KINETIC, RESPONSIVE AND PERFORMATIVE: A COMPLEX-ADAPTIVE APPROACH TO SMART ARCHITECTURE

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Abstract

Smart architecture is fast becoming a buzzword in architecture and related disciplines. However, it is not entirely clear what constitutes smart architecture and how it relates to or differs from such closely related camps as responsive architecture, performative architecture, kinetic architecture, and adaptive architecture. This paper poses the essential and critical questions about smart architecture from a complex-adaptive systems point of view. The paper also illustrates the attributes of smart architecture with a number of seemingly disparate, yet conceptually connected design developments.

1. Introduction

Smart architecture is fast becoming a buzzword in architecture and related fields. Although AT&T toyed with “intelligent buildings” back in 1982 (Graham and Marvin, 1996), much of the research and development work in this important area is still in its infancy. Although significant amount of work has been done in the area of “smart houses,” scalability, portability, and conceptual clarity have been the limiting factors in extending that research to larger building applications (Trulove, 2002). If we scan the literature on the subject, it is not entirely clear what exactly constitutes smart architecture and how it relates to a number of closely associated camps such as responsive architecture, performative architecture, kinetic architecture and adaptive environments. What does it mean for architecture to be smart? How smart is too smart? How is smartness measured? How does it differ from previous attempts at making architecture mechanically and/or computationally intelligent? How does it relate to or embrace design computing, computer aided architectural design and energy efficient design? Is there a possible computational and architectural framework that can be used to provide the necessary direction to the myriad academic and professional pursuits currently underway at various institutions? A number of pursuits -- previously purely technical or purely theoretical or predominantly environmental camps -- have merged and begun to share their concerns under the rubric of smart architecture. The paper attempts to outline a complex-adaptive systems framework for smart architecture, outline an agenda, and connect the dots of some significant conceptual, technological and architectural developments in this direction.

2. A complexity framework for smart architecture

One of the goals of this paper is to begin to define what legitimately constitutes smart architecture. This task involves defining the attributes of smartness. The notion of smart architecture is wrought with unintended vagueness. Vagueness can be good sometimes to enable multiple and competing notions to develop. However, there has been no fundamental discourse about what constitutes smart architecture and what its principles are. Is anything with a microchip smart? Is anything networked worthy of attribution of intelligence? What are the benchmarks for smartness in architecture? Such a definition might lead to, a qualitatively and quantitatively measurable quotient, which the author likes to call “smartness quotient” or SQ. But before we can attempt to measure a building’s SQ, we need an understanding of the attributes of smartness. As a systems theorist with a particular interest in complex-adaptive systems, I find a number of basic systems
concepts to be of great help in accomplishing the present task of framing smart architecture.

2.1. Complex versus Complicated

Complexity is not an oft talked about concept in architecture. Robert Venturi’s *Complexity and Contradiction in Architecture* does venture to some extent in connecting with the notions of complexity in other disciplines while focusing almost exclusively on mannerist complexity of meaning, surface, iconography and historic references.

What is complexity? The word complexity is a derivative of the Latin root *complexus*, which means totality and embrace. Complexity refers to a systemic totality and the interrelationships between various subsystems. This differs from common parlance that complexity is opposed to simplicity. The word simplicity descends from Latin roots *sim+plec*, which literally means single fold. The true opposite of simplicity is complication, which means to fold together. While there is a synonymous relationship between complexity and complication, they are distinctly different notions. Complex systems can be simple or complicated. Complicated systems are not necessarily complex. Complex systems, as they are understood today and defined in no fewer than millions of words of cross-disciplinary discourse, are closely related to such phenomena as adaptive systems, non-linear systems and living systems. In complex systems there is an element of learning and adaptation. There is also an element of self-awareness, which differs significantly from automation. Paul Cilliers, a leading proponent of complex systems theory sums it up thus:

