

Application of Model-based Testing and Runtime Verification for Distributed Systems Protocols -Research Proposal-

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1 Introduction and Motivation

Today, some of the most exciting innovations are increasingly dependent on distributed systems and cloud-based services. However, a key challenge now is to develop the techniques and methods for boosting their applications and innovation in different areas and ensure the systems work in a correct and stable way. A solution to realize robust distributed systems are sophisticated distributed protocols for replication and reconfiguration. However, these protocols are notoriously difficult to understand, design and often rely on complex logic. Their design, testing and implementation are error-prone. For these reasons, our research idea is to combine and integrate model-based testing and runtime verification to design, implement and test these protocols for distributed systems and cloud-based services.

For the sake of improving the fault tolerance and availability of distributed systems, sophisticated distributed protocols for replication and reconfiguration can make it possible to handle inevitable application and server failures, to replace failed servers and to extend the capacity of the system. Replication protocols play a key role in building reliable large-scale distributed systems and they can provide a better foundation for system building. Reconfiguration protocols are able to modify the deployment configuration of the distributed applications during their life-time for maintenance purposes.

When verifying distributed systems, one approach is to employ testing to improve systems' reliability. However, testing is seldom exhaustive and cannot always guarantee correctness. Another option is to use runtime verification. Runtime verification can cope with the inadequacies of testings through reacting to systems failures as soon as they occur by the use of runtime monitors. Nevertheless, one drawback of runtime verification is that runtime monitors only recognize bad states when faults happen. Model-based testing is one approach to testing. It has commonalities with runtime verification and makes the use of models of systems to generate test cases. By deploying these two techniques, a single system would increase its reliability, since runtime verification could be used to guard against faults which escape detection during model-based testing.

2 Research focus and questions

For the sake of contribution to the development of distributed systems and cloud-based services, our research idea is to combine and integrate model-based testing and runtime verification for the design, implementation and test of distributed systems protocols. We propose below, concrete research focus and questions:

- *What kinds of properties, common models or testing artifacts can be shared for model-based testing and runtime verification for the development of distributed system protocols?*
- *In order to effectively combine and integrate model-based testing and runtime verification for the development of distributed system protocols, can we specialize the runtime monitors in the implementation so that we do not need to run any monitors in those parts that have been proved as correct through exhaustive model-based testing?*
- *What are the current techniques and appropriate tools that can be used to contribute to the development of distributed systems protocols by combining model-based testing and runtime verification and how can we use them?*

3 Research approaches

In order to find out answers to the research questions mentioned, the research will be divided into the main work packages described below. We mainly concentrate on the following research approaches:

- 1: *Investigation of distributed system protocols, which involves summary and comparison of replication and reconfiguration protocols.*
- 2: *Review of methodologies and tools to combine model-based testing and runtime verification for the development of distributed systems protocols.*
- 3: *Development of the case study by selecting a basic distributed systems protocol and employ model-based testing and runtime verification for this protocol.*
- 4: *Investigate and find out existing limitations and questions from the development of the case study and develop new theory in order to solve the limitations and questions.*
- 5: *Focus on the development of new tools to combine model-based testing and runtime verification for the development of distributed systems protocols.*
- 6: *Experimentally evaluate the new theories and tools of model-based testing and runtime verification, which aims to contribute to the development of distributed systems protocols and cloud-based services.*

The final goal is to contribute to the development of distributed systems protocols and cloud-based services by using model-based testing and runtime verification.

4 Outlook

During our research, we will investigate existing distributed systems protocols, with a special focus on the replication protocols and reconfiguration protocols. We will also analyze and compare the current distributed systems protocols, and design, test and implement protocols. Meanwhile, we will consider the use of model-based testing and runtime verification techniques for the implementation of replication protocols and reconfiguration protocols. During this process, we will find out how to effectively combine these two techniques. Finally, we will focus on the application of the protocols with model-based testing and runtime verification for effective development and reliable implementation of advanced online cloud-based services and distributed systems of the future.