct linkages. These new tools are changing the ways consumers realizing and customizing their own future residences. (Schodek et al, 2005)

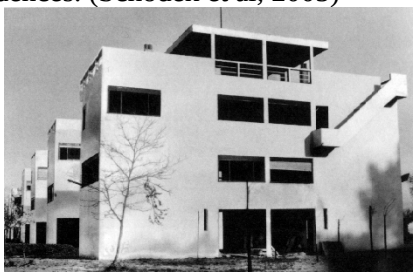

Figure 1. Pessac Housing. Source:www.arth.upenn.edu/spr01/282/w5c2i11.htm

1. Commoditization of residences

2.1. FORM MASS PRODUCTION TO MASS CUSTOMIZATION

The industrial revolution had a great influence on domestic architecture at the first half of the century and a machine made future captured the imagination of the architects at that time .It was characterized by the statement of the house was a “Machine for living." But after the turn of the 21st century, commoditization of residences became possible with the help of mass customization which makes the building once again can be seen as both art and commodity (Figure 2).

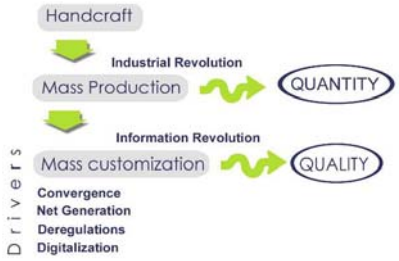

Figure 2. The 3 phases of commoditization and the macro trends driving this revolution
Source: Researcher

1.2 MASS CUSTOMIZATION AND USER INTEGRATION

"At the beginning of the twenty-first century machines have taken the place of humans for the production and actual execution of the building elements.

And now, based on digital techniques, we are able to establish a very similar peer to peer network of machines communicating with each other to produce an endless variety of different building elements, visually rich and complex, but still based on a set of simple rules. Humans connect to the machine-to-machine communication through conceptual interventions and through a variety of input devices. This process is called mass-customization, based on file to factory (F2F) production methods. Now everything is different in absolute size and position, not because of human non-accuracy, but thanks to computational processing of diversity."(Oosterhuis,2005)

The success of the idea of mass customization lies in the co-designing of the customer, where the customers are integrated into value creation by defining, configuring, matching, or modifying an individual solution. Different possibilities for building up a lasting relationship between the manufacturer and the customer are being established through customer's co-design in a mass customization context. The idea of integrating users into the design and production process is a promising strategy for companies being forced to react to the growing individualization of demand (Piller et al) such as the future construction industry. In the mass customization concept, goods and services are to meet individual customer’s needs while being produced with near mass production efficiency. (Tseng, and Jiao, 2001)

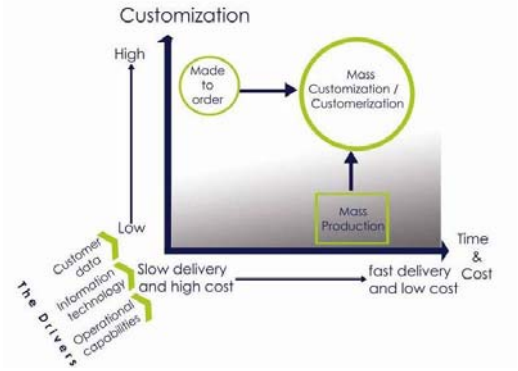

Figure 3. The Mass Customization Paradigm – Source: (Wind, 2001)

Mass customization is often connected closely with the capabilities offered by new manufacturing technologies reducing the trade-off between variety and productivity (Figure 3). 'But the main distinctive principle of mass customization is a mechanism for interacting with the customer and obtaining specific information in order to define and translate the customer’s needs and desires into a concrete product or service specification' (Piller 2003) .This will lead the customer to integrated effectively into the value creation of the supplier. (Zipkin.P, 2001) .Without the customers' deep involvement, the manufacturer would be unable to adequately fill each

individualized product demand. Co-design is the core element that differentiates mass customization from other strategies like agile manufacturing or postponement strategies in the distribution chain. (Ulrich,2003)

Clients can play potentially an important role through sharing in the design process by participating efficiently in a participatory decision making process what will enable them experiment different design transformations and expresses their views over main issues. Providing clients with choice creates competition and incentives for innovation. This will be flourished by entering the new concepts of mass customization into the building industry.

