Rule-based spaces configuration procedures to support user-designed housing.

Dirk Donath and Luis Felipe González.

InfAR - computer science in architecture, Bauhaus-Universitaet Weimar, Germany.

caad@archit.uni-weimar.de , www.uni-weimar.de/ia r

This article reports on our current explorations on systemizable tasks of architectural design and parametric design supported by rule-based generation methods of spatial configuration alternatives to assist user-design processes of progressive development low-cost dwellings. This exploration is part of an ongoing major research towards an integrated planning support system for low-income housing; we called *Esther*, which is focused on the development of a network-based set of tools to support logistics of self-designed /-built dwellings life-cycle. *Esther* addresses the systemized collaborative work between dwellers and specialists during the whole development cycle of dwellings.

Planning tool; user-designed housing; parametric design; decision support; adaptable dwelling.

Progressive development housing for low-income households.

Self-built dwellings in continuous change (enlargement), are currently a well-advised alternative to overcome housing deficit in areas shaped by resources shortage of many South American countries. Resources optimization and self-help strategies intend to provide effective ways to generate reasonable living space for the poorest households. Therefore, instead of mass-producing very little and repetitive houses, the state subsidizes minimal dwelling units, that can evolve to individual houses by means of the progressive aggregation and adaptation of dwelling components. Dwelling components mean both, complete spaces (enlargement units) or separated elements (roofs, walls, etc). The dweller is responsible for this development, depending on her needs, means and preferences.

Nevertheless, due to low construction technology of self-builder dwellers, low standardization of dwelling components and low systemization of self-construction, this progressive development becomes very difficult to plan and further dwelling components very difficult to interconnect (adapt). Furthermore, dwellers generally lack of appropriate technical and legal knowledge. And current technical support procedures are slow, expensive and tricky. Dwellers lack of tools to visualize and to decide among design alternatives, as well as to evaluate the endproduct (home) in advance. This ends into inadequate habitability standards, inefficient cost estimation, low quality construction, and disagreement with development ordinances and security norms.

An efficient dweller support shall consist of a systemized planning process together with the standardization of dwelling components. The progressive development house has to be understood as an open system, flexible enough to accept addition, replacement and modification of dwelling components during its life-cycle.

Design constraints

Self-builder dwellers need to be able (1) to efficiently manage their resources, (2) to shape their living space by their needs and preferences, (3) to decide the most appropriate design solution (shape/function/cost/etc) among several alternatives, (4) to work within the established rules, (5) to estimate construction costs with anticipation and to optimize them. In summary, to be capable of planning their homes.

Self-designed and progressively built dwellings have to (1) respond specifically to dwellers organization, (2) be adaptable to dwellers dynamics, (3) house the dwellers with dignity and safety at every development stage, independently of dwelling's transitory size, (4) be legally constituted and proved, and (5) be cost-efficient.

The dwelling life-cycle is shaped by add-in and add-on of spaces. Connectivity between dwelling components (structure, circulations, installations) becomes determinant. Several changes of spaces function, in order to adapt dwellers organization at every development stage, demand a space feature called 'convertibility' (Haramoto, 1987) or 'capacity' (Habraken, 1998).

Unlike conventional planning, time lapse in progressively self-built dwellings (usually 10-15 years) and discontinuity between development stages, determine a very special planning modus carried out almost parallelly to construction processes.

Goals of the system

Imagine a family sitting in front of a terminal in a community center or mobile, periodically visiting removed areas. Dwellers fill some text-boxes with descriptive data, click on option-buttons and menus to choose some layout typologies, materials, etc. The user-design module, translates data into design constraints, supported by a rule-based system. After visualizing some design alternatives, getting some warnings, they change any parameter, like 'estimated cost' of a room, and the system generates a set of new alternatives that match the new value by replacing different space features shown on screen. They consult a specialist online, explaining specific queries on a 3D model linked to user database. The cycle can be interrupted and continued any time they want. At the end, they print drawings and work schedules to build the next enlargement unit.

Face-to-face meeting time between architect and client is always limited, while a computational system is infinitely patient. (Larson, 2001) A network-based system of integrated planning-relevant tools to support self-builder dwellers will reduce costs of technical support procedures, incrementing the action range, and improving habitability standards. Interactive techniques of IT will improve dwellers know-how, and ADH will improve construction monitoring and design validation procedures.

