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THE ART AND CRAFT OF DESIGN AND CREATION OF BUILDINGS IS UNDERGOING A RADICAL PARADIGM SHIFT.
This shift is being driven by diverse novel cross-disciplinary technical possibilities, as well as by ongoing cultural transformations. They all, directly or indirectly, originate from omnipresent advancements in information technologies. Instant and ubiquitous availability of information and immediate access to computing power pervasively penetrating our lives is profoundly transforming our culture. This phenomenon has enormous implications for architecture in a multitude of ways.

Firstly, the speed of changes that occur in modern-day culture and society makes it inconvenient or even entirely impossible to design buildings with fixed and permanent functionalities. As lifestyle patterns, production methods and environmental conditions, to name a few factors only, may now dramatically change from one day to another, architecture has to become flexible. It has to allow dynamic, active, or even pro-active adaptation and customization of spaces on many levels of its functionality.

Secondly, these profound cultural changes are not only of technical relevance. In its process-driven character, information technology strongly mandates the already widely recognized ontology of becoming, proclaimed by the prominent minds of contemporary philosophy and science. This process-oriented worldview, supported by latest technological possibilities, has caused a radical change in the common sense of the manner in which architecture has to be understood and dealt with. As an effect, it requires an in-depth reconsideration of the nature of processes of both creation and participation in spatial environments.

‘iPortals’ as a Case Study Prototype of an Evolving Network of Interactive Spatial Components
1 Architecture As An Open Complex System

For many years, alongside the developments in information technology, building automation systems have widely proliferated in architecture. These systems are usually in control of HVAC installations, lighting, security, communication or even entertainment devices in buildings. Whether structured in a centralized or distributed way, they always operate by responsively reacting to a selected set of conditions. Sometimes those conditions are as simple as a signal of a light switch being pressed. In other cases they are derived using complicated formulas from combinations of parameters such as time of day, week and year, weather data and climate conditions inside the building, all in real-time collected by a variety of sensors. In any case, systems like this are always fully predictable in their behavior. They adapt to changing conditions, but only in ways which had been anticipated and preprogrammed by their creators.

The big challenge for architecture is to go beyond such limited reactive behavior. Buildings have to be able to adapt to a much wider variety of factors and conditions, which in many cases cannot be predicted in advance. For this, building automation systems are not suitable, or at least they need to be extended with radically new features. An approach has to be found that could potentially deliver a much more appropriate foundation for creation of dynamic architecture.

In contemporary science, employment of complex adaptive systems for studying and simulating many otherwise unexplainable phenomena has proven very beneficial. Creating models consisting of autonomous discrete elements turns out to deliver systems which are capable not only of efficient performance, but in certain cases may also develop features such as ability of creative problem solving and other characteristics similar to the ones of living organisms. If applied to architectural systems, all elements constituting both; the studied building and its spatial ecology could become agents of such a complex adaptive system.

This concept ultimately leads to a model of an architectural system that operates as a non-hierarchical and dynamic network with a non-predetermined topology. Nodes of such networks may be building components, human users or other entities considered relevant for given project, which dynamically and continuously interact with each other. What comes out of this model is a vision of architecture being open, dynamic and continuously developing.

The concept of “open architecture” is by all means not a new idea. Structures found in nomadic settlements or simple slum shacks can be often easily reconfigured by their users whenever there is need for their spaces to be adjusted. However, ironically, the more technologically advanced it gets, the more likely it is for architecture to lose this adaptive quality.

Bringing back the quality of “openness” to architecture has long been anticipated by many visionaries, among which a great example is this of Peter Cook and his Plug-in City project. However, this concept only gains feasibility when combined with technical possibilities coming from rapidly developing information technologies. Another project, The Media House, a collaboration between MIT, Metapolis Group and Fundacio Politecnica de Catalunya, is a more recent example of a prototype of an open architectural system. Besides the installation’s behavior, being inherently contained in the network of elements that build up the architectural construct, the system is also open to any number and potentially any kind of possible extensions and reconfigurations. Comparing it to Cook’s project, it shares the similar idea of an open system of plug-in elements. Yet, in case of the Media House, basic elements are much smaller, thus the spatial “resolution” of the system is much greater.

