MiNEMA Grant - Scientific Report

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Abstract

This report describes the work carried out during a visit at the Distributed Systems Group (DSG) at Trinity College in the period April 7th to June 6th 2008.

1 Introduction

Comhordù is a decentralised coordination model, that supports the creation of entities that adapt their behaviour to ensure safety constraints. The model supports timeliness requirements and ensures that safety constraints with associated timeliness are met even in the case of possible communication failures. The entities in the model adapt behaviour depending on available information, to ensure the system wide constraints.

Comhordù is based on a Space-Elastic model, where real-time communication is guaranteed within some geographical proximity of the sender in a wireless network. A sending entity defines a *desired coverage*, a geographic area, where it wishes for messages to be delivered. The *actual coverage* may change over time, due to changes in the topology of the network, and the sending entity is informed in real time of changes to the actual coverage. The *critical coverage* defines the area in which communication must be present to ensure safe behaviour. If the actual coverage becomes smaller than this, the entity may have to adapt it's behaviour to ensure safety.

The model deals with *scenarios*, consisting of *entities*, a *goal*, and *safety constraints*. The entities are the active objects in the scenario, the goal is what the entities wish to accomplish, and the safety constraints are constraints the entities must obey. Each entity has a set of *modes* of operation, which define actions to take and transition rules between modes. Each entity further has a set of *default modes*, which are modes the entity can be in when it has no information about the environment. Each entity has a *state*, consisting of it's mode, location, and additional application specific information.

A set of states are defined to be *compatible*, if the safety constraints are not violated when some entities are in these states at the same time. Safety constraints can then be expressed as incompatability between states.

A protocol is derived from the safety constraints by introducing three coordination primitives: *adapt*, *delay*, and *transfer responsibility*. Adapt performs an action other than the planned, delay performs an action later than planned, and transfer responsibility communicates with other entities. The protocols are concerned with *contracts* and *zones*. A contract uses a combination of coordination primitives to ensure that some incompatibility it is responsible for does not occur. The contracts may be without transfer of responsibility, without feedback, or with feedback. Which type is used has implications on safety in the sense that they determine the duration in advance in which other entities must be warned that a violation may occur. All contracts are related to geographical zones around the entities: the safety zone, the consistency zone, and the critical coverage. Safety constraints are usually only impose constraints on the states of the entities when they are close, and the safety zone defines the area where safety constraints apply. The consistency zone is the zone in which entities must change behaviour to ensure consistency when entering the safety zone. To enable this, timely communications must be ensured within a zone around the consistency zone, the critical coverage.

The development process now becomes a matter of specifying safety constraints, deriving mode compatibility, distribute responsibilities to entities of certain types or roles to ensure that some entity has the responsibility to avoid each possible inconsistency, define the contracts of the entities, and assess the solvability and derive the requirements on the behaviour of the entities.

Previous work by Bouroche [1] has developed the model, and determined which protocols can be used in solutions for a given scenario. Furthermore, some initial evaluation of each of the solutions is described, including identifying which solutions will allow for progress of the entities, with regard to different priority of the entities involved in the scenario. The purpose of the work carried out during the visit was to extend on this work, to determine whether a given protocol could be said to be the best solution, and, if possible, derive heuristics for determining the best protocol.

The work carried out relates to the research performed at Aarhus mainly at the methodological level. The work carried out is concerned with formal models of coordination, which are then used to generate code templates, in a model driven development process. The research in Aarhus is concerned with coordination and composition at a more general level. We believe this research can benefit from experience with model driven development, and plan to incorporate this into the next prototype to be build in the project. The model we will use, however, will be quite different from the one employed in the work described in this report, but we envision a similar workflow and use of model. That is, properties of systems are described as models, which are then used for generating code. Future collaboration with the Distributed Systems Group will concentrate on aspects of model driven development which are even closer related to the research in Aarhus, such as XML modeling, which we only worked on briefly during the visit.

2 Work Carried Out

Slight variations in descriptions of scenarios may potentially give rise to different solutions, but even given a static scenario, some choices will have to be made during the development of the protocol. These choices may influence the choice of protocol. Furthermore, protocols have different impact on the behaviour of the entities involved. For instance, some protocols may allow entities to change behaviour fast, while others may have a higher probability that the entities will be able to stay in a mode that has the highest priority.

During the visit, additions to the information in the model necessary to determine metrics for such evaluation where identified. Specifically, a model of the communication environment was shown to be useful for determining probability that the requirements for entering a certain mode where met.

Heuristics for determining which metrics would most likely be suitable for evaluating protocols in a given scenario where explored. Using the heuristics, a tool will be able to make a guess at which protocol is the best for the scenario. It was also shown though, that these heuristics do not result in the correct metric in all cases. This implies, that a design for a tool supporting the developer must allow for feedback on different metrics, so the developer may choose a protocol which is different from the proposed.

3 Future Work

The work described is initial work, which will be expanded upon by other researchers. The heuristics identified will be incorporated into the existing ComhorMOD tool, to provide the developer using the tool with better support for choosing the best protocol given the scenario.

Future work between the author and DSG at Trinity College will consist of writing a paper on the development process, as implemented in the tool chain, once the implementation is complete.

4 Summary and Conclusion

During the visit at DSG, work was carried out on heuristics for determining which protocol is best suited for a given scenario. Some heuristics where identified, and a suggestion for incorporating it into the existing tool chain.

Previous work identified valid solutions for scenarios, and identified which solutions would provide progress for the entities involved with regard to priority list. This work is implemented in a tool chain, and the work carried out during the visit will be incorporated into this tool chain.

References

[1] Mélanie Bouroche. *Real-Time Coordination of Mobile Autonomous Entities.* PhD thesis, University of Dublin, Trinity College, December 2007.