Mass customization will create a pathway for new players to enter the construction market.(Larson,K et al . 2004)

"Digital technologies are driving architectural practices in ways that few were able to anticipate just a decade ago. Digitally driven design process characterized by dynamic, open ended and unpredictable but consistent transformations of three dimensional structures are giving rise to new architectonic possibilities .The generative and creative potential of digital media, together with manufacturing advances already attained in automotive, aerospace and shipping industries is opening up new dimensions in architectural design generally and precisely in domestic architecture." (Kolarevic, 2003)

1.3 IDENTITY ASSERTION AND 1:1 MARKETING

Identity assertion is important to human existence and influences how people shape their public and private environments. Identity it intimately found in our homes and in the community where we belong to. This important aspect is pointing us to new modes of self expression where the future home should be explored in relation to emerging technological opportunities. Identity assertion can be applied by the adoption of the concepts of 1:1 marketing or (personalized marketing). It is a Customer Relationship Management (CRM) strategy which can be defined as an information industry term for methodologies, software, and usually internet capabilities that help an enterprise manage customer relationships in an organized way, emphasizing on personalized interactions with customers. (Demchak, G.2000)

2. The Open building concept

Market studies indicates that tomorrow's generations are demanding more sophisticated, more choices and tailored solutions in homes that closely reflect their values and needs(Vance, K.2004). In addition to adaptation as family financial and health conditions change and accommodate rapidly

evolving technologies and services in the home. This generation has a deeper understanding and comfort with technology than their parents. Generally human behavior resists convergence, but a whole new generation who already “buy in’ to convergence are coming of age. The future of home technology products depends not only on advances in components, but also on how people's expectations for them evolve.

2.1 LEVELS OF DECISION MAKING

The concept of levels is the central idea of Open Building. Three levels of decision making are distinguished; the being tissue, support and infill. They are separated, yet co-ordinate. In this paper our concern in infill level .The Open building method is based on variable apartments , which vary in size depending as family size and lifestyle .The variation in sizes mainly derives from the space measurement and non-load bearing walls (Kahri ,E. 2000)

2.2 SYSTEMS AND SUB-SYSTEMS

Within the residential building block, a distinction can be made between the support and the infill, systems and sub-systems. (Cuperus, Y. 1996). A residential building is a system, consisting of many sub-systems, such as the load bearing construction, inner partitions, facades, roof, plumbing, electrical and mechanical engineering and so on. Systems building can be seen in a form of an open structure which is a result of disciplined integration of independent subsystems. Such structures have form of an open system that permits continuous changes and additions, these subsystems have different life cycle. (Brouwer & Durmisevic, 2002)

2.3 LIFE-CYCLES

The future residential buildings that depend on the Open Building strategy developed for mass customization of buildings contain parts with different life-cycles, that can be replaced independently (Figure 4).

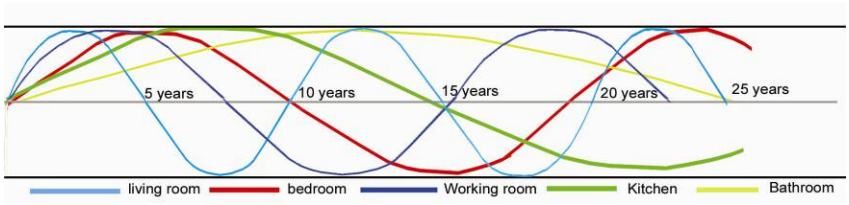

Figure 4. Pulse of the dwelling –the spatial organization of a dwelling changes in a period of 5-25 years. Source : Durmisevic & Linthors ,2000

The OB separates the building into a chassis ('support') and infill ('fit-out').They can be treated as separate entities, with different life cycles, in order to build an environment that can respond to individual needs of the resident. This flexibility can be obtained wither by spatial or technical. (Cuperus, Y. 1996).

3. The chassis and infill system

The need for change is market phenomena on the turn of the 20th century. As a result of changing life styles the diversity of housing use requirements is increasing and demanding more flexible solutions. Conventional building structures are not designed for change .For that reason every transformation with in the home has to do with demolition of a part of a building or sometimes whole built structure.

