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Mat-2.177 Project Seminar in Operations Research

Grid Computing in Home Environments – does it make sense

Nokia Research Center

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1 Introduction

This project, ordered and supported by Nokia Research Center, is part of the course Mat-2.177 Project Seminar in Operations Research organized in spring term 2004 in Helsinki University of Technology. The aim of the project is to examine the possibilities of grid computing in home use.

2 Background

Despite the continuous exponential growth in computing power of microprocessors, some demanding tasks such as NP-complete problems in large scale require computational resources that are too time-consuming for even the most powerful ordinary computers. The rapid development of information networks has enabled the possibility to divide the problem to a number of smaller ones and then distributing these to independent computing nodes which can process smaller problems simultaneously. This kind of processing is known as Grid computing. According to Grid Computing Info Centre [1], “Grid is a type of parallel and distributed system that enables the sharing, selection, and aggregation of geographically distributed autonomous resources dynamically at runtime depending on their availability, capability, performance, cost, and users' quality-of-service requirements.” Currently grid computing is used in many computationally demanding scientific experiments and also several public grid computing projects exist; the most well-known being the SETI@home project [2]. In many of these, the computational data is distributed through the Internet and the computing workload is divided between users who have voluntarily joined the project.

In late 2002, Sony filed a patent application relating to use of grid computing in its forthcoming Playstation 3 gaming console [3]. The idea is that instead of single processing unit inside the console, the computing tasks are divided between similar computing components or “cells”. The console itself contains some cells and additional computing power can be obtained from other cells connected to the console via optical link or broadband connection. The total benefit from this kind of distributed computing is not yet known, but Sony’s original goal with Playstation 3 was to create a gaming console with 1000 times the processing power of Playstation 2 [4].

3 Objectives of the project

3.1 Research problem and research questions

The objective of the project is to find the answer to the client's problem that can be defined as follows: Does the idea of splitting computing tasks between different home-based devices have any relevant use or advantages now or in the future from the computing point of view?

To find the solution to this research problem the following research questions need to be answered:

- What is the best topology to connect terminal equipment together?
- What kind of performance improvements can be achieved?
- How sensitive is the performance to the topology, to the types of the equipment and to the bandwidth of the communication channels?
- What would be good applications for this concept?
- How to split the tasks between the devices?

3.2 Research scope and exclusions

Only technical side of the home grid concept and its appropriateness is considered in this research.

The research concentrates only on those different devices that the research team found appropriate and interesting and could be the nodes of the home grid network. These devices are PC, laptop computer, gaming console, PDA, mobile phone, digital camera and calculator.

Some simplifications are made in the model of home grid network and its performance. Only relative computing power of nodes, connections available between the nodes, bandwidths and latencies between nodes are considered. In addition, relative computing capabilities (measured for example in operations per second) of different equipment are assumed to be proportional to their relative CPU speed (measured for example in MHz).

One practical case is selected for testing of the constructed network model.

4 Structure of the research

The research is very explorative in nature. At present it is not exactly known through, which phases the project will evolve to reach its final goal. However, there are some high level tasks, which are to be completed that will form the basic structure of the project. The research can be divided to seven phases – some of those are concurrent.

- Literature study
- Screening and selecting cases
- Collecting information regarding parameters of the model
- Structuring the selected case
- Structuring a mathematical model
- Testing the case and model together
- Drawing conclusions

In exhibit A the steps of the study are presented in logical manner. Next the individual steps will be discussed in more detail.

4.1 Literature study

Literature will be examined to gather information of grid computing, performance measurement of data networks in general. Even though called here a literature study, the aim is not to make a complete review into what, for example, grid computing is, but to broaden the knowledge of the project team regarding the subject area and to structure a background, which to reflect on during the research and in the final report.

4.2 Screening and selecting cases

In this phase the objective is to find appropriate ideas of applications that could benefit from home grid computing. The most prominent one of the application ideas is selected and further analyzed. The ideas will be elicited during workshops (of team members only) and also ideas from the client will be used.

4.3 Collecting information regarding parameters

To develop a mathematical model[1] the following information must be gathered.

- Available connections in each terminal equipment (e.g. ADSL, WLAN, USB, GPRS)
- Relative computing power of terminal equipment. This will be approximated with the CPU speed of the processors (MHz)
- Bandwidth of each type of connection (bits per second)
- Latency of each type of connection. Here latency means the time it takes to send smallest amount of data between two nodes using the specific connection (ms)

Primary source will be technical documentations, standards and academic articles.

4.4 Structuring the case

At this point we should have a case which at least at a intuitive level should seem reasonable for home grid computing. The problem at this phase is to simplify the case in order to measure the benefits with some mathematical model. Questions like, what are the computing requirements for the case and how the computing can be split into parts, must be answered at this phase.

4.5 Structuring a mathematical model

Each terminal in a grid forms a node in the network. Each available connection between terminal nodes forms an arc (USB between digital camera and PC, for example). The bandwidth defines the upper limit for the capacity of each arc. The cost associated with each arc can be approximated with the bandwidth and latency.

The above together with the numeric variables for each parameter should form the basis for building a mathematical model that captures the benefits of solving a computational task in a home grid.

[1] At present a linear model of a network (LP-model) seems like a prominent mathematical model.

4.6 Testing

The testing phase is about applying one case to the mathematical model. The results will reveal what benefits were accomplished, what problems emerged, and gives guidance whether to look for more case, refine the model or be satisfied with the results.