> The concept “complexity” is not not univocal either. Firstly it is useful to distinguish between the notions ‘complex’ and ‘complicated’. If a system – despite the fact that it may consist of a huge number of components – can be given a complete description in terms of its individual constituents, such a system is merely complicated. Things like jumbo jets or computers are complicated. In a complex system, on the other hand, the interactions among constituents of the system, and the interaction between the system and its environment, are of such a nature that the system as a whole cannot be fully understood simply by analyzing its components. Moreover, these relationships are not fixed, but shift and change, often as a result of self-organization. This can result in novel features, usually referred to in terms of emergent properties. The brain, natural language and social systems are complex (Cilliers, 1998).

Truly smart architecture has to be complex, though not necessarily complicated. This and other systems concepts will be elaborated further in the following sections.

2.2. Automatic versus Autopoietic

Smart architecture is often confused with automated architecture. Smart systems are confused with automated systems. While smart systems do involve great degree of automation they go beyond mere automation to embrace complex cybernetic processes and learned behaviors. *Autopoietic*, on the other hand, is about self-production or self-organization. Organisms, corporations, societies, and minds are self-producing and self-organizing. Also, as Maturana and Varela define it, autopoietic systems have a clear systemic boundary and closure that makes them autonomous. Smart architecture can be truly smart only when it is truly autopoietic. Mere automation and mere use of logical circuits and discrete sensory mechanisms are not sufficient for a system to be smart.

One example of an autopoietic architectural system is the so-called Topotransegrity project.

The Latent Utopias exhibition curated by Zaha Hadid and Patrick Schumacher featured a groundbreaking kinetic responsive prototype named Topotransegrity. It was a curious mix of topological manipulation through pneumatic space frame structure. The project, designed by 5Subzero, a group of architects from London, featured surfaces that can be manipulated through either an automated control mechanism or a real-time feedback...
system or a pre-programmable system. The system, if developed as illustrated here, could become a self-organizing system that approaches a spatio-temporal smartness with a high SQ.

The system consists of a kinetic space frame driven by three sets of Festo pneumatic pistons. The original prototype was designed to sense the audience movements through pressure sensitive mats and translate the impulses into valve operations controlled via the computer. The scenario depicted in Figure 4 envisages some dramatic architectural possibilities. Topotransegrity proposes to program the walls and floors along with people and events in an all enthralling four-dimensional framework for smart architecture.

More and more architects are beginning to explore the form and format of such smart and supple architecture. The Muscle, a prototype featured at the Non-standard Architecture exhibition held at Centre Georges Pompidou from December 10th, 2003-March 1st, 2004. The Muscle was designed by the Dutch design firm Oosterhuis_Lénárd and dons a pneumatic structure that behaves like a gigantic, digitally mediated muscle. The building would flex, contract, expand and mold itself to

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Figure 1: Topotransegrity by 5 Subzero

Figure 2: Topotransegrity Prototype in Latent Utopias Exhibition, Graz, 2002

Figure 3: Pneumatic Pistons

Figure 4: Topotransegrity Scenario
suit changing programmatic conditions over time and in real-time. The architects propose that the place be used for a variety of activities such as a disco or a television studio or a meeting place. The synthetic muscles of the Muscle react as people move near the sensor points. Another way to manipulate the structure is by moving the sliders on a remote computer screen. Thus, the building becomes spatially interactive and can be plugged into the Internet. This alien-looking blob is not necessarily how buildings might look as a whole in the future. Some buildings might look that way. However, the Muscle, as ONL proposes, can literally be used as a series of muscles in a building to control any environmental or other parameters in real-time. Perhaps the buildings might be able to literally express their feelings by flexing their facial and spatial muscles, thereby leading to truly complex, kinetic, performative, and supple architecture.