In order to increase buildings transformation capacity building construction should be focused on further systematization of building and development of innovative building methods that will provide flexible structures whose parts could be easily replaced, reused or recycled. The chassis/infill approach (Figure 5) has been developed to allow every home to be unique, and to efficiently accommodate new technologies and change over time. (Larson & Intille, 2004)

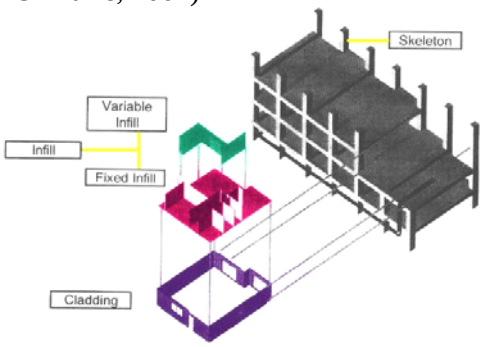

Figure 5. Composition of skeleton, infill and cladding .Source: Yasueda, H.2000

3.1 THE CHASSIS

It resembles the skeleton ; the immovable part .The chassis contains the prefabricated assemblies: structure, , power, insulation, built in sensors, communications network power cable raceways, ductwork and connections.(Figure 6) The mass customized infill components can be quickly installed, replaced, and upgraded without disruption. It must be extremely durable and flexible. (Wacks, K., 2003)

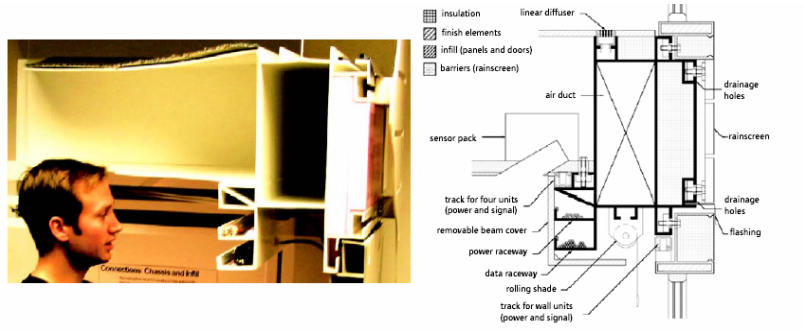

Figure 6. House_n pultrusion chassis — full-scale model (left) and detail drawing (right) of a prefabricated pultrusion chassis showing beams, column, connectors, raceway for power and data, attachments for exterior wall and floor, housing for equipment, exteriorinsulation, and linear diffuser . Source : (Lawerence , 2003)

3.2. THE INFILL

It can be defined as any freely changeable part that is configured by the user. It can be altered by the resident whether plan, installation of fixtures and finishing .It is composed of mass customized modules containing sub systems for power , communications , lighting , environmental sensing and HVAC systems . which can be classified into the ; a) variable Infill such as movable storage, variable interior partions, wirings and fittings ; b) fixed infill such as exterior cladding , fixed storage units like closets , ceiling and floors.

The interior infill technology is generally characterized by five concepts, a) reduction of unit area and providing scalability ; b) allowing flexible modification of the floor plan; c) utilization effectively of the available space; d) alteration of the intended use ; e) minimizing the environmental load.(Ohara and Suzuki;2000)

To make continues customization and reuse possible of a dwelling , there are five types of requirements needed to be satisfied; a) Changing floor plan; moving partitions to rearrange room layouts for different use, b) changing infill elements ; reconfiguring infill elements like wall,door,window,etc. for better spatial quality in terms of changing size,shape or material, c)expanding spaces: enlarging existing interior spaces to the limit of given structure, d)Maintaining existing functions: replacing deteriorated components of facilities with equivalent products .e) upgrading performance: renew components or facilities for better performance by new products.(Lin &Wang , 2000).The infill can also include parts of the façade .The facades can be designed to incorporate a variety of infill parts chosen by the tenant , while the support was designed so that a chaotic appearance could be avoided .

4. Experiment Project House-ID v.2

The experiment is an extension to a project called House-ID v.1;one route software, which presented how the client can participate in the design of the a single family house composed of two levels .This experiment presents how the client can co-design his own living environment within a multi storey building. The essence of project House –ID v.2 lies in the open building .The open building concept aims to use cost and quality benefits as a key factor to "mass customized" production . This type of production will require a flexible management and production system.