4.7 Conclusions

Based on the testing phase the conclusions are drawn from the results.

5 Resource allocation and project schedule

5.1 People involved

Persons involved in the project are the project team members, Nokia Research Center contact person and the course personnel. The project team consists of four undergraduate students

- **Pasi Kuusela** (project manager), major Strategy and International Business, minor System and Operations Research
- **Anton Danielsen,** major Strategy and International Business, minor System and Operations Research
- **Henri Hytönen**, major System and Operations Research, minor Strategy and International Business
- **Tero Ylä-Anttila**, major Strategy and International Business, minor System and Operations Research

The contact person at Nokia Research Center is **Jukka K. Nurminen**. Furthermore, the project will be supervised by course personnel consisting of Professor Ahti Salo and assistant Antti Punkka.

5.2 Schedule and Workload

The scope of the course is 3 credits. Thus, it means work of about 120 hours per person, which is approximately 13 hours a week during 9 weeks. Because of the nature of the project it is most important to keep the schedules during early phases of the project to allow room for contingencies later. Table 1 depict the schedule of the project.

Table 1. The project schedule and responsibilities.

	Week									
Action	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**Responsible**
Project plan presentation (20.2)										
Literature study										**AD, HH**
Screening and selecting cases										**TYA, PK**
Collecting information regarding parameters of the model										**all**
Interim report and its presentation (19.3.2004)										
Structuring the selected case										**PK, AD**
Structuring a mathematical model										**HH, TYA**
Testing the case and model together										**all**
Drawing conclusions										**all**
Writing final report										**all**
Final report deadline (19.4.2004)										

6 Risks concerning the project

We recognized the following risk for the project.

6.1 Project team skill risk

There is a risk that the skills of the project team do not match those required in the assignment. The project team is exceptionally homogenous, what comes to background knowledge *(see 5.1 People involved)*. Thus, the span of knowledge of the team is not as wide as one could hope for. Unfortunately there are many fields the project team lacks deep knowledge in, like for example grid computing, computer architectures, software algorithms and to some extent even mathematical modelling.

To minimize this risk we intend to use much time in the beginning of the project to familiarize ourselves with the required fields of knowledge and possibly use expert interviews during the project.

6.2 Risk of not finding a suitable case

If the project team can not find a suitable case to start analyzing, the project results might become impractical. For example, if the chosen case or cases are not suitable in themselves for distributed computing, the results will not say much whether some other case or application is or isn't suitable for distributed computing. On the other hand, the chosen case might be feasible for distributed computing but far from practical application.

We intend to be in a close contact with Jukka Nurminen to ensure that we keep our project on right track from the beginning.

6.3 Risk that the mathematical model is inadequate

The chosen and developed model might not capture the essence of the problem area. Thus, the results would not be realistic.

In addition, to our own critical examination, we hope that others reading our interim report and final report can give critical feedback.

7 References

[1] Grid Computing Info Centre, URL www.gridcomputing.com

[2] SETI@home Project, URL http://setiathome.ssl.berkeley.edu

[3] United States Patent Application: nr 0020138637

[4] Becker, David: Playstation 3 takes the grid, URL http://zdnet.com.com/2100-1105-866388.html

Appendix A

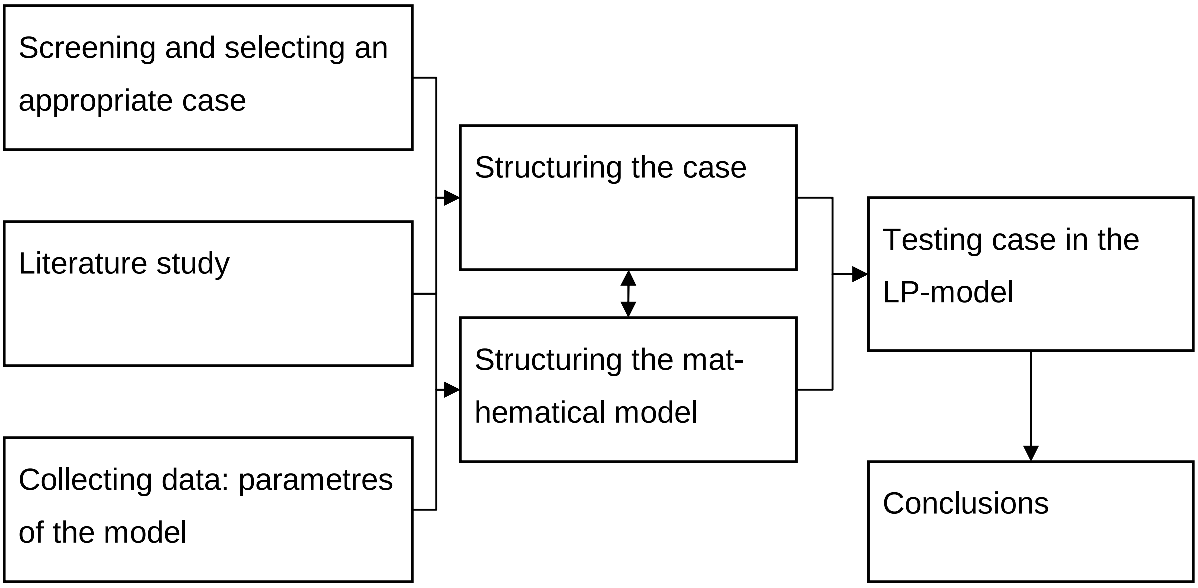

Figure 1. Tasks to be completed in the project and their dependencies