Real-time online emulation of real applications on SimGrid with Simterpose

Executive summary: The goal of this project is to design an evaluation environment for distributed applications (e.g.; P2P applications) where the instances of the real application (a standard & unmodified BitTorrent client) are executed in a virtual environment simulated by the SimGrid simulator.

Key skills required: system programming in C on Linux; deep understanding of OS principles

Research team name:	AlGorille (leader: Martin Quinson)
Research Unit:	Nancy – Grand Est
Intern tutor:	Martin Quinson `<martin.quinson@loria.fr>`
Intern level:	Master student (or PhD student)
Internship duration:	4 to 6 months
Followed by a PhD:	possible

Context

Distributed systems such as grids, clusters, peer-to-peer systems, high-performance super-computers, cloud computing infrastructures or desktop computing environments, 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 elements that are heterogeneous and shared among several users. This make these systems very challenging to study, test, and evaluate. Computer scientists traditionally study their systems *a priori* by reasoning theoretically on the constituents and their interactions. But the complexity of these systems make this methodology near to impossible, explaining that most of the studies are done *a posteriori* through experiments.

Three main methodologies exist to experiment with computer systems: real-scale experiments using testbeds, simulation and emulation. *Real-scale* (or *in situ*) consists in executing the real application under study on an experimental platform like Grid'5000 or PlanetLab. On the opposite, with *simulation*, both the application and the environment are replaced by models, and the interactions between both models are computed by a simulator. *Emulation* can be seen as an intermediate approach where the real application is executed within a synthetic environment. Typically, one will use a homogeneous cluster of machines as an execution environment, and use an emulation layer to reproduce the complex conditions found on the real Internet.

SimGrid (developed by the AlGorille team in collaboration with other teams) is a toolkit providing core functionalities for the simulation of distributed applications in heterogeneous distributed environments. The specific goal of the project is to facilitate research in the area

of distributed and parallel application scheduling on distributed computing platforms ranging from simple network of workstations to Computational Grids. It is however not possible to use real applications directly on SimGrid: users have to extract the logic of their applications and rewrite them using the specific interfaces of SimGrid.

The Simterpose project, which is the core of this internship proposal, tries to alleviate this by providing a way to use SimGrid as an emulator. This would allow real applications to be executed on virtual platforms emulated by SimGrid. This project naturally relates to the *Distem* emulator also developed in the AlGorille team, but follows a completely different approach. Distem emulates the target platform by limiting the performance of the host platform running the experiment.

Instead, Simterpose intercepts all system calls corresponding to communications and delay them according to the computations of the simulator. Application's computations are benchmarked and the resulting delays are also injected within the simulator.

Description

We currently have a prototype of Simterpose, but many things remain to be done before it can be used in production. Only a very small subset of syscalls are handled, and pure library calls that do not relay on syscalls (such as pthread calls) are not intercepted by the tool.

The goals of this internship are:

- Continue the development of Simterpose by implementing more syscalls on top of the SimGrid simulator;
- Propose a mechanism to intercept library calls, and leverage it for pthread calls as well as for DNS resolution calls.
- Extend Simterpose to the analysis of Storage applications, leveraging the model of performance that already exists in SimGrid.
- Evaluate Simterpose through the emulation of some previously selected real distributed applications such as the BitTorrent P2P protocol, the Ceph large-scale storage application or an implementation of the MPI standard such as OpenMPI or MPICH. Simpterpose could for example be used to evaluate the semantics of collective operations in MPI implementations.

Skills required

In addition to the skills that can reasonably be expected from Master-level students, the applicant should have a **very strong** knowledge of system programming in C, and of Linux and other modern Unix-based Operating Systems.

Links

- SimGrid : http://simgrid.gforge.inria.fr/
- Research team (ALGORILLE): http://www.loria.fr/equipes/algorille/
- Tutor: http://www.loria.fr/~quinson/
- Publication from a previous intern on Simterpose:
  M. Guthmuller, L. Nussbaum et M. Quinson. Émulation d'applications distribuées sur des plates-formes virtuelles simulées
  http://hal.archives-ouvertes.fr/inria-00565341/en/