Ideas presented further in this paper are an attempt to extend logics of such open architectural systems with a more diverse collection of possible building components and by providing these components with experimental sensorial, processing, learning, communicating and actuating capabilities.
2 Taxonomy And Systematics For Creation Of Complex Interactive Building Systems

Since approaching architecture as a complex system is not yet common in architectural praxis and the universally used typologies of architectural components are in most cases not suited for system-oriented design approaches, new classifications and fundamental design artifact definitions need to be reconsidered.

The empirically redefined taxonomy of design components utilized for projects presented further in this paper includes three main categories of elements found in architectural systems. These are named spaces, building components and user activities. ‘Spaces’ have been defined as nonmaterial nodes representing open volumes of buildings, their properties and affordances. ‘Building components’ category includes all material components of architectural constructs with explicit functionalities. ‘Activities’ category contains all actions of users that are to be accommodated by designed architectural systems. Systematic connections, in form of relationships and dependencies between elements coming from these three groups can be very rich and diverse; however, they can always be defined using simple rule sets.

In comparison to more traditional architectural classifications, inclusion of spaces that accommodate dynamic, user performed activities as the main, driving force and core of the system is a radical change. None of the elements of the three categories or any explicit relations between them are by definition constant.

While spaces and activities are in general hard to be classified and deliberately unconstrained in their modus operandi within the proposed system, it may be attempted to distinguish sub-categories among building components. In currently tested projects parts that are explicitly differentiated are ‘floors’—being all artifacts that allow walking on, ‘membranes’—used to connect or separate spaces in various aspects, ‘structure’—components supporting other components, ‘appliances’ which are artifacts of specific functional properties related to selected activities and ‘distributing networks’ the function of which is to distribute and supply energy and matter. These sub-categories remain nevertheless flexible and allow for creation of hybrid elements.

3 Virtual And Actual, Development And Evolution

Many design questions emerge from the presented design approach. Since proposed architectural systems are open, continuous reconfiguration becomes one of their inherent properties. No clear boundary can be drawn between design and performative phase of building creation. Design and performance of open dynamic buildings become interwoven...
and concurrent activities. Actualized and virtual building components coexist within the same system. Designer input and user input merge into one information stream.

Taking analogy from biology, the system, being open, is essentially in a state of continuous development. Because radical reconstitutions of basic properties of its components are also expected, it can be stated that the evolution of the system is also going to take place. In this case, we may ultimately achieve a situation when evolution of architectural “species” can happen during development cycle of only one of its representatives.

4 Swarm Toolkit In Protospace System As Environment For Virtual Prototyping Of Interactive Building Components

For the purpose of prototypical creation of presented systems, author’s research also includes development of a software application capable of handling interactions between autonomous digital objects of different, flexible types. Developed under the working name of Swarm Toolkit, the application can deal with a variation of object state-types, thus with elements that can multiply and diversify themselves and in this way form greater systems. Such design environment may be remarkably powerful, yet if not supported by other more specialized tools it could only be used in very early design stages. In order to enhance the system with parameters related to, for example, structural performance, cost analysis or environmental factors, it needs to be linked with other expert applications capable of dealing with more specific problems. To allow this kind of performance, the toolkit is part of a development of a system named Protospace, allowing creation of parametric, dynamic and relational semantic networks bridging diverse software and hardware platforms, possibly also at remote locations.

