Real-time online emulation with Simterpose

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General information

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Context

Distributed systems such as grids, clusters, peer-to-peer systems, high-performance supercomputers, cloud computing infrastructures or desktop computing environments, benefit of an ever increasing popularity nowadays. Distributed applications (such as decentralized data sharing solutions, games, scientific application, high-traffic web applications or scientific computations) 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 is 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, simulation and emulation. *Real-scale* (or *in situ*) consists in executing the real application under study on an experimental platform like Grid'5000 (a large scale experimental platform in France, composed of more than 1600 machines). On the opposite, with *simulation*, both the application and the environments 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) 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 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 reducing the performance of the host platform running the experiment while Simterpose intercepts all computations and communications and delay them according to the computations of the simulator.

Description

Simterpose is still under development. It currently only allows to extract a trace of applications' actions that could be suitable for replay in SimGrid. The simulator is not able to deal with these traces yet, neither for offline analysis once the complete trace has been captured, nor online directly to delay the application's actions according to simulation results provided by SimGrid.

The goals of this internship are:

- Develop a simple offline simulator of Simterpose traces;
- Continue the development of Simterpose to provide real-time online emulation on top of SimGrid;
- Evaluate Simterpose by running real distributed applications: P2P applications, high-performance computing applications written using MPI, ...

Future plans (most likely beyond this internship) include:

- Distributing the execution of the user application on several cluster nodes (with a centralized SimGrid instance to provide the simulation) to achieve large-scale emulation using SimGrid and Simterpose. The developed solution will be evaluated on Grid'5000;
- Use Simterpose to understand the semantics of collective operations in MPI implementations such as OpenMPI and MPICH2. The long term goal is to integrate the resulting models in SMPI, the SimGrid-based MPI simulator.

Skills required

In addition to the skills that can reasonably be expected, the applicant should have a strong knowledge of system programming in C, and of modern Unix Operating Systems such as Linux.

Links

- SimGrid : http://simgrid.gforge.inria.fr/
- Research team (ALGORILLE): http://www.loria.fr/equipes/algorille/
- Tutors: http://www.loria.fr/~quinson/ and http://www.loria.fr/~lnussbau/
- 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/