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A STANDARDIZED METHOD FOR BUILDING SIMULATION-BASED DECISION SUPPORT SYSTEMS USING HIGH LEVEL ARCHITECTURE

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ABSTRACT

This research develops a standardized Federation Object Model (FOM) for Simulation-Based Decision-Support Systems (SB-DSS) in construction. SB-DSS are vital for tackling project complexities, but their development requires considerable time and expertise, leading to underdeveloped systems and limited adoption. To address this, the study adopts High-Level Architecture (HLA) standards, integrating autonomous simulations into a single distributed simulation. The FOM includes object classes, interactions, and datatype definitions, enabling efficient communication among federates. The initial FOM version was successfully tested with five federates, demonstrating its effectiveness. This standardized FOM promotes simulation reusability, interoperability, and data-driven decision-making, ultimately enhancing construction project execution and competitiveness.

1 INTRODUCTION

Simulation-based decision-support systems (SB-DSS) are valuable tools in construction, addressing project complexities and uncertainties (Shahraray and Maeschke 1990). However, developing comprehensive SB-DSS requires significant time and expertise in both industry practices and programming (Fujimoto 2003). This results in underdeveloped systems, inefficient project execution, and limited adoption (Rinaldi et al. 2015; Taroun 2012).

The High-Level Architecture (HLA) standards, introduced by the US Department of Defense, integrate multiple autonomous simulations into a single distributed simulation (Azimi et al. 2011; Kuhl et al. 1999). HLA enables the reuse of simulation models for various purposes, reducing the effort and time required for model development. In HLA, independent simulators are referred to as "federates," and the distributed simulation execution is called a "federation" (Gan et al. 2000). This concept can be adapted for construction, allowing, for instance, a weather federate to be developed once and reused in different federations enhancing efficiency.

For the federates to communicate and exchange information with each other, a Federation Object Model (FOM) must be specified. The FOM is sometimes called “the language of the federation” (Möller et al. 2014) and contains components such object classes, attributes, interaction classes, parameters, and datatype definitions. Developing a comprehensive FOM is a challenging and research-intensive task in distributed simulation, as it involves linking computer simulations of discrete physical entities into complex virtual worlds (Kuhl et al. 1999). The lack of a well-defined standardized FOM has hindered the construction industry's ability to fully leverage the benefits of HLA.

Using standardized FOMs, commonly referred to as Reference FOMs, and then customizing them to meet specific project or program requirements is a common practice. This approach offers several benefits, including time and cost savings, as previous efforts from similar projects can be reused. Moreover, the use of Reference FOMs reduces risk, as they have undergone testing, adjustments, and proven success in previous projects. An additional significant advantage is the enhanced ease of reusing simulations that support reference FOMs in new combinations. Since these simulations are already capable of exchanging data in a compatible manner, integrating them into different contexts becomes considerably easier and more seamless (Möller et al. 2014). The initial research step is creating a standardized FOM for construction, enhancing interoperability among different federates. Incorporating these concepts into user-friendly simulation software will enable easier model building and component reuse across multiple simulations.

2 FRAMEWORK

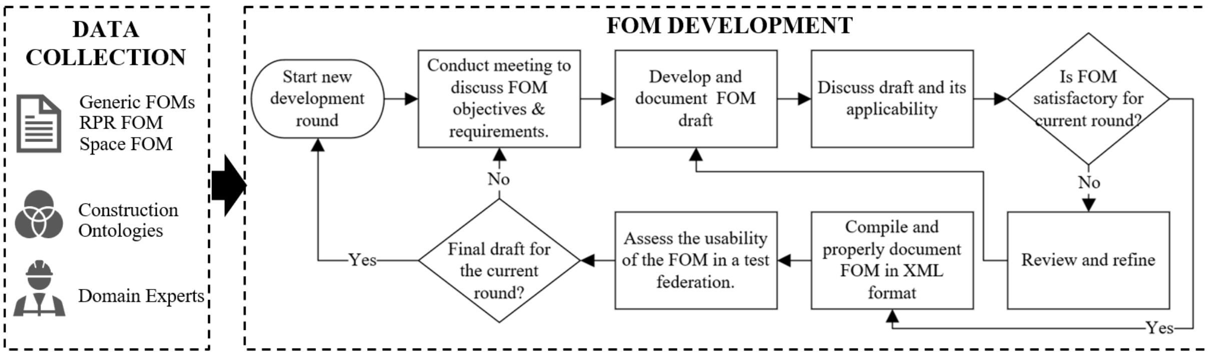

Figure 1: FOM Framework Development

3 PRELIMINARY RESULTS

The initial version of the FOM underwent successful development and testing in a federation comprising five federates: planner, progress, safety, weather, and visualizer. The planner federate handles project planning, activity identification, resource assignment, and relationships. The progress federate simulates on-site work progress, considering constraints like weather, safety incidents, and congestion. The safety federate models site incidents during work progress, while the weather federate provides daily weather parameters. The visualizer offers a 3D representation of the project's progress. The FOM efficiently supported the federation's development, allowing for future enhancements without revising the FOM. By enabling seamless exchange of information among simulation components, the FOM aims to streamline the development of simulation-based decision-support systems, resulting in improved project execution, sustainability, and competitiveness in the construction industry.

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