5 iPortals As Physical Prototypes Of Interactive Building Components

While Swarm Toolkit allows for creation of virtual prototypes, the iPortals project has been an attempt to materialize a pre-prototype of this vision in form of a network of interactive spatial installations to be placed in actively used environments. It was organized as a cross disciplinary design studio, where students of architecture and industrial design, together with tutors coming from different fields ranging from building science to communication technology were working together in mixed groups. The leading theme of the project was to reinterpret the idea of a portal in form of an interactive installation. The assignment was to create dynamic spatial constructs which in real-time interact with their users, but also which communicate and interact between one another. In this way, installations all together, seen holistically, formed a larger, open and extensible network of a distributed building.
There were two installations built in the first round of the project, interrupted by the unfortunate fire at the faculty of Architecture of TU Delft which hosted the prototypes. Two other installations have been developed during the second, partly parallel track of the project, taking place at the faculty of Industrial Design. While being built, the entire system has been evolving on various levels. The basic objective of each of the four constituting projects was to create prototypical objects which fall under the category of building membranes. Activities taken into consideration were limited to leisure-related and the dominant measuring factor used to determine their states was the continuously recorded intensity of movement of people. Spaces affected by installations were not predefined, since objects were designed to be installed at varying locations. In this way the system was bound to certain activity types, but not to any particular spaces. The development of the network has been achieved by gradual addition of components. Its evolution was reached by manual, gradual improvements to the installations, both in terms of advancement of their physical performance and continuous re-designing of their behavior.

5.1 THE LEAVES PORTAL

The original idea of the project was to build an interactive surface that would curl up from the ground and form an interactive spatial landscape. Eventually this concept has evolved, from the design of one surface to a distributed system of smaller objects, interconnected to operate as one entity.

Three different behavior states of the leaves were defined and related to different action patterns of passers by. The stand-by state would occur when no users were present in the surrounding, in which the surface elements remained stretched flat on the ground. The passage status occured, when users passed without stopping through the space in which the elements were situated. In this state surfaces would start to play simulated or real time sounds coming from other portals and begin to move accordingly. The third, enclosure status, would begin when users stopped at a determined distance. In this state they were allowed to intervene with the data flow of the network by moving in the space of the portal and in this way directly affecting the sound and ambient motion of the elements.

5.2 THE SKIN PORTAL

The second portal has been based on an interpretation of the concept of a portal as a barrier which can be passed through under certain conditions. It was argued that the skin of a building could be more than only a passive wall with static, predefined openings. An interactive wall should not only dynamically create openings to entrants but also select them according to certain parameters and invite them to pass through. Such structure could also influence either of the adjacent spaces in accordance to activities happening on the opposing sides. A vision was formulated that membranes should communicate a meaning or spatial emotion in a dynamic way and react instantly to their surroundings.

The eventual installation has been built as a lounge object. Curtain of flexible tubes dynamically created openings for those that approached it, according to their proximity and position along the structure. Additionally, it also generated other, spontaneous apertures...
and audio-visual feedback, based on information coming from other portals and simulating remote, virtual guests.

5.3 THE JEALOUS PORTAL

The jealous portal concept was to create a structure that would be a centrally placed element, separating spaces around it by lowering and raising its outstretching branches. It not only creates spontaneous divisions of spaces surrounding it, but also affects the atmosphere of its environment by actively engaging passers by in playful experiences. Its operates by locally communicating and entertaining its visitors, but also senses amount of activity present in other portals in the network and tries to attract their users to itself. In this way, it develops a “jealous” behavior, trying to steal user attention from other surrounding spaces.

The bubble pods portal design deals with the notion of a portal in a similar way to the leaves project. Although it operates in a more ambient manner, it provides a flexible spatial setup and involves its users in a playful spatial interaction, allowing manual relocation of its man-sized elements. When sensing motion or proximity, elements act accordingly with light and sound feedback, encouraging to be moved or discouraging from being touched.

6 Conclusion

Presented building component pre-prototypes demonstrate the potential of presented approach only in a very limited way. However, they do prove that creation of architecture as evolving networks of interactive spatial components is possible and can bring unprecedented qualities to spatial environments. These playful experiments allow expanding knowledge which will ultimately lead to the application of this approach to full featured building system prototypes, eventually to result in creation of working building systems.

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