Time-accurate Network Simulation
Interconnecting QEMU VMs

Executive summary: The proposed work aims at designing an evaluation environment for distributed infrastructures where the instances of the real application are executed in full QEMU-based virtual machines, interconnected by a network simulator. Starting from an existing prototype, the work should enable the study of unmodified real infrastructures such as the Storm Event Processing Infrastructure and the Ceph Distributed Storage.

Advisors:
- Martin Quinson (ENS-Rennes, IRISA, team Myriads) Martin.Quinson@ens-rennes.fr
- Louis Rilling (DGA, team Myriads) Louis.Rilling@irisa.fr

Level: Master.

Key skills: Deep understanding of OSes, Networks and VMs; System Programming on Linux.

Context and Description

Distributed systems such as Peer-to-Peer systems, Internet of Things and Cloud Computing, benefit of an ever increasing popularity nowadays. Distributed applications (such as decentralized data sharing solutions, games, scientific applications, high-traffic web applications) are executed routinely on these systems.

By nature, the resulting environments and applications are extremely complex and dynamic because they aggregate thousands of heterogeneous and dynamic elements. This make these systems very challenging to study, test, and evaluate. Purely theoretical studies rely on assumptions that are at best simplistic and often unrealistic. Most of the studies are thus done through experiments, often on dedicated facilities. But the recent evolution of the target systems in size, dynamity and complexity makes it difficult to even test the infrastructures in a reliable and reproducible manner. An appealing alternative is to rely on simulation.

SimGrid (developed by M. Quinson in an international collaboration) is a toolkit providing core functionality for the simulation of distributed applications in heterogeneous distributed environments. Over the years, SimGrid has emerged as one of the key scientific instrument in this domain. It grounded the experiments of over 30 PhDs works, 90 journal articles and book chapters as well as 200 conference papers, and is cited by over 500 other articles in the literature. Its key features are its sound performance models (enabling accurate performance prediction in non-trivial scenarios) as well as its efficiency and scalability.

The performances of MPI applications can directly be evaluated with SimGrid, as the standard is reimplemented on top of the simulator. For other real applications, users have to extract the applicative logic and rewrite it using the SimGrid interfaces. Several application authors did so to test and tune their application within the simulator but this work remains labor-intensive.

The overall goal of this internship is to leverage the predictive power of SimGrid on unmodified, non-trivial distributed applications executed within modified QEMU-based virtual machines. In the future, this work could be extended towards the stealthy analysis of malicious distributed applications.
Detailed Work Plan

The proposed work consists in three main steps:

- Modifying QEMU’s user mode network emulation (based on SLIRP) to make the VM communicate with the network simulator instead of the real network. This work will leverage an existing PoC prototype interfacing simple mocked applications within the SimGrid simulation framework.

- Building a minimal required network environment to run the applications, that is typically a DNS and possibly file and mail servers. The building blocks could use parts of QEMU’s user mode network emulation as well as real servers in virtual machines. Building this environment should be automated.

- Validating the network environment on top of the network simulator by experimenting with real applications. We especially propose to experiment with ShareLatex and Ceph to gradually stress the implemented mechanisms and show their completeness.

The experiments will leverage the Grid’5000 testbed and associated tools like EnosStack that are developed in part in the Myriads team.

Bibliography

- https://www.grid5000.fr/