The Impact of Grid Computing on E-Business

A Research Report

presented to

The Graduate School of Business

University of Cape Town

in partial fulfilment

of the requirements of the

Masters of Business Administration Degree

by

Godwin Sweto

November 2002

Supervisor: Kurt April
PREFACE

The report is not confidential, and may be used by the Graduate School of Business, University of Cape Town, as they wish.

I must express my sincere appreciation for the assistance provided by the following people:

- Kurt April, Senior Lecturer at the Graduate School of Business, who introduced me to the subject area, and provided valuable guidance throughout the research;

- Associate Professor Trevor Wegner, who assisted with some advice on statistical data analysis;

- Ms Julie Wulf of the Global Grid Forum, who helped arrange sponsorship for my trip to the Global Grid Forum Conference in Edinburgh, July 2002, and

- Susan Sweto, who consistently provided valuable support and encouragement.

I certify that, except as noted above, this report is my own work and that all references and quotations have been properly identified.

Signed: _______________

GODWIN SWETO
THE IMPACT OF GRID COMPUTING ON E-BUSINESS

ABSTRACT

This research investigates the impact of Grid Computing on e-business, exploring both the opportunities the technology presents, and the challenges it faces.

The research highlights the various benefits that have been realized by more than twenty early adopters of Grid technology. These benefits include improved resource utilization, enhanced intra- and inter-enterprise collaboration, and opportunities for new revenue streams.

The key challenges facing the commercial adoption of Grid Computing, are identified to be bandwidth constraints, security concerns and the current shortage of robust, Grid-enabled applications. Important differences of the significance of these challenges across regions are explored.

Finally, important conclusions are made, and recommendations for further research presented. The conclusions reached include the need for enterprises to seriously start exploring Grid Computing. Managers are encouraged to recognize that this technology could enhance the return on investment of their information technology assets. Advice is given to South African enterprises to keep a watchful eye on Grid technology.

GLOSSARY OF TERMS

i. **Bandwidth**: The amount of data that can be sent through a network connection, measured in bits per second. Bandwidth represents the range of frequencies occupied by an electronic signal on a given transmission medium.

ii. **E-Business**: Business performed through the Internet, e.g., buying, selling and the servicing of customers. It also includes collaborating with business partners (e.g., via Extranets), as well as the provision of services and tasks over the Internet by application service providers. E-Business includes online exchanges of information, e.g., letting suppliers access an organization’s Extranet, or banks giving clients access to their accounts through the Web. E-business also includes the transformation of existing business processes to make them more efficient (Darwin Magazine, 2002).

iii. **E-Commerce**: The buying and selling of goods and services on the Internet, especially using the World Wide Web. E-commerce and E-Business are often used interchangeably, though E-Business should be seen as much broader than just selling on the Internet (Darwin Magazine, 2002). For online retail selling, the term e-tailing is sometimes used.

iv. **Global Grid Forum (GGF)**: A forum of individual researchers and practitioners from over 200 organisations, working on Grid technologies and standards. Member companies include IBM, Intel, Fujitsu, NASA, Sun Microsystems and Microsoft. The GGF is the result of a merger of the Grid Forum, the eGrid European Grid Forum, and the Asia-Pacific Grid Forum.

v. **Globus Toolkit**: A set of services and software libraries that support Grid and Grid applications, covering such issues as security, data management and communication (Foster, Kesselman, Nick and Tuecke; 2002).

vi. **Grid Computing**: Grid Computing can be described as:
“A collaborative, network-based model ... (that) enables the sharing of data and computing cycles among thousands of processors to create the ultimate brainstorming tool: a virtual supercomputer” Fixmer (2002:1).

vii. **Internet**: A huge network of millions of computer hosts spanning the whole world, mainly using TCP/IP as the communication protocol, and using a common address system.

viii. **“Last Mile” Bandwidth**: The bandwidth of the network connections from homes and businesses to local service providers. These connections are still largely dependent on copper cables, rather than the more expensive, optical fibre (Onfibre, 2002). “Last mile” bandwidth remains a significant challenge to fast Internet access.

ix. **Utility Computing**: an IT delivery model in which enterprises do not operate their own computing infrastructure, but access, and pay for computing offered by a service provider (Shread, 2002i: 2).

