XtremLab:
A System for Characterizing Volunteer Computing Resources

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Abstract

Volunteer computing (VC) systems use the idle computing power of many volunteered desktop PC's to support large-scale computation and storage. For over a decade, VC systems have been the largest and the most powerful distributed computing systems, offering a plethora of computing power at a fraction of the cost of supercomputers. The volunteer desktops participating in VC projects are volatile and heterogeneous, but there is little detailed information about their volatility and heterogeneity. Yet this characterization is essential for the simulation and modelling of such systems. We are conducting a project whose goal is to obtain detailed picture of the VC landscape. To this end, we have deployed resource sensors on the volunteer desktops to measure the availability of CPU, disk space, memory, and network bandwidth. Users can participate by visiting the project website at `http://xw01.lri.fr:4320`*. The resulting resource measurement data and characterization will be useful for a broad range of research areas, including distributed and peer-to-peer computing, and fault tolerance.*

1. Introduction

Since the late 1990's, VC systems, such as SETI@Home [7], have been the largest and most powerful distributed computing systems in the world, offering an abundance of computing power at a fraction of the cost of dedicated, custom-built supercomputers. Many applications from a wide range of scientific domains – including computational biology, climate prediction, particle physics, and astronomy – have utilized the computing power offered by VC systems. VC systems have allowed these applications to execute at a huge scale, often resulting in major scientific discoveries that would otherwise had not been possible.

The computing resources that power VC systems are shared with the owners of the machines. Because the resources are volunteered, utmost care is taken to ensure that the VC tasks do not obstruct the activities of each machine's owner; a VC task is suspended or terminated whenever the machine is in use by another person. As a result, VC resources are volatile in the sense that any number of factors can cause the task of a VC application to not complete. These factors include mouse or keyboard activity, the execution of other user applications, machine reboots, or hardware failures. Moreover, VC resources are heterogeneous in the sense that they differ in operating systems, CPU speeds, network bandwidth, memory and disk sizes. Consequently, the design of systems and applications that utilize these system is challenging.

2. Challenges and Opportunities

While VC systems consist of volatile and heterogeneous computing resources, it unknown exactly how volatile and heterogeneous these computing resources are. While there have been previous characterization studies on Internet-wide computing resources, these studies do not take into account causes of volatility such as mouse and keyboard activity, other user applications, and machine reboots. Moreover, these studies often only report coarse aggregate statistics, such as the mean time to failure of resources. Yet, detailed resource characterization is essential for determining the utility of VC systems for various types of applications. Also this characterization is a prerequisite for the simulation and modelling of VC systems in a research area where many results are obtained via simulation, which allow for controlled and repeatable experimentation.

3. Approach

We propose to design, implement, and deploy a resource monitoring project called XtremLab via the Berkeley Open Infrastructure for Network Computing (BOINC) [3, 1] software system. BOINC projects are arguably the largest distributing computing projects in the world, as the number of active participants is more than 500,000 desktop PC's. The goal of XtremLab will be to monitor the availability of a large fraction of these in an effort to paint a more detailed picture of the Internet computing landscape.

Specifically, the XtremLab application will periodically measure the availability of the CPU, memory, disk space, and network bandwidth, and write these measurements to a trace file. These trace files will then be collected and assembly to yield a continuous time series of availability for each hardware resource. We will then analyze these trace files to determine aggregate statistics of the system as a whole, and per-host statistics.

4. Impact

The results of this research will be useful to distributed computing research and other fields in many of ways. First, the trace data will enable accurate simulation and modelling of VC systems. For example, the traces could be used either to directly drive simulation experiments or to create generative probability models of resource availability, which in turn can be used by simulators to explore a wide range of hypothetical scenarios.

Second, because the traces will contain the temporal structure of availability, the traces will enable the assessment of the utility of volunteer computing systems for a wide range of applications. Currently, the range of applications that utilize VC systems effectively has been limited to applications with loosely-coupled tasks that are independent of one another; the volatility and heterogeneity of VC resources makes the execution of tightly-coupled applications with complex task dependencies extremely challenging. With the traces, we could conduct a cost-benefit analysis for a wide range of applications; specifically, we could determine the limitations that prevent certain types of applications from utilizing VC systems effectively, and suggest new research directions to address these limitations.

In addition, we believe our measurements could be useful for other sub-domains in computer science such as fault tolerance, peer-to-peer computing, and Grid computing. For example, one issue relevant to the fault tolerance research community is how often resources crash and why. The data we collect will reflect the time to failure for each desktop resource and thus be a valuable data set for those researchers. We will make the traces publicly available to all these research communities, such as those participating in the French Grid5000 project and CoreGrid, a research organization for fostering European collaboration.

Finally, we believe that the project will the raise the visibility of scientific research with emphasis on distributed computing, and will be a means of outreach and education to participants and the general public. To that end, we will ensure that the project will provide detailed information about its goals and results, in addition to the computing and software technologies used for deployment.

5. Past and Future Work

We have conducted a number of related research efforts. First, in [6, 5] , we measured and characterized several VC systems at the University of California at San Diego and the University of Paris-Sud. We obtained several months of traces of the availability of hundreds of desktop PC's within these organizations. We then characterized the VC systems by obtaining several aggregate and per-host statistics. This characterization formed the basis for a model describing the the utility of the VC systems for different applications, and for developing efficient ways of scheduling tasks to VC resources [4]. So that others could use our gathered trace data sets, we created an an online VC trace archive publicly accessible at `http://vs25.lri.fr:4320/dg`. The limitation of this work, which we address in our proposed project, is that no measurements were taken of home desktop PC's, which contribute significantly to Internet-wide VC projects.

Second, in [2], we measured aggregate statistics gathered through BOINC. A limitation of this work is that the measurements do not describe the temporal structure of availability of individual resources, and so it would be difficult to use these statistics for detailed simulation or modelling purposes. Again, our proposed work addresses this limitation by obtaining a time-series of measurements of VC resource availability.

Currently, we have an initial version of the XtremLab system based on BOINC deployment and running. Interested users can partipate by visiting `http://xw01.lri.fr:4320`. For future work, we plan on expanding XtremLab's software infrastructure to support end-to-end network and distributed computing experiments.

References

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