A SEMANTIC APPROACH FOR AUTOMATED RULE CHECKING IN HEALTHCARE FACILITIES

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1 BACKGROUND

The Lean Philosophy has become in the last 20 years a major research topic in the field of construction management. Based on the concepts of flow and value, in line with the principles of waste reduction, value generation for the customer, transparency and continuous improvement, among others, the Lean Construction community has established a solid conceptual framework. While Lean provides a conceptual basis, Building Information Modelling (BIM) has been recently recognized as the most important transformation related to information technology (IT) that has happened in the construction industry. Most of the research done so far indicates that there are numerous synergies between the Lean Philosophy and BIM [1]. BIM could be seen as a processual and technological approach which supports the implementation of Lean concepts and principles. This could help to deal with some of the challenges faced by the construction industry. In the context of healthcare projects, these issues are related to the complexity, which tends to be very high in all lifecycle phases. The design process for this kind of building is highly influenced by existing regulations, which usually contain a large amount of prescriptive information. In the design review phase, the design specifications must be checked against those regulations with the aim of assuring that the built environment attributes are suitable to the operational demands. This process typically is done manually, and is often inconsistent, time consuming and error prone. For this reason, the development of an automated code checking system tailored to the healthcare environment, with support of BIM and semantics, could overcome some of the limitations of the traditional process. However, attempts to develop these types of systems have encountered difficulties, mostly related to the typology of information bounded by those regulations and the way they flow along the processes. This is where the Lean Philosophy could offer some support.

2 RESEARCH AIM

The aim of this paper is to explore the relationship between Lean and BIM in order to support the development of an automated code checking system for the healthcare context. This application assumes that previous work [1] developed on the synergies between Lean and BIM are a starting point for a different approach in code checking, by exploring the role of semantics.

3 RESEARCH METHOD

Design Science Research (DSR) was the research approach adopted in this investigation. The research process was divided into three phases: understanding of the problem, development of the artefact, and analysis and reflection. An empirical study was conducted in close collaboration with a University Hospital in Porto Alegre, at the Emergency unit. This healthcare facility is under a major process of expansion, with the construction of two new buildings (84.000 m², 70 % of new built-up area). Multiple sources of evidence were used in this study such as unstructured and semi-structured interviews with the hospital staff, and engineers and architects involved in the construction project. The aim of this study is to understand the process of regulation compliance in both traditional and automated methods. First, RDC 50 [2], which is the most important regulation for healthcare projects in Brazil, was mapped and the requirements derived from this document were classified under four different categories: (a) nature; (b) possibility of translation into parametric rule; (c) IFC object related to the requirement in the 3D model; and (d) classes of parametric rules [3]. After that, some of the rules were modelled by using the Solibri Model Checker® v9.6 platform, and the design specifications were checked against those regulations. The 3D model was built

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up to LOD 350. Then, the interactions between Lean principles and BIM functionalities, identified by Sacks et al. [1], were explored, in order to identify which ones of the 56 interactions are directly related to the automated code checking process, and how these could contribute to the application of semantics principles.

4 RESEARCH FINDINGS

Based on the analysis of regulations from RDC 50, it was possible to identify 1284 requirements originated from 820 different regulations. According to their nature, 56% of requirements were classified as qualitative, 37% as quantitative and 7% as ambiguous, in case where it was not possible to identify whether it was qualitative or quantitative. In a similar way, it was possible to determine that 63% of requirements could be translated into parametric rules (i.e. re-written in a logic way). Additionally, the relationship between the IFC object on the 3D model and the requirements was explored. Hence, 371 standalone occurrences of IFC space and 349 occurrences of IFC space combined with other IFC types (i.e. object, door, wall etc.) were identified. Furthermore, from Solihin and Eastman's classification of parametric rules, it was determined that 70% of requirements fit into class 1, 28% class 2, while the 2% remain are classified as class 3 or 4. The translation of some of the requirements into parametric rules with support of Solibri Model Checker®, and the related automated checking process appeared to be difficult to expand into a broader range of requirements (RDC 50 included). These flaws are related to the software black-box effect, already described by previous research studies [4]–[6]. Additionally, the translation process of requirements into parametric rules is challenging due to the pre-defined structure of information from the software tool. However, some of the accessibility and spatial requirements were successful translated and verified with support of Solibri®. The analysis of Lean and BIM interactions have shown that, from the 56 identified synergies [1], 13 appear to be related to an automated code checking system (e.g. *9. Testing the design against performance criteria ensures that the design is appropriate for the chosen function, reducing the variability and improving the performance of the end product*; and *43. Where clients or end users are engaged in simultaneous reviews of different system design alternatives they can more easily identify conflicts between their requirements and the functionality the proposed systems will provide*). This research work provides evidence that semantics play an important role in value generation, when BIM is used for code checking.

5 CONCLUSIONS

One of the main conclusions is that the nature of regulations and their design may have a major impact on the possibility of translating them into parametric rules in a healthcare environment. Koskela (2000) [7] states that information must flow down along the design processes and this is where semantics meets Lean. Therefore, the processes of translation have to be made on a semantic-level basis to ensure that accurate information flows properly (with no waste) along the design review stages. Then, the development of an automated rule checking system for the context of healthcare relies upon three factors: the core information derived from regulations – semantics; the translation processes associated to the review stages – interpretation; and the technology tools to support such inputs and interfaces – BIM.

6 REFERENCES

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