x. **Web Services**: A standard-based framework for accessing applications via a network. Applications are broken down into reusable components or services, each capable of performing a distinct function. The services are then linked together using data exchange standards like XML. One can then build applications using the web services quickly.

xi. **World Wide Web (WWW or Web)**: The part of the Internet comprising documents linked to each other. The Web originated in a research laboratory at the European Institute for particle physics (CERN, in Switzerland), whilst the Internet began as an experimental US Department of Defence network (Global Grid Forum, 2002).
TABLE OF CONTENTS

Page

ABSTRACT ...................................................................................................................................(iii)
GLOSSARY OF TERMS .....................................................................................................................(iv)
1. INTRODUCTION ........................................................................................................................1
   1.1 RESEARCH OBJECTIVES ............................................................................................3
   1.2 DISSERTATION LAYOUT ............................................................................................3
   1.3 THE IMPORTANCE OF THIS STUDY .........................................................................4
2. LITERATURE REVIEW .................................................................................................................6
   2.1 DEFINITION AND ORIGIN OF GRID COMPUTING .................................................6
      2.1.1 Definition of Grid Computing ................................................................................6
      2.1.2 The History of Grid Computing ............................................................................8
      2.1.3 How Grid Computing Works .............................................................................10
   2.2 SCIENTIFIC AND ACADEMIC APPLICATIONS .....................................................10
   2.3 E-BUSINESS AND GENERAL COMMERCIAL APPLICATIONS ..........................13
      2.3.1 How Grid Technology Can Be Applied To E-Business ........................................13
      2.3.2 The Benefit Matrix .............................................................................................15
      2.3.3 Other Possible Benefits .......................................................................................17
      2.3.4 Challenges To The Implementation Of Grid Computing.....................................20
   2.4 CONCLUSIONS FROM THE LITERATURE SURVEY ..............................................21
3. RESEARCH METHODOLOGY ...............................................................................................22
   3.1 PHASE I: EXPLORATORY RESEARCH ....................................................................23
   3.2 PHASE II: PRIMARY RESEARCH .............................................................................23
      3.2.1 Objectives Of Primary Phase .............................................................................23
      3.2.2 Research Approach .........................................................................................24
      3.2.3 Data Collection Methods ...............................................................................25
      3.2.4 Data Collection at the Global Grid Forum Conference .......................................28
      3.2.5 Ethical Issues ..................................................................................................29
4. FINDINGS, DISCUSSIONS AND ANALYSIS ..................................................................30
   4.1 RESULTS FROM EXPLORATORY RESEARCH ..................................................30
      4.1.1 Profile Of Respondents ......................................................................................30
      4.1.2 Summary Of Results From Exploratory Survey .............................................31
4.1.3 Conclusions from Exploratory Research.................................................................32
4.2 RESULTS FROM PRIMARY RESEARCH PHASE .........................................................34
  4.2.1 Descriptive Statistics............................................................................................35
  4.2.2 Grid Computing Usage.........................................................................................37
  4.2.3 The Importance Of Grid Technology In E-Business .............................................39
  4.2.4 Analysis Of Benefits Achieved To Date ...............................................................42
  4.2.5 Applications As A Barrier To The Adoption Of Grid Technology .......................44
  4.2.6 Security As A Hindrance To Grid Computing.....................................................46
  4.2.7 Bandwidth As A Constraint To The Adoption Of Grid Technology .......................47
4.3 HYPOTHESIS TESTING............................................................................................52
5. LIMITATIONS OF THIS PROJECT ............................................................................55
  5.1 SAMPLE SIZE AND COMPOSITION.......................................................................55
  5.2 DISTANCE PROBLEMS.........................................................................................55
  5.3 VERIFICATION.......................................................................................................55
  5.4 THE NEWNESS OF THE TECHNOLOGY ...............................................................55
6. FURTHER RESEARCH................................................................................................57
7. CONCLUSIONS...........................................................................................................58
8. BIBLIOGRAPHY...........................................................................................................60
9. APPENDICES...............................................................................................................66
  9.1 APPENDIX 1: QUESTIONNAIRE FOR SOUTH AFRICAN BUSINESSES.................66
  9.2 APPENDIX 2: QUESTIONNAIRE FOR GLOBAL GRID FORUM............................69
  9.3 APPENDIX 3: RESULTS FROM EXPLORATORY SURVEY...................................72
    9.3.1 Quotes from Exploratory Survey ......................................................................72
  9.4 APPENDIX 4: RESPONSES FROM THE GLOBAL GRID FORUM (GGF)..............76
    9.4.1 Responses To Open-Ended Questions ............................................................77
TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1</td>
<td>Scientific Projects Using Grid Computing (Grid Computing Planet, 2002)</td>
<td>12</td>
</tr>
<tr>
<td>Table 2</td>
<td>Commercial Applications of Grid Computing</td>
<td>14</td>
</tr>
<tr>
<td>Table 3</td>
<td>The Benefit Matrix: Benefits Achieved To Date</td>
<td>15</td>
</tr>
<tr>
<td>Table 4</td>
<td>Questionnaire Design: Information Sought</td>
<td>26</td>
</tr>
<tr>
<td>Table 5</td>
<td>E-Business Activities In Participating Organisations</td>
<td>31</td>
</tr>
<tr>
<td>Table 6</td>
<td>Results from Exploratory Survey</td>
<td>32</td>
</tr>
<tr>
<td>Table 7</td>
<td>Respondents' Countries Of Origin</td>
<td>35</td>
</tr>
<tr>
<td>Table 8</td>
<td>Contingency Table: Grid Usage and E-Business Role</td>
<td>39</td>
</tr>
<tr>
<td>Table 9</td>
<td>Analysis Of Comments On E-Business Role</td>
<td>41</td>
</tr>
<tr>
<td>Table 10</td>
<td>Contingency Table on Bandwidth</td>
<td>50</td>
</tr>
<tr>
<td>Table 11</td>
<td>Exploratory Surveys: Results</td>
<td>72</td>
</tr>
<tr>
<td>Table 12</td>
<td>Responses to GGF Questionnaire</td>
<td>76</td>
</tr>
</tbody>
</table>

FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>Grid Architecture (Foster, Kesselman and Tuecke, 2001)</td>
<td>9</td>
</tr>
<tr>
<td>Figure 2</td>
<td>Respondents Broken Down By Sector</td>
<td>37</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Importance of Grid Computing in E-Business</td>
<td>40</td>
</tr>
<tr>
<td>Figure 4</td>
<td>Grid Computing Benefits</td>
<td>43</td>
</tr>
<tr>
<td>Figure 5</td>
<td>Respondent Views On Applications</td>
<td>45</td>
</tr>
<tr>
<td>Figure 6</td>
<td>Views of Bandwidth As A Constraint to Grid Computing</td>
<td>48</td>
</tr>
<tr>
<td>Figure 7</td>
<td>Differences In Ratings Of Bandwidth As A Barrier</td>
<td>51</td>
</tr>
</tbody>
</table>
1. INTRODUCTION

E-business requires an information technology architecture that provides “infinite availability” (Hoard, 2000:1). When your company’s Web site is down, your customers, spoilt for choice in an increasingly competitive world, will simply move to a competitor’s Web site. Once the customer is gone, he or she might never return.

It is the demand for such a “24 x 7” architecture, which now forces enterprises to search in such areas as science and academia, for an answer. And in Grid Computing, they may have just made the right strike. Or, have they?

Grid Computing is a technology whose vision is to enable the large-scale integration of processing power, data and other resources across organisational and geographical boundaries (Withers, 2002:8; Foster, 2000). The term “Grid” emerged in the early 1990’s, as a metaphor to describe a method of making computer power as accessible as Grid electricity (Avaki Corporation, 2002). This technology was developed to promote resource sharing, and scientific collaboration (Foster, Kesselman, Nick and Tuecke, 2002). It would also serve as a “lower cost alternative to supercomputers” (Fixmer, 2002:1).

Grid Computing has increasingly attracted interest within the e-business fraternity. This is largely because some of the key challenges, the technology is meant to address in science, mirror closely the problems routinely faced by business enterprises. For instance, the need to integrate heterogeneous systems in distributed environments, and the need for robust, scalable systems, are common in both scientific communities and commercial enterprises (Foster, Kesselman, Nick and Tuecke; 2002). Similarly, the desire to “cut costs, boost teamwork and speed-up product development” (Bonasia, 2002:1), is, arguably as important in e-business as it is in science.