The proposed system depends on the idea of flexibility in design which has the capacity to install various kinds of replaceable and exchangeable infills (By replacing infills and building services, residential building could be upgraded over time during its lifecycle .It is expected that the benefit contribute to the improvement of functional sustainability of residential building . Customization can be found in the prefabricated units or in the design of the spaces it's self

4.1 THE DESIGN PHASE

The architect / design team passes through a series of steps. It can be classified into customization by introducing the infill level through design/modeling and programming / deploying the model on a the residential project website (Figure 7)

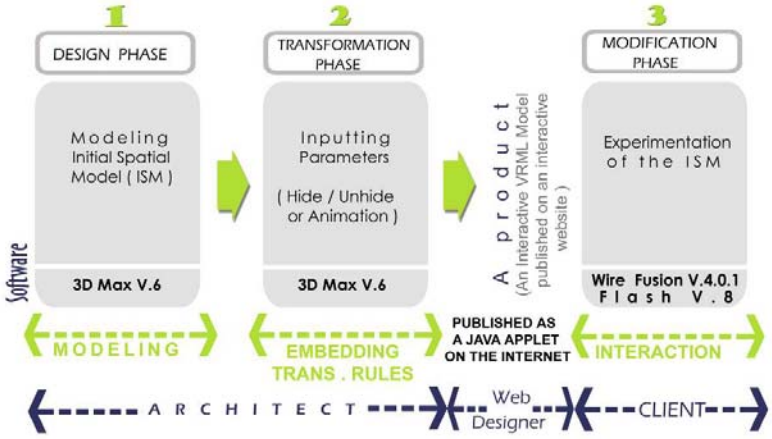

Figure 7. The process of producing an interactive model with embedded transformations ready for the non expert designers; users to experiment it -Source: Researchers

4.1.1 Customization by introducing an infill level

Customization of units whether small or medium or large can be realized if an infill level is clearly designed inside the units (Figure 8).In this paper the researchers present customization within the geometrical composition of the infill level. The floor plan of the unit can be divided freely into 3 types of apartment variations; small, medium and large.

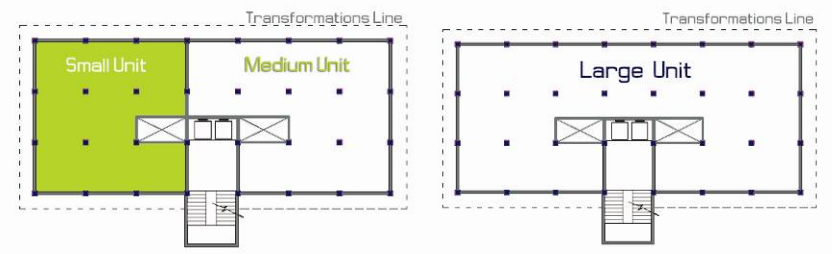

Figure 8. The Skeleton plan of project House-ID; illustrating the 3 Units types in the residential building – Source: Researchers

Pre-designed optional floor plans are being prepared for each unit due to estimation of the users requests (Figure 9). Depending on the concept of open spaces area, the spaces are divided into open spaces (OS) and wet spaces (WS). The apartments are sold as one open area, with wet spaces planned (Kitchen and bathrooms) which in this case can then be exploded by the user if decided to make changes, (Figure 10).

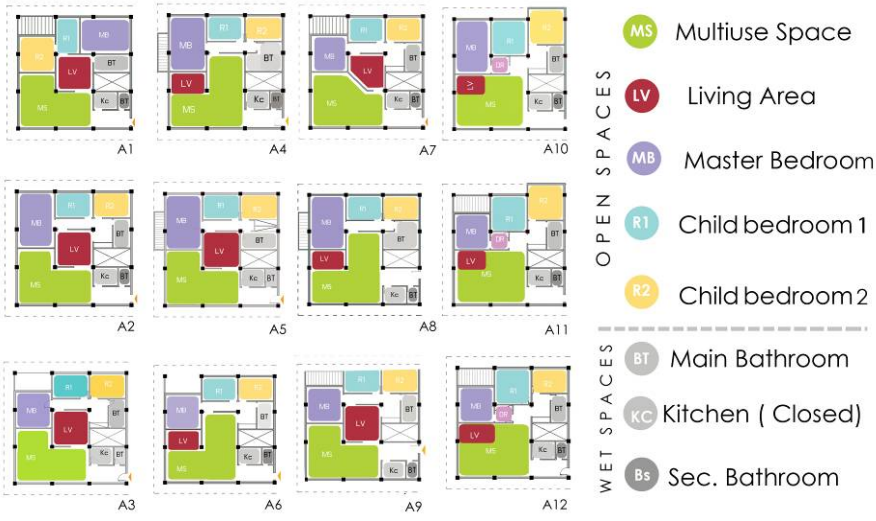

Figure 9. Examples of Apartment A plan variations resulting from user participation. Source: Researchers

A transformation guide is being proposed around the apartment level gives the client the flexibility to make some future transformations which may increase the overall area of the apartment. This flexible area will open options for future changes or even changes that may occur during the client's participation in the design process. This guide is being designed according to the elevation study which may vary from a level to the other in order to avoid the chaos facades.

