Location! Location! Location! The Architect's Contribution to IoT for Healthcare

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1 Introduction to BIM in the Healthcare Typology

This paper aims to introduce the IoT community of scientists and technical researches to the concepts integral to BIM and the Architectural design process in large scale healthcare projects. In particular, this paper puts forward the potential for BIM database systems to be used as primary sources of building information and locational data for IoT systems, and makes suggestions about further studies.

1.1 The Room as the Architect's Base Product

We generally think of Architects as creators of buildings, but the building is, in fact, a conglomeration of individual rooms, each designed to fulfill a specific function for the users and owners. Architects will often begin healthcare projects with lists of room types that must be designed and detailed.

Rooms have requirements. In the healthcare space, rooms have requirements such as hygiene class, security level, acoustics, radiation shielding etc. Through the work of designing hospitals, Architects will create relationships between room objects, according to functional neighborhoods, or departments such as Acute Care, Operation, or Intensive Care. We group these departments together into user-friendly buildings and wrap it all in a pleasing and functional aesthetic shell. Architects combine art, healing spaces, protection, heating/cooling, logistical flows, people flows, and many other aspects together the final buildings, but we always return to the room.

Healthcare projects, in particular, are amongst the most complex building types for an Architect to design. Hospitals have high information density and complexity of function, logistics, equipment, and staff. To give a sense of scale, a recent large-scale hospital in Stockholm comprises of 300,000 + sq meters of new hospital, including 11,000 + rooms, and over 300,000 pieces of equipment or furnishings. A more typical new hospital may hover around 50,000 sq meters, with over 2,000 rooms and 50,000 distinct facility assets to keep track of. Each object may also have 20 + columns of parametric data to fully identify the instance or type. Add it all up, and we are rapidly approaching big data scale.

To organize this complexity, current Architectural best practice is to use specialized, spatial, relational database systems; the Building Information Model. Popular platforms include Autodesk's Revit and Graphisoft's Archicad, for example. The Building Information Model combines 2-D/3-D visualization, document creation/management,

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information management, object creation/management and design flexibility into a single visual database system, or BIM. In practice, for larger or more complex facilities, Architects will network multiple BIM databases together, each having specific purposes; for example, façade, structure, base-building, mechanical-electrical-plumbing etc. In current best practice we also provision additional custom databases to mediate specific information types across the entire BIM network; for example, change management, room requirements, or equipment/furnishing specifications.

Through it all, Architects always deal with objects, whether those objects are rooms, building parts, doors, MR scanners, or electrical sockets. All objects are uniquely identified via a GUID, or another custom identity code. All objects can thereby be traced through the BIM network for quantity surveying and cost estimation. These objects are all parametric, portable, and reproducible across the BIM network.

The preceding description is to introduce that Architects now design healthcare projects in a data rich environment. Some firms push the state-of-the-art, while others are slowly pulled along by the evolution of the industry.

1.2 So What Happens to All This Information?

Traditionally, the Architectural design is focused on the production, or construction, of the new or improved healthcare facility. Drawings and documents on paper or .pdf are the traditional deliverables to our clients. A subset of the design data is preserved as a record-keeping reference. Despite the dynamic and rich information design environment of BIM, many clients and Architectural firms deliver information as static and barren analogue formats. When the facility or hospital is built, the design documents are put away on dusty shelves.

Increasingly, however, regional healthcare agencies or healthcare developers have adopted a more datacentric model. More complex and high-tech facilities have shifted the production of healthcare facilities away from static documents towards dynamic information structures. Architectural firms by necessity must meet the demands of their evolving clients, and in many cases Architects are leading their clients towards more efficient and useful information management techniques.

The datacentric design is further complemented by the operations and maintenance specialists, structural consultants, plumbing and electrical consultants, security specialist and many others. The design data flows much deeper beyond production and into the life of the healthcare facility. New deliverables include the BIM models, specialized databases, and sharepoints, in addition to the dusty drawings, documents and static.pdfs. Many of these deliverables are used in real-time, and are accessible in mobile formats. See Fig. 1 in the afterword.

There exists, therefore, a rich well of information upon which IoT for Healthcare can draw.

1.3 How to Draw from the Well

Each BIM platform has its own proprietary format which is generally obtuse. The industry standard for sharing BIM data among design professionals is the .ifc format, or Industry Foundation Class, which is maintained and developed by the Building Smart organization. The .ifc is usable across a wide variety of design, analysis, and facilities management software platforms. It is becoming an official International Standard ISO/IS 16739, and the newest version includes a more robust XML interchange ability. The.ifc is an open format, and the complete specifications are available for anyone to view.

Fortunately, the major BIM platforms also have maturing APIs in C#, VB.net, and other supported flavors. Custom and creative tools are built on top of the BIM platform. The trend is to use the BIM platform as the primary tool during the design process, and extract the BIM data to an open database SQL or noSQL for a wider array of non-production uses. The APIs are well supported, and allow flexible and creative management of BIM data and data flows.

1.4 A Word of Caution

As a whole, the construction and development industry moves very slowly towards adopting new technologies. Some of the larger players are leading the way towards exploiting the data density of healthcare projects, but many others are happy to continue with analogue or thin data processes. Forward-looking professionals are able to demonstrate the advantages of managing healthcare design complexity with deeper integration of datacentric methodologies.

1.5 Where Does IoT Come into the Picture?

Let's go back to the room. The room object is a unique entity, comprising of a relative location, a spatial quantity, and a variety of requirements that are described as distinct parameters. Location data can be GPS specific, but is often relative to a regional x,y,z base point. Placing it in a global positioning system, however, is trivial. Spatial quantities can be in terms of volume, areas, and can be measured together into larger grouped volumes and areas. Within and around the room object are building parts, finishes, moveable equipment, fixed furnishings, and people. Furthermore, each room object exists in relation to other room objects, building parts, things, as well as the building or facility as a whole.