Desplat, Hardy, Antonioletti, Nabrzyski, Stroinski, and Meyer (2002) report that several companies have already been formed, specifically to explore commercial applications of Grid
Computing. Several major information technology providers like IBM, Microsoft and Sun Microsystems are investing heavily into this technology, with IBM alone having “landed hundreds of millions of dollars in contracts to build Grid infrastructures”, since August 2001 (Fixmer, 2002:2). Several vendors are now selling hardware equipped with Grid products, like the Globus Toolkit, which enable buyers to construct their own Grids. IBM, for instance, includes the Globus Toolkit on its AIX and Linux servers. Compaq deploys the Grid Suite (from Platform Computing) on its Unix and Linux servers (Berkman, 2002).

These information technology vendors are also being spurred by the belief that Grid Computing could provide a way of delivering information technology as a utility, and now see Grid Computing as a “paradigm shift that will provide the next big boost in corporate productivity since the Internet and the World Wide Web” (Shread, 2002d: 1). Irving Wladawsky-Berger, Vice President for Technology and Strategy at IBM, even claims:

“Grid Computing will take E-Business to the next level, by giving customers a resilient, flexible, virtual IT infrastructure readily available from any location, on demand” (Shread, 2002a: 1).

Similarly, Sara Murphy, product-marketing manager at Hewlett-Packard, argues that, even if users were to be “disillusioned” with Grid Computing, the same concept would “reappear under another name, and still advance over the next 5-10 years” (Shread, 2002h: 2).

On the other hand, there are many organisations and individuals who are not so optimistic about the role Grid Computing will play in e-business. Manuel Peitsch, Head of Informatics and Knowledge Management at Novartis, Switzerland, whose organisation has actually used Grid Computing for many years, is quoted as having said, rather bluntly:

“Grid Computing is good for large computations with small data transfer that don’t require shared memory. It’s not good when you have someone waiting behind a Web page for an answer. What you don’t have is predictable, 100% throughput. Grid Computing is not for E-business”
-Ricadela (2002:3).
With so many sharply contrasting views about this technology—whose global market is expected by some, to rise from US$180 million in 2002, to over US$4.1 billion in 2005 (Shread, 2002e)—it is imperative that managers investigate the opportunities the technology could help create, and the threats it poses. Managers must seek to understand how this technology could be exploited, in order to advance their business and organisational goals. In addition, they must also seek to understand what challenges the technology faces.

It is hoped that this research will make a significant contribution towards that understanding.

1.1 RESEARCH OBJECTIVES

This investigation sought to identify e-business initiatives are going to benefit from Grid Computing. The research would also examine the challenges that face commercial adoption of Grid Computing.

The study would seek to test the following hypotheses:

i. **Significant obstacles must be cleared before Grid Computing can become a commercial reality.**

ii. **Grid Computing is not just for research and science communities.**

iii. **Grid Computing will change the competitive landscape, quite quickly.**

iv. **South African businesses do not need to currently concern themselves with this technology.**

1.2 DISSERTATION LAYOUT

This dissertation discusses the importance of carrying out research in the area of Grid Computing, and then summarises a review of relevant literature. An extensive coverage is made of the application of Grid Computing in scientific research, as well as its migration to the commercial arena.
The dissertation then discusses the research methodology used, before giving a detailed analysis of the findings from the research. Finally the conclusions are presented, followed by recommendations for further research.

1.3 THE IMPORTANCE OF THIS STUDY

Companies that pay attention to this evolving technology will stand to reap huge gains in the coming years. It (Grid Computing) will arm corporate executives, service providers, venture capitalists, governments and individuals with a set of decision tools to prepare and successfully win in this new computing paradigm- (Shread, 2002d: 2).

The dramatic changes that characterise today’s technological environment demand that enterprises consistently monitor emerging trends. The opportunities and threats presented by these emerging technologies must be explored and understood, and this understanding must then be used to craft competitive strategies. Hofer and Schendel (1978:1) support this assertion when they argue for the need to monitor environmental changes, in order for organizations’ continued survival. They cite Baldwin Locomotive Works - the now defunct, American steam locomotive manufacturer, as having failed as an entity because of their failure to notice the changes in the demand of steam engines. Kalakota and Robinson (1999), invoke the memory of the Titanic, as they argue for “trend-spotting” among businesses:

“The smart manager stands at the forefront of trends... before they become mainstream topics. Since it takes years to steer large organisations in new directions, towards new horizons, company captains must be aware of what lies ahead, or their companies will sink quickly as the Titanic when it hits the iceberg. Trend spotting has fast become a ‘plan or be planned for’ issue”.
- (Kalakota and Robinson, 1999: 30)

