CIAS-DM: A Model-Based, Human-Centered Architectural Modeling Method + Tool

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Design Challenge

A recent trend in architecture is for the built environment to pro-actively contribute to enhancing human health, well-being, performance, and social interactions in measurable, predictable, and adaptable ways. Buildings are becoming interfaces and digital machines and their roles and capabilities are expanding. Accomplishing this trend will require architectural design methods and tools to evolve. Sensing, monitoring, actuation, intelligence, and communication sub-systems are now integral components of environmental designers' vocabularies and considerations when designing space and form. At present, the theories, methods, and tools for representing and incorporating these elements during design do not exist. Developing these artifacts is an active area of research.

This dissertation focuses on representing the affordances of complex, interactive, architectural systems (CIAS) and proposes, evaluates, and refines the Complex, Interactive, Architectural System Design Methodology (CIAS-DM). The purpose of CIAS-DM is to aid designers in making sure they understand the design challenge well at the start of the project. The Validation Square Research Design is used to evaluate CIAS-DM.

Case Study / Qualitative Evaluation

Evaluation of the CIAS-DM is qualitative and uses the Validation Square Research Design Method [2] with influences from Design Science Research [8, 9]. Data collection is now wrapping up. Preliminary indications are that designers more quickly develop a much clearer understanding of the present scope, the likely interfaces between people and the systems, and are able to hone in more quickly on a focus for the project.

CIAS-DM Method Summary

STEP 1: Review Owner’s Project Requirements (ORP) & Identify Goals, Use Cases, Requirements, and other systems in which system belongs, subsystems of the system of interest

STEP 2: Engineering Activity: Abstract Decomposition Space (ADS) followed by the Decision Ladder (DL)

STEP 3: Refine products of STEP 2 based upon information gained from STEP 2 and revise Goals, Use Cases, Requirements, and other systems in which system belongs, subsystems of the system of interest

STEP 4: Engineering Activity: High-Level Space (HLS) & Role & Role of system of interest, supersystems & subsystems

STEP 5: Refine products of STEP 4 based upon information gained from STEP 4 and revise Goals, Use Cases, Requirements, and other systems in which system belongs, subsystems of the system of interest

Mapping the Design Domain

Structure of the Research: The research did not begin with a theory but with an expansive review of literature and something like a grounded approach to theory development. Based on the developed theory (classifying complex, interactive architecture as a subset of cyber-physical systems and socio-technical systems) I developed a method and tool for improving the design of CIAS.

Lessons from the Literature: How to design these types of projects remains an open question. However, approaches are starting to take shape. All involve a mix of analytical and creative techniques. The analytical techniques ensure that clear, simple, logical aspects of the design challenges are understood and addressed. The creative techniques help uncover the aspects of the challenge that are not immediately obvious based upon a purely logical approach. CIAS-DM also addresses both aspects of the design challenge.

Method + Tool: CWA Mapped Into SysML

At first, CIAS-DM is a representation system. It involves three components.

1. A CWA (Component and Work Activity) model of the CIAS-DM (Iteraction 1)

2. A CWA model of the CIAS-DM (Iteration 2)

3. A CWA model of the CIAS-DM (Iteration 3)

But CIAS-DM extends the SysML profile within MagicDraw because it is designed to represent human–digital–physical systems during the design phase of a project. For environmental designers to begin reasoning about the challenges of their projects it is necessary to have an incremental, evolutionary improvement to process mapping, execution verification, and validation.

CIS are a subset of cyber-physical systems (CPS) and socio-technical systems (STS).

Cyber-physical systems (CPS) are “...engineered systems that are built from and depend upon the synergy of computational and physical components. Emerging CPS will be coordinated, distributed, and connected, and must be robust and responsive. Examples of the many CPS application areas include the smart electric grid, smart transportation, smart buildings, smart medical technologies, next-generation air traffic management, and advanced manufacturing. CPS are a subset of socio-technical systems, just as the internet transformed the way people interact with information [4].

Socio-technical systems (STS) are defined as having the following relationships between social and technical systems: 1) the technical component can be specified, its behavior modeled, and it can structure how work is done; the social component cannot be specified and must be incrementally redefined in symbiosis with the technical component in order to result in an effective, efficient, robust system [5].

Map Context: Existing: Embedded Systems, Mechatronics, Robotics

Emerging: CPS, STS, ULS, CLIOS, MSS

Rehabilitation Patient Room Ecosystem of Intelligent/Responsive/Interactive Systems: CIAS-DM is evaluated based upon a series of design challenge scoping exercises for an assistive patient room.

To these analytic, microscopic methods, CIAS-DM adds a method intended to encourage co-creation and discovery during the design challenge. It uses iterative design/prototyping/designing activities [12, 13] to bound the design problem spaces and limit the degrees of freedom.