Figure 10. Open Spaces .Source: www.madinaty.com

The client can potentially play and important role through sharing in the design process by participating efficiently in the design process at an early stage (Table 1) .The proposed infill variation exploration system is expected to be divided into two phases of research; a) geometric composition and infill variations , b) future upgrade variations.

TABLE 1. An example of the tracked changes due to the resident's participation
Source: Researchers

Apt	I/T	Open Space							Wet Spaces		
		RC	D	MB	R1	R2	LV	E	BT	Kc	B
A1	Initial Position	●	●	●	●	●	●	●	●	●	●
	Transformation										
A2	Initial Position	●	●				●	●		●	●
	Transformation			TG/S+	R-S+	TG/S+			R		
A3	Initial Position	●	●				●	●		●	●
	Transformation			TG/S-	R-S+	TG/S-			R		
A4	Initial Position		●					●		●	●
	Transformation	TG	C	TG/S+	R	TG/S-	TG/S-		S+		

The design tool will act as an interface between clients and user specific solutions. All variables in this initial phase of the design sequence can be adjusted at any point in the process. Depending on Permutation laws a number of proposals are being expected to evolve due to the user's participation.

Different transformation rules are being modeled with 3D max v.9® such as scale (S+ ,S-) , rotate (R) , toggling (TG) , changing shape (C),etc. (Figure11).These rules may differ from a project to another due to the vision of the design team. Mapping variables into a spatial grammar will reveal organizations and formal expressions that relate directly to client-initiated decisions.

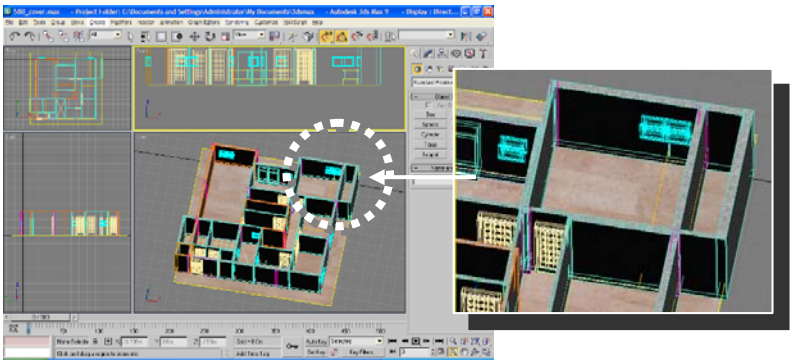

Figure 11. Modeling the initial model and embedding the transformation rules on the model. Source: Researcher

$$X1\,P\,Y1 \times X2\,P\,Y2 \times X3\,P\,Y3 \times X4\,P\,Y4 \text{ ----------etc} \quad (1)$$

P: Permutation - x: number of probabilities – y: selected case

4.1.2 Programming and deploying the model

The transformations rules which have been applied to the 3d model in the 3D Max becomes live on the internet through a software called Wire Fusion V.4.0.10; a drag & drop visual programming tool developed for creating advanced , interactive and dynamic Web 3D presentations and is capable of handling real-time image processing.(Figure 12) It has a comprehensive visual programming environment which allows non programmers (architects) to create advanced logic quickly without any prior programming or scripting skills. The high performance interactive, dynamic presentation can reach a very large internet audience. The website on the internet helps transmitting and exchanging information efficiently and effectively with initial clients in order to take advantage of multi directional exchange between different participants in the design process and the most updated information available.