Each IoT node is embedded in this web of relationships and the things that comprise and reside therein. Within the finished building, objects are asset-coded and tagged via nfc tags, rfid tags, QR code stickers or bar-codes and referenced back to facilities management systems. Often this is a manual process of identifying, tagging and scanning, but increasingly manufacturers are delivering custom tagged materials, furnishings and equipment according to the BIM data. This is ambient level data, and does not rise to the level of IoT ambitions, however it can be accessed as a data environment via scanning technologies.

As IoT matures in the built environment, the BIM data can be fed to the node and backed by a persistent Building Information data structure. The location and relational information provide a valuable basis for the IoT systems. The information flow from design to living building becomes much more complete and evolved.

1.6 Sounds Great! What's the Catch?

The catch is providing a standardized data and delivery system. The Building Information data structure can and probably should be a cloud-based information store to alleviate the necessity for hospital and building organizations to maintain the IT infrastructure. Collecting and maintaining the design data will need to be organized as a standard building design process. New deliverables will need to be specified and detailed at the beginning of the design process, when healthcare developers are hiring design professionals. Further studies will need to delve into the legal and professional implications of adding new deliverables to the architect's basic services. Return on Investment will need to be studied in detail to motivate healthcare organizations to develop towards IoT applications.

Other complications are more familiar: security, privacy, and maintenance. Security is a serious concern for healthcare facilities. IoT enabled equipment requires a high level of security. Healthcare facilities require very high reliability for all equipment, systems and building components.

- Equipment including cloud and mobile apps, require strong password and permissions.
- Equipment must not collect data that violates patient privacy.
- Equipment must encrypt communications and software updates.
- Equipment requires secure Web interfaces where applicable.
- The Building Information Data must be maintained and updated.

Perhaps the biggest challenge is proving conclusively that IoT for Healthcare provides a compelling advantage for healthcare facilities. The status quo is a powerful force, and healthcare developers and authorities have many bigger priorities; for example, providing a healthy and healing environment for patients. Further studies will need to explore and demonstrate the benefits of IoT for healthcare for various stakeholders and participants; for example doctors, patients, visitors technicians, administrators etc.

2 Pointing Forward

2.1 Afterword and the Datacentric Organisation Model

I am reminded of the early days of the internet, when the web was a barren place. Content creation was a priority, back in the day before everybody had their own blog. IoT for Healthcare has a major advantage, in that the healthcare design process creates a large volume of very useful content. Architects have felt for years that the BIM data was being underutilized and undervalued beyond the building process. IoT is an opportunity to use this content towards its potential.

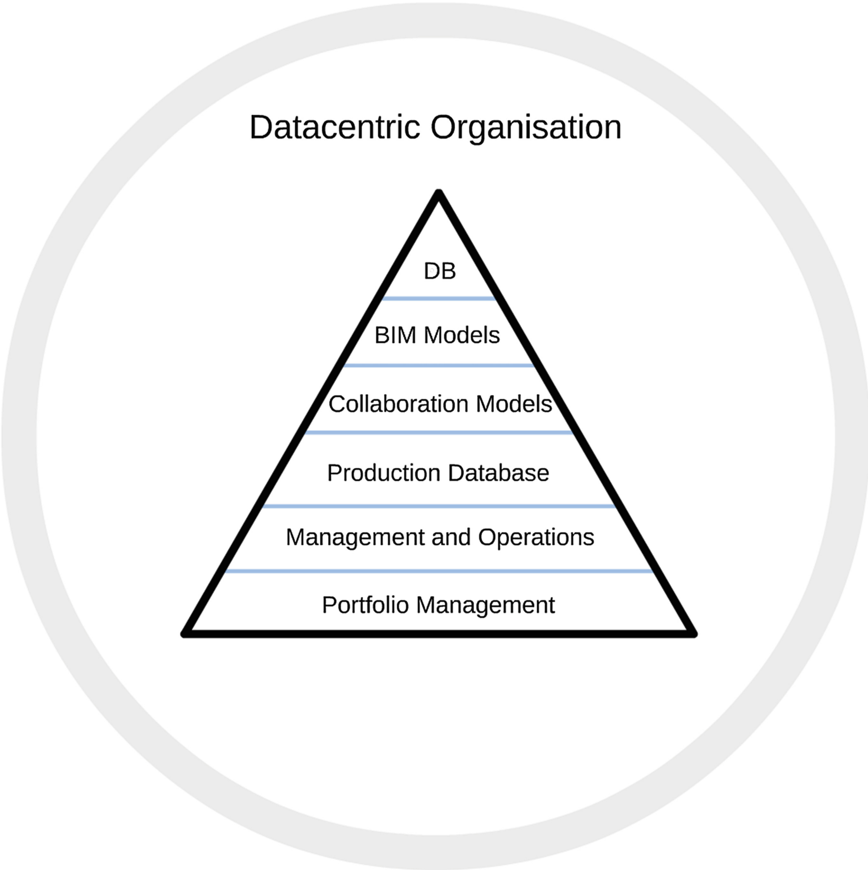

Fig. 1. Datacentric Organisation.

The Datacentric Organisation shown below is descriptive of the current best practice of healthcare design in major Scandanavian markets. Specialized design databases (DB) sit at the apex, filtering and mediating information through the BIM models. In practice, this tends to be a weblike network, but the hierarchy is generally correct. IoT systems can overlap at several levels, especially in the lower tiers.