Similarly, in the information technology environment, it is essential to monitor the emergence of technologies like Grid Computing, for these changes might well threaten the very survival of some organizations, while creating great opportunities for others, and changing the very purposes of some organisations over time (Lynch, 2000: 494). Armed with the knowledge about how the technology works, managers can then plan for the organisational adjustments that may be necessary to fully exploit the new technologies.
If the vision of Grid Computing improving return on investment, through the improved utilisation of existing computer processing and storage investments, is real, then business must pay attention at once. The example of Intel, where only 5-20% of server capacity is utilised during the day, and virtually 0% at night, is a case in point (Ricadela, 2002). Goyal (2002) describes such underutilisation of resources as typical, and asserts that, by using Grid technology, with each computer contributing to operations according to each unused capacity, greater efficiency should be achieved.

From a South African perspective, this research represents one of the first research efforts into the impact of Grid Computing on e-business in South Africa, and should, hence, become an important reference for future research.
2. LITERATURE REVIEW

A literature review must be written with a particular reader in mind (Hart, 1998). This review is aimed at a reader who is unfamiliar with Grid Computing, and wants to know where the technology originates, how it is defined, where it has been applied, what benefits have been realised, as well as the challenges that lie ahead.

This literature review starts with a broad historical perspective, and then explores specific examples of applications of Grid Computing in science, as well as in E-Business. An analysis is then made of some of the potential benefits and challenges.

2.1 DEFINITION AND ORIGIN OF GRID COMPUTING

2.1.1 DEFINITION OF GRID COMPUTING

Several sources (Fixmer, 2002; Foster, 2002, Bonasia, 2002; Avaki Corporation, 2002) attempt to define Grid Computing.

Fixmer (2002:1) defines Grid Computing as a:

“Collaborative, network-based model ... (that) enables the sharing of data and computing cycles among thousands of processors, to create the ultimate brainstorming tool: a virtual supercomputer”.

Fixmer’s definition makes no explicit reference to the capacity to share application resources, nor the key attributes of cross-platform functionality, as well as the capacity to integrate geographically disparate resources.

On the other hand, Avaki Corporation (2002) emphasises the dynamic nature of the Grid, highlights the key ability of the Grid to span geographical and administrative boundaries, and avoids specifying which computing resources are to be shared:
“A dynamic network of computing resources that work together as a single, uniform operating environment. It can span locations and administrative domains, and can flexibly support dynamically changing organizations and computing requirements” - Avaki Corporation (2002:1).

Meanwhile, Berkman (2002:1) simply defines Grid Computing as:

“An army of processors networked together—either over the Internet, Intranet or corporate WAN—to handle enormous computing tasks by distributing the work among the processing resources”.

Berkman’s definition makes reference to the geographical spread, the possible use of Internet technologies, but makes no reference to the dynamic nature of the Grid. This definition is very much like that by Leone (2002), who describes Grid Computing as:

“A massive smoothing technique for asset allocation. In Grid Computing, PCs, servers, and workstations are linked together— one daisy chain, if you will. That linking of systems means computing capacity is never wasted” - Leone (2002:1)

Perhaps the most comprehensive definition of the Grid is the one proposed by Ian Foster, (Associate Division Director, Senior Scientist, and Head of the Distributed Systems Laboratory at the Argonne National Laboratory, Chicago). Foster is often credited with coming up with the concept of Grid Computing (Foroohar, 2002), though, as will be seen in the next section, this concept actually pre-dates him.

A Grid is a system that coordinates resources that are not subject to centralised control, using standard, open, general-purpose protocols and interfaces to deliver nontrivial qualities of service (Foster, 2002:2).

Foster (2002) identifies three features that can help identify a Grid Computing system:

- A Grid system must be pervasive, providing coupling to resources and spanning multiple domains;
- The system must provide well-defined, non-trivial functions, e.g., security, availability and performance; and
• The system must be based on open standards, which will enable the integration of heterogeneous systems (Withers, 2002). The Grid will employ protocols for addressing issues like authentication, authorization, and resource discovery and access across different platforms. It is vital that these protocols be based on open, rather than proprietary standards.