Distinguishing characteristic of *Esther* is to support the planning of flexible dwellings, adaptable to their progressive development, improving habitability standards and resources optimization.

Methodology.

The system architecture consists of three modules to support: (1) acquisition and management of planning-relevant data (DBMS), (2) user-design and cost-estimation, and (3) consulting procedures. Within the current explorations aimed at the user-design module, we first focused on defining a model of architects design procedures. Based on common client-architect dialog to plan a home, some features were included regarding cultural data and economic aspects of Chilean low-income households, like family social structure, income-generating activities related with the house, circulation/living patterns, etc. Usually, dwellers begin by knowing the next space function they need (program), then some whishes, e.g. mother wants to have her younger daughter's bedroom near hers, and a little shop near the sidewalk (topological relations). The preliminary model helped us to determine I/O data and processes involved, and some clues for user interface design. Consequently, input data sources and interrelations were determined in order to configure a data model for the DBMS module.

We set up a repertoire of enlargement units alternatives for six different dwelling functions, based on the 'Supports Design Method' (Habraken, 1976), originally created to help architects to design flexible mass housing using an infill-system. We preset the enlargement units based on the analyzed space features.

Enlargement units dimensions are organized in symmetric matrixes made up of 30cm-modulated rectangles. That solves 'capacity' in most of the cases, for example when replacing a 210x300cm living-room with a 210x300cm single bedroom, both available in the repertoire. Circulation areas within every unit supports connectivity problems. The units were modeled as CSG with a standard CAD program (Autodesk's Autocad), converted to 3D Studio files, then to VRML files. Within a network-based system,

the visualization component must be able to construct on-the-fly a 3D model, download the model to user terminal, render it, and provide fluid navigation with short elapsed time. (Rau-Chaplin, 1997)
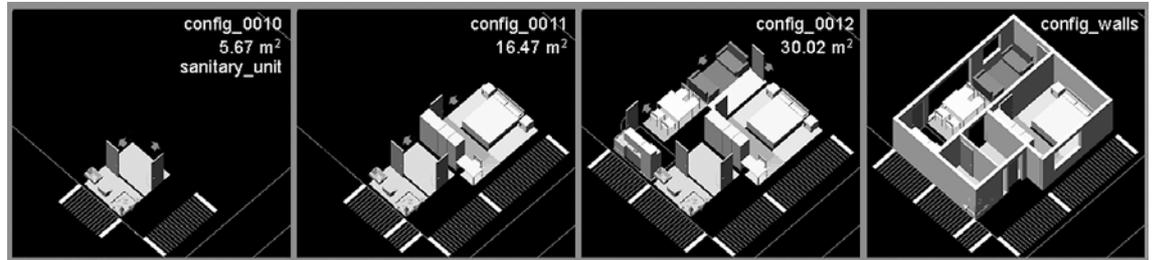

Figure 1. Progressive spaces configuration.

Based on an object-oriented approach, methods can be embedded as attributes of enlargement units e.g. to put wet rooms together reduces costs, to link them by the pipelines side, is considered attribute of the enlargement unit.

We are setting up a development ordinance model to determine further design constraints that create rules for positioning the matching enlargement unit alternative. House shape coarse layout is supported by a set of typologies to choose on screen.

Observations.

Part of mass-customization concept, feasible thanks to current IT skills, is today a promising cost-efficient and non-paternalistic way to improve, self-built housing standards, and low-income dwellers participation into social housing production. Emphasis is in the human component. Unlike 'do-it-yourself' restrictive idea of 70's Automated Design, our support concept addresses a multi-user tool that equally supports dwellers and architects, within a collaborative planning system, in order to be able to respond to this particular user group.

References

Habraken, J: 1981, *Variations: The Systematic Design of Supports*, The MIT Press (ed. 1976), Cambridge.

Haramoto, E (ed.): 1987, *Tipología de desarrollo progresivo*, FAU, Universidad Central de Chile, Santiago.

Larson, K: 2001, A New Epoch: Automated Design Tools for the Mass Customization of Housing

Rau-Chaplin, A. et al.: 1997, Graphics support for a World-Wide-Web based architectural design service, *Computer Networks and ISDN Systems*, Volume 29, Number 14, pp. 1611-1623.