By applying the previous steps, it is easy to create an easy presentation to the website, that contains the model which the client will interact with live on the internet. Publishing HTML presentations can optionally be encrypted,

preventing users preventing the users from stealing the resources of the project

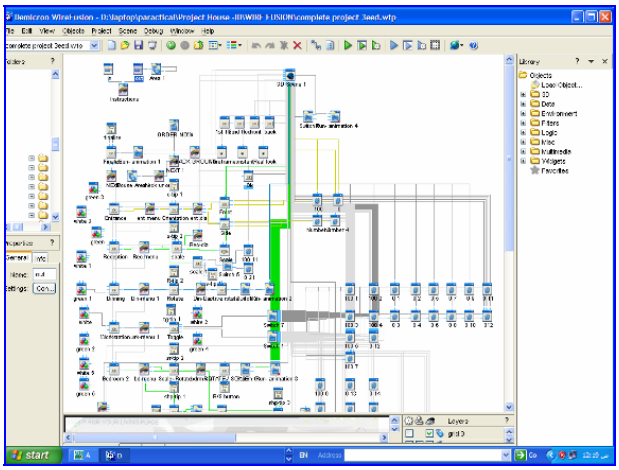

Figure 12 The programming in Wirefusion. Source: Researcher

4.2 THE USER'S PARTICIPATION PHASE

A truly user participation procedure should include an interactive design process. This approach allows the clients to concern the layout, finishes, utilities, storage etc. to be reflected in the apartment design before their occupancy so as to ensure greater satisfaction,(Figure 13) In this paper the researchers only experiment different design transformations .The client experiments 3 phases:

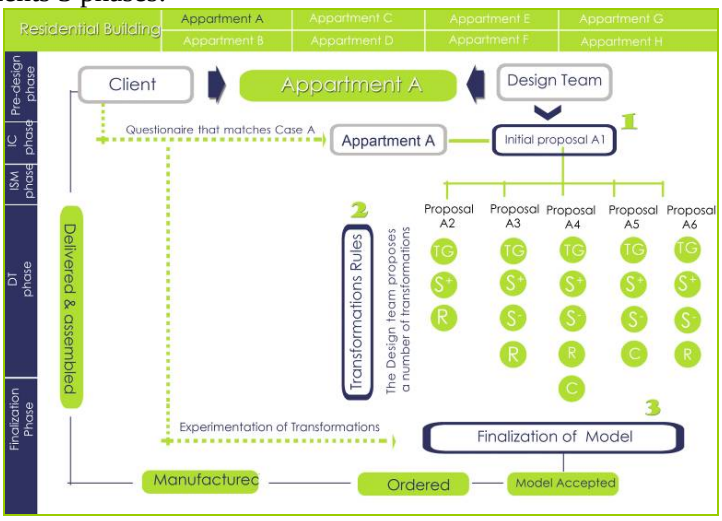

Figure 13. An overview on the process (TG: Toggling / S+: Increase scale / S- Decrease scale / R: Rotate / C: Change Shape). Source: Researchers.

4.2.1The information collection phase

The data needed from the client is being gathered at this phase about that is by checking a The client passes through a series of information gathering sequences about his needs, values, lifestyle and design limitations within a pre-prepared interactive questionnaire (Figure 14) by the design team, which then consolidate information in the form of several design proposals .

4.2.2 The initial spatial model phase (ISM)

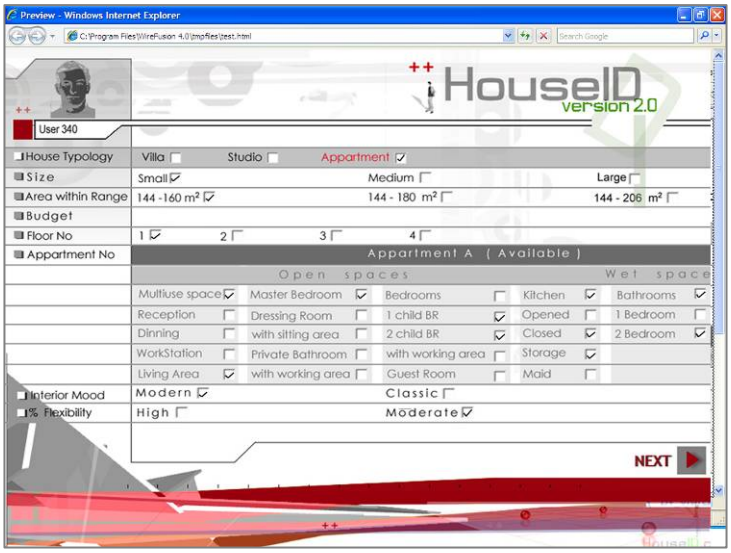

Figure 14. The Information collection phase – Source: Researchers.