2.1.2 THE HISTORY OF GRID COMPUTING

Though Grid Computing is often referred to as new (Adams and Couture, 2002), the concept has been around for decades. Adams and Couture (2002) declare that the concept of Grid Computing emerged in the 1950’s at the time electric grids were being established, with the idea being to establish similar systems for the delivery of computing power. No details, however, are given to indicate what efforts, if any, were actually made in those early years to achieve the vision. On the other hand, Ricadela (2002), refers to a 1960 paper, “Man-Machine Symbiosis” by J.C.R. Licklider of the Massachusetts Institute of Technology (MIT), as evidence of computer scientists having thought of large scale resource sharing, as early as the 1960’s. This assertion is echoed by Ian Foster, who quotes Len Kleinrock’s 1969 suggestion:

“We will probably see the spread of ‘computer utilities’, which, like present electric and telephone utilities, will service individual homes and offices across the country” (Foster, 2002:1).

The 1980’s saw several companies establishing small Grids, as they found even supercomputers inadequate for some of their tasks, e.g., climate simulation and particle physics (Foroohar, 2002). Ricadela (2002) describes DuPont Corporation’s efforts, in the 1980’s, aimed at linking computer systems between their geographically dispersed factories, and how such efforts were hampered by the low microprocessor- and network speed at the time.

It was really the advent of “high speed gigabit networks” in the early 1990’s, and the pioneering efforts of such scientists as Foster, and Carl Kesselman, of the University of Southern California, that finally gave impetus to Grid Computing as we know it today (Ricadela, 2002:3).
A key development was the publication, in 1998, of a book titled, “The Grid: Blueprint for a New Computing Infrastructure” by Foster and Kesselman (editors). In this book, Foster and Kesselman outlined a model for “bringing together the power of mainframes, personal computers and the Internet” (Foroohar, 2002:2).

Foster and Kesselman then co-authored with Steven Tuecke (of The University of Southern California), The Anatomy of the Grid, a paper in which they defined, and proposed, an architecture for Grid Computing. The Anatomy of the Grid defined the “Grid problem” as: “flexible, secure, coordinated resource sharing among dynamic collections of individuals, institutions and resources” (Foster, Kesselman and Tuecke, 1999; 1).

The architecture so proposed comprises five layers, as shown in Figure 1. The fabric denotes the resources being shared, e.g., computing power, storage, data and bandwidth. The Connectivity layer defines core communication and authentication protocols required for Grid-specific network transactions. A third layer, that of resources, comprises protocols for accessing the various resources. This layer lies below the collective protocols, which coordinate the use of multiple resources. The final layer is that of the applications run on the Grid.

A subsequent paper, The Physiology of the Grid, proposed a service-oriented architecture for the Grid - the Open Grid Services Architecture (OGSA), and also proposed a way of integrating Grid
Computing with web services, in a commercial computing environment (Foster, Kesselman, Nick and Tuecke; 2002). The *Physiology of the Grid* further asserted that, in addition to enhancing capability, Grid Computing would help solve the challenges of establishing secure, scalable and reliable computing systems within commercial enterprises.

### 2.1.3 How Grid Computing Works

Several sources discuss how the Grid operates. Berkman (2002) gives a simple description of how an individual computer on a Grid submits a job, as well as the sequence of steps the job goes through up to completion:

- First, a computer user submits a job to the Grid through an interface on his, or her, computer;
- The job is accepted, and broken down into thousands of independent tasks by some special software on the Grid;
- The special software locates idle processors on the Grid, and allocates the tasks to these processors; and
- The software then aggregates the work and delivers the result (Berkman, 2002).

On the other hand, Lamnitchi, Foster and Nurmi (2002) focus on how the large scale sharing of resources in a computing Grid occurs. They describe how resources are located through specifying both desired static (e.g., operating system versions) and dynamic attributes (e.g., available network bandwidth).

### 2.2 Scientific and Academic Applications

*In a future in which computing, storage, and software are no longer objects that we possess, but utilities to which we subscribe, the most successful scientific communities are likely to be those that succeed in assembling and making effective use of appropriate Grid infrastructures and thus accelerating the development and adoption of new problem solving-methods within their discipline- Foster (2002:9).*
Several scientific research initiatives have employed Grid Computing to expedite large-scale computation, resource sharing and collaboration. Areas of such research include the search for cures for diseases (e.g., AIDS and cancer), gene sequencing and climatology.

