From Concepts to Agents: Towards a Framework for Multi-Agent System Modelling

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ABSTRACT

Whilst tools assist the various tasks required to develop a multi-agent system (MAS), yet there still remains a gap between the generation of MAS models and program code. AUML development has enabled MAS designs to be specified in detail, including the complexities of agent communication protocols, which was a shortcoming of the Unified Modelling Language (UML) standard. However, the creation of MAS designs using AUML still requires a significant amount of design expertise on the part of the designer. We describe an approach to the development of a complex healthcare information system that defines specific steps along the path to MAS implementation. In particular we explore the use of conceptual knowledge modelling techniques by means of conceptual graphs and a transactions-based architecture for model verification during requirements gathering, together with a translation to AUML for design specification, proposing a framework to extend existing AOSE methodologies.

Categories and Subject Descriptors

H.4 [**Information Systems Applications**]: Miscellaneous; D.2.1 [**Software Engineering**]: Requirements/ Specifications—*Elicitation methods, methodologies*

General Terms

Design, Verification

Keywords

Multi-agent system, conceptual graphs, requirements

1. INTRODUCTION

MAS design and development makes specific demands upon the developer, especially with regard to the engineering of system requirements. In recognition of this, a number of MAS methodologies have emerged from established software engineering methodologies, together with a number of toolkits that assist the generation of MASs. Our aim is to provide an extended means of capturing requirements for agent-based systems, by addressing the need to scrutinise qualitative concepts that exist in the MAS environment, prior to more detailed analysis and design with existing methodologies. Extensions to the UML [3] meta model such as AUML [1], have simplified the design and specification of agent characteristics such as interaction protocols, yet the process of gathering and specifying initial requirements is often limited to the discipline and experience of the MAS designer, using a range of established notations such as use case modelling [3].

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2. REPRESENTING THE MODEL

Our experience with AUML [2] has led us to conclude that whilst this notation permits models to be created at differing levels of abstraction, it is still possible to produce models of a MAS that are require significant design experience to refine the detailed model to a point where it achieves the original goals. Whilst AUML offers use-case analysis as a high-level requirements gathering notation, we propose that a notation be used to supplement the process that permits the capture of qualitative topics, in order that the essential issues within 'the big picture' are retained and explored.

2.1 Conceptual Graphs

Conceptual graphs (CGs) [5] are a means by which otherwise intricate logic can be expressed in a more human readable form, whilst remaining rigorous in their formalism and suitable for exchange between computer systems. They are represented in both text (Linear Form) and graphical format (Display Form), the latter assisting human comprehension during requirements gathering and systems analysis.

2.2 Model Verification

We chose to represent the requirements capture process at a much more abstract level, by considering a means by which a model could incorporate verification. This would assist the whole process by enforcing a rigour upon the requirements capture stage, to elicit agents, roles and ontological terms from a conceptual perspective, and also provide a model check much earlier in the process, supporting the design and deployment of robust MASs.

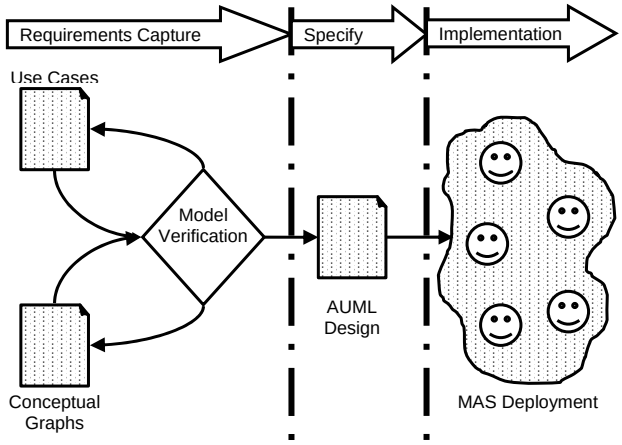

Figure 1: Proposed framework.

In a MAS trading environment, the goal-directed behaviour of an agent dictates that success occurs when both parties have gained from their participation in a transaction. In essence, the transaction describes a condition where both parties have exchanged resources, resulting in a 'balance'.

3. PROPOSED FRAMEWORK

Throughout the process of developing a MAS for complex healthcare systems, we have encountered an increasing number of qualitative issues that support the need for a framework that considers the wider issues of community healthcare provision [2].

Figure 1 illustrates the three abstract, conceptual stages of the proposed framework:

1. *Gathering Requirements* - The domain is modelled with UML use cases and CGs and projected through the transaction model [4]. This model enforces a discipline upon the process, reflecting the inherently transactional nature of MAS. As such, further specification cannot take place until all aspects of the model are complete and a balance is achieved.

2. *Creating a Design Specification* - After the model has been verified at the previous stage, the model is translated into AUML activity diagrams.

3. *Implementation* - The AUML design specification is then translated into program code.

We have now established that there is a stage whereby the elicitation of qualitative issues within a problem domain can assist the MAS development process. The combination of requirements capture and analysis with CGs, and projection with the transaction model, provides a much more rigorous input artefact in readiness for design specification with AUML.

4. CONCLUSIONS

Figure 2 illustrates the representation of agent-managed transactions which were assembled at a much faster rate, the key features being:

1. CGs represent the problem in a more abstract way, and provide a foundation for modelling the knowledge exchange within a system.

2. CGs are similar to AUML in that there are some obvious mappings from concepts to agents, however there are also subtleties that CGs appear to reveal more consistently.

3. Using the transaction architecture, it becomes possible to force a set of rules (checks and balances) upon a model before it is represented in AUML.

4. Ontological terms are derived from the transaction model during the process of capturing requirements.

5. The transactions approach makes model verification implicit as any missing nodes (concepts or relations) renders the model out of balance and thus unable to satisfy both sides of the transaction.

We feel that this approach would be a suitable 'bolt-on' discipline for the myriad of agent-oriented software engineering methodologies that lack the necessary detail for successful MAS requirements capture.

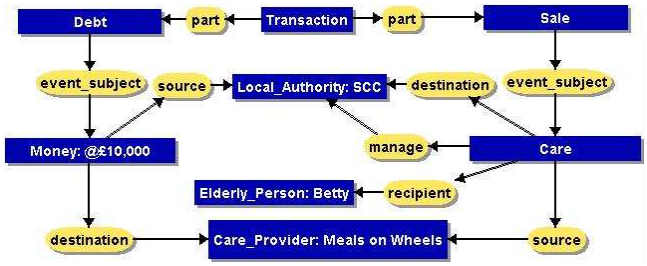

Figure 2: Community healthcare scenario.

5. ACKNOWLEDGEMENTS

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