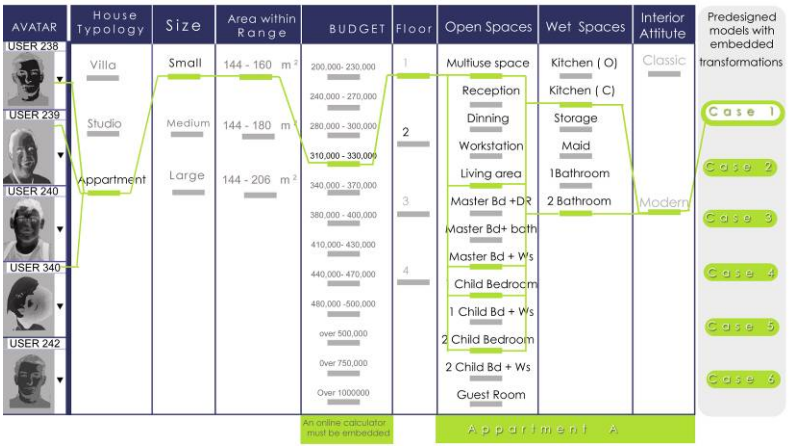

Figure 15. Customer's segmentation and linkage to an ISM .Source: Researcher

The system easily collects the input data need it about different clients and cluster them to direct them to the initial model that suites their request. At this stage many clients can be experiencing the same model but can hardly achieve the same result .This can be named as customer segmentation .It is a process of partitioning markets into groups of potential customers with similar needs and/or characteristics. (Figure 15)

4.2.3 The design transformation phase

The client explores various architectural options being proposed by the design team such as abstract geometry, symmetry, asymmetry, material / color selection or even the furniture. The transformation rules add or subtract complexity to the model based on the geometry of the initial spatial relationships generated by client information input, (Figure 16).

Once a solution is accepted, an order can be automatically issued to the housing factory. This order should include a detailed list of parts and the digital information to manufacture the parts using computer aided manufacturing techniques. At the end of the manufacturing process, these parts are transported to the site and assembled.

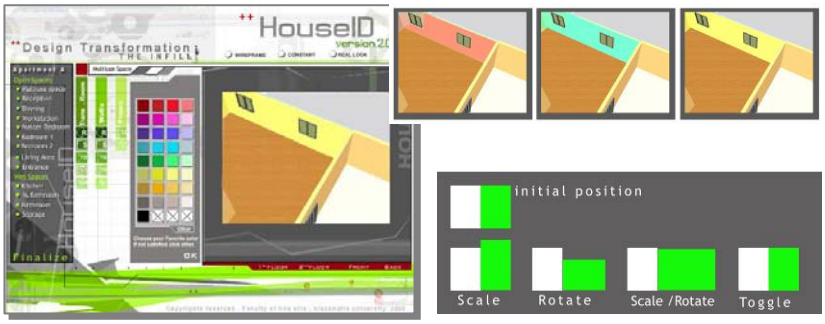

Figure 16. Color exploration and examples of geometric composition –Source: Researcher

Conclusions

The participation of the client at the early planning phase will surely maximize influence on the whole design construction process, giving him the opportunity to enjoy and experiment greater flexibility and choices in creating his own living spaces. Flexibility in design can only come by the rules predefined by the design team .Adoption of the restrictions, understanding the principles will lead to participation on many levels of process and production.

Connecting the consumer directly with industry and design/construction process can open the door to endless possibilities solutions, creating viable alternatives to current housing trends. That will lead to segmentation of

clients which helps different design companies to target groups effectively, and allocate marketing resources to best effect for a high value , customized, reconfigurable , adaptable multi family housing .

Recommendations

1. The design of future residences should be client centric where clients share in the design of their own houses and have control over the budget by using the integrated online cost calculator updates the price after every decision.
2. It is necessary to understand the expectations of various customers. These expectations are a result of characteristics of consumer behavior that changes overtime .By analyzing these changes it is possible to more accurately forecast future expectations.
3. The acceptability of mass customization under the current regulatory and funding framework needs to be addressed.
4. The opportunity to change domestic architecture into a commodity needs a new vision of process not just a product. A vision of an integrated process in which a collective intelligence replaces the architect's singular imposed intelligence must become widespread before off-site fabrication can become the standard means of architectural construction.
5. A design help must be embedded in the system as a supporting tool that can provide the client with information as an aid to the client decisions.

