Reviewer statement on the PhD thesis

Integration Paradigms for Ensemble-based Smart Cyber-Physical Systems

submitted by Vladimír Matěna,
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Reviewer: doc. Přemysl Brada, University of West Bohemia in Pilsen, CZ

Overview

The thesis deals with the challenges brought by the inherent unreliability of real-world data communication channels to the smart cyber-physical systems (sCPS), particularly those using dynamically established coalitions of components ("ensembles"). The topic is a timely and important one from both theoretical and practical standpoints. The candidate approached the challenges by combining the expertise in computer networks and sCPS, putting the thesis at the cross-section of both areas.

The thesis achieved all the goals as stated in Chapter 3: extended the DEECo approach to sCPS with means to handle the realistic properties of the networking infrastructure in ensemble formation and communication, e.g. by introducing the notion of communication groups to optimize message propagation, and created several implementations validating the approach (which also enable independent evaluation and extension).

Important parts of the underlying work were published at six international conferences and in one journal article; two of the papers already collected 7 citations.

Evaluation

The thesis shows a commendable breadth of treatment, covering sufficiently both of its core areas. Especially the parts derived from published papers also provide considerable depth of discussion and elaboration, describing clear and solid contributions to the research in the area of sCPS. The text also documents that the work followed a sound methodology, starting with realistic yet challenging target use cases, deriving goals and selecting solution approach based on their analysis, and evaluating the proposed concepts appropriately (using well-engineered implementations).

Related work covers all important topics and follows recent research. Some areas could have been treated in more detail, e.g. agent coordination esp. under varying conditions (cf. Li, T. and Zhang, J.F. Consensus conditions of multi-agent systems with time-varying topologies and stochastic communication noises. IEEE Transactions on Automatic Control, 55(9), 2010).

The text is very well written and focused, especially in the parts derived from published papers. However, in the introductory parts there are some overlaps (namely between chapters Introduction and Goals, partly also Background and Related work) and slightly superfluous content – in particular, Chapters 4 and 5 feel needlessly long because the scenarios are not used elsewhere in the thesis and even for the purpose of deriving important properties (sections 5.2.3 and 5.3.6) their set could be minimized. Also on the presentation side, despite the overall high level of English, there are a few places in text which suffer from incorrect spelling and usage (e.g. page 18, 72).

Candidate's contributions, and their comparison with the work of others, are briefly mentioned in the Introduction, somewhat out of place. A better approach would have been to summarize them as part of the Conclusion, together with an (missing) evaluation of how the thesis goals were achieved.

My biggest formal concern with the thesis relates to the fact that major parts of its technical content are almost verbatim copies of published papers which mostly have several co-authors, but the candidate does not indicate the extent and nature of his contribution to the individual papers. This may raise questions as to which ideas presented in the thesis stem from his own original research, and should be clarified during the defense.

Conclusions

Overall, the presented thesis by Vladimír Matěna clearly shows that the candidate is able to approach a relevant, complex issue in a methodical manner with high degree of research and technical rigor, contribute to the state of the art at a cross-section of several areas of computer science, and present and defend the results in a wider scientific community. I *recommend* that *the thesis be defended* and that the candidate be awarded the title of Ph.D.

Questions for the Defense

1. A switch to manual mode of the sCPS and-or its components is assumed in several places, as a safety mechanism in case communication degrades beyond tolerance limits. What would be the appropriate reaction in a system where no manual mode is possible (e.g. fully autonomous vehicle)? Can the approach support any notion of fail-operational mode or a "safe state" into which the system and-or individual components would switch?

2. The communication groups are defined over the node knowledge like "the same destination", i.e. on the domain level. Could the (actually observed) network state be taken into account in group definition, to enable adapting the communication to its changes? For instance, could the "same destination" ensemble be further split into (dynamically changing) low-latency vs high-latency groups, using different message exchange protocols/optimizations for inter- and intra-group communication?

Pilsen, August 23, 2018

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