2.3. Ip versus XP: a building is not a box

A building is a network for living in. While all autopoietic and complex-adaptive systems have a clear sense of autonomy, they are a clear part of a larger system. Just as a human individual has a clear-cut identity, every human being in an integral part of a large life-world system. Likewise, smart systems would be very dumb if conceived as self-contained systems largely disconnected from the larger world systems. A network is always a more capable, adaptive and complex system than any of its components. Just as a computer as a box that is not connected to the larger networks is very limited in its role in our societies, architecture conceived as boxes that are not a part of larger networks is also very limited in its smartness.

A network is an interconnected system with a certain structure of relationships. Kevin Kelly, executive editor of WIRED magazine summed up the essence of the current paradigmatic shift: “the central act of coming era is to connect everything to everything. All matter, big and small, will be linked into vast webs of networks at many levels. Without grand meshes there is no life, intelligence, and evolution; with networks there are all of these and more” (Kelly, 1994).

Intel’s new WiMAX technology buoys these possibilities by preparing to introduce cell phone-like ubiquitous and wide-ranging network coverage for laptops and other computational devices (www.intel.com/netcomms/technologies/wimax). A WiMAX-equipped laptop or computational device can stay connected to the Internet...
all the time without any wires. Such a technological network would be a crucial turning point in the journey toward the emerging noosphere.

At a time when even the toasters and refrigerators are being hooked up to the Internet, architecture is not going to be left too far behind, despite the best efforts to resist the evolution by the profession’s conservative core. Connection is the keyword, the buzzword and the overarching concept of how buildings could become networked computer systems. General Motors’ OnStar® vehicle security system has already transformed our automobiles, which are now controlled by dozens of embedded computers and networked via satellites, into GPS-powered real-time network nodes. An OnStar operator can access most of the critical systems of an automobile remotely and suggest or coordinate a course of action at the touch of a remote button. The biggest evolutionary jump for automobiles is not in their growing engine size or seductive body shape; it is in the pervasive computerization and wireless digital networking. The mobile space of the automobile has been transformed into an interactive real-time network node capable of keeping us connected to the rest of the world. Automobiles are already a part of the emerging noosphere. Architecture is also becoming a part of the post-spatial network ecosystem. The current preoccupation of the profession with digital fabrication (based on manufacturing paradigms) and complexly curved surfaces (visual complexity) are both based on outmoded or soon to be passé models based on the rapid evolution of smart networks and their market share in the coalescing global economy. Architecture would be better served to take a systems approach, particularly the complex-adaptive approach of IP (network) in contradistinction to elitist, formal and XP (box) based approach.

The Internet Home Alliance (internethomealliance.com), a remarkable cross-industry collaboration between GM’s OnStar, Invensys, ADT Security Systems, HP, Panasonic, and many other corporate partners have launched, in early 2002, a post-spatial initiative to integrate OnStar’s Virtual Advisor® service with home security control, telecommunications control, and climatic control from any Internet enabled appliance anywhere in the world. This system also gives the customer visual access to his or her house at any time. Garage doors, access doors, windows, all the major home appliances, HVAC system, security system, and telecommunication systems are networked using the HP Application Server 8.0 framework as gateway. The participating customer would be able to access any and all of these aspects in real-time from any computational device such as a cell phone or a PDA or a laptop. The customer would be able to remotely turn on or off the appliances such as kitchen stove or refrigerator. Panasonic’s smart doorbell would notify the customer anywhere, through audiovisual access, anytime his or her doorbell is rung. Thus, appliances, HVAC systems, security systems, and a host of other building systems are computationally networked and connected to the global nomads – the home owners.

3. Epilogue

This paper serves as one of the first attempts to understand, define and frame smart architecture from a complex-adaptive systems approach. The paper raises important questions about the meaning of smartness in architecture and proposes the need for Smartness Quotient (SQ) and Building Operating System (BOS) as a way to arrive at truly smart architecture. The paper also attempts to bring together the camps of performative, kinetic, responsive and adaptive environments under the rubric of smart architecture.
References


Semiotext(e).


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