References

BROUWER & DUMISEVIC, 2002. *Towards dynamic building structure; Building with systems* . [Online].
Available at: http://www.4darchitects.nl/download/Beyond_Sustainability_2002.pdf [Accessed 27 September 2007].

CUPERUS , Y., 1996. An introduction to Open Building OB. [Online].
Available at: http://cic.vtt.fi/lean/singapore/CuperusFinal.pdf [Accessed 27 September 2007].

DEMCHAK, G., 2000. *Towards a post industrial architecture* .Master of Science in Architecture Studies.MIT.9. . [Online].
Available at: http://architecture.mit.edu/house_n/documents/Demchak00.pdf [Accessed 16 September 2007].

DURMISEVIC & LINTHORS . 2001. *Industrialization of housing – building with systems*. Published papers. Delft University of technology. Faculty of Architecture. Netherlands .

KAHRI , E., 2000.*Integrated open building projects ; multi storey housing system* . OBT proceedings .Tokyo .Japan

KOLAREVIC, B., 2003 . *Architecture in the digital age. design and manufacturing* . Taylor & Francis group . New York .U.S.A.p:3-4

LARSON , K. ET AL , 2005. *Open source building –reinventing places of living* . BT Technology Journal. Vol 22 No 4 .188-189

LAWRENCE , T., 2003. *Chassis + infill: a consumer-driven, Open Source Building approach for adaptable, mass customized housing* . MS Thesis, Mechanical Engineering, Massachusetts Institute of Technology.

LIN, L & WANG, M., 2000. *Technological change of infill construction for continuous customization* . Proceedings of continues customization in housing .Tokyo .230

OHARA ,T & SUZUKI , K., 2000. *SI Housing project flexsus house 22 ,sustainable housing system* . Proceedings of Continuous Customization in Housing .Tokyo.49-53.

OOSTERHUIS, K., 2005. *Programming the Point Cloud* . Architecture & Interiors lecture series at the RCA,Royal College of Art, Kensington Gore, London .1

PILLER, F & FRANKE ,K., 2003. *Configuration Toolkits for Mass Customization* . International Journal of Technology Management, Vol. 14 [Online]
http://www.mass-customization.de/download/TUM-AIBWP033.pdf [Accessed 25 September 2007]

PILLER ET AL, 2005. *Overcoming Mass Confusion: Collaborative Customer Co-Design in Online Communities.* Journal of Computer-Mediated Communication, Vol. 10.4 [Online]

Available at: http://userinnovation.mit.edu/papers/Piller_etal_JCMC_2005_collaborative_co-design.pdf [Accessed 12 September 2007]

SCHODEK ET AL, 2005. *Digital design and manufacturing –CAD/CAM applications in architecture & Design* . John Wiley & Sons .inc. Hobken. New Jersey. U.S.A.

TSENG, M. & JIAO, J., 2001 . *Customization', in G. Salvendy (Ed.)* Handbook of Industrial Engineering, 3rd edition, New York: Wiley, 684-709.[Online]
http://www.mass-customization.de/cce/info.pdf [Accessed 24 September 2007]

ULRICH ET AL , 2003. *Consumer co-design of apparel for mass customization* . Journal of Fashion Marketing and Management.V.7 . Issue 4 . P**:** 398 – 412

WACKS, K., 2003., *MIT Open Source Building Alliance* . publication in the CABA Home and Building Automation Quarterly . 1-3

WIND, J., 2001.*Customerization :The next revolution in mass customization*. Journal of interactive marketing.Vol 15.6

ZIPKIN, P., 2001. *The Limits of Mass Customization* . Sloan Management Review, Vol. 42.81-87.

VANCE , K., 2004 . "The Changing Face of Marketing in the Next 25 years"[Online]
http://www.franklincollege.edu/pwp/kvance/changingmarketing.html [Accessed27.September.2007]

www.en.wikipedia.org/wiki/Personalized_marketing [Accessed 24 September 2007]

www.obom.org/PAGES/Concepts2.html [Accessed 24 September 2007]

www.mass-customization.de/glossary.htm [Accessed 2 September 2007]

www.madinaty.com [Accessed 3 July 2007]