Successes to date include the discovery of the rice genome, 6 years ahead of schedule (Shread, 2002g) and the discovery of the largest known prime number.

One well-known Grid Computing project is the SETI@home project (Search for Extraterrestrial Intelligence), a scientific project searching for evidence of life in space (Desplat, Hardy, Antonioletti, Nabrzyski, Stroinski and Meyer; 2002). SETI@home harnesses the unused compute cycles of millions of volunteered home computers worldwide, to analyse signals from outer space.

An even bigger project is the TerraGrid - a massive Grid being developed by the National Science Foundation (NSF), linking four US supercomputing centres. This project, when complete, should be able to produce 13.6 trillion teraflops (trillion floating-point operations per second) (Waldrop, 2002). The TerraGrid, described as “the world’s largest, fastest, most comprehensive, distributed infrastructure for open scientific research”, will have 450 terabytes of storage (Withers, 2002:1).

The muscular dystrophy research project, being carried out by the French Myopathy Association (AFM), is a good example of how much the Grid technology speeds up computation. This project is expected to take 7 months, whereas, were it run on a single personal computer, it would take 1170 years to complete (IT-Director, 2002).

Other examples of scientific projects employing Grid Computing are shown below (see Table 1). All the projects shown involve massive computation, and are using Grid technologies in order to meet the compute power demands, as well as to promote resource sharing among geographically dispersed individuals.
<table>
<thead>
<tr>
<th>Project</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>United Kingdom National Grid</td>
<td>A $50m British government initiative connecting thousands of computers on 9 Universities, for physics research.</td>
</tr>
<tr>
<td>Oxford University’s Cancer Research Project</td>
<td>Project for the analysis of billions of molecules in search for a cure for cancer.</td>
</tr>
<tr>
<td>Netherlands</td>
<td>Grid connecting resources of 5 universities.</td>
</tr>
<tr>
<td>NEESGrid Project</td>
<td>Network for earthquake engineering simulation, led by the National Centre for Supercomputing Applications (NCSA) at Chicago, Illinois.</td>
</tr>
<tr>
<td>CERN Openlab</td>
<td>An industrial collaboration trying to establish solutions for massive data storage and analysis.</td>
</tr>
<tr>
<td>Folding@home</td>
<td>Project for studying protein folding, misfolding and related diseases, e.g., Alzheimer’s and Parkinson’s diseases.</td>
</tr>
<tr>
<td>Compute-against-Cancer</td>
<td>Cancer research.</td>
</tr>
<tr>
<td>Fight AIDS@home</td>
<td>Research into treatment and possible cure for AIDS.</td>
</tr>
<tr>
<td>Casino 21</td>
<td>Climate simulation.</td>
</tr>
</tbody>
</table>

**Table 1: Scientific Projects Using Grid Computing (Grid Computing Planet, 2002)**

The challenges that Grid technology is helping the scientific community address, e.g., large-scale resource sharing and collaboration requirements are not unique to the scientific communities, but are also a common feature in the commercial arena (Foster, Kesselman, Nick and Tuecke, 2002). The next section explores the migration of Grid Computing to the commercial area.
2.3 E-BUSINESS AND GENERAL COMMERCIAL APPLICATIONS

2.3.1 HOW GRID TECHNOLOGY CAN BE APPLIED TO E-BUSINESS

“By Grid-enabling our products, we give customers the ability to share computing resources such as applications and data and computing power, both internally over Intranets and externally over the Internet” - Irving Wladawsky-Berger, IBM (Shread, 2002a: 1)

Several sources have described the various ways by which Grid Computing could have an impact on e-business (Berkman, 2002; Bonasia, 2002; Foroohar, 2002; Hirsh, 2002, Osadzinski, 2002; Neel, 2002). The common thread among the sources is the possibility of greater internal and external collaboration, more robust and dependable information technology systems, greater system scalability and higher returns on investment, through the greater utilisation of existing investments. Robust and dependable technology systems would help improve customer service.

Table 2 lists examples of cases where Grid Computing has actually been employed commercially, with significant benefits being achieved:
<table>
<thead>
<tr>
<th>Company</th>
<th>Grid Technology Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merrill Lynch</td>
<td>Portfolio analysis system integrating information on disparate systems. Also gives to brokers &amp; clients access via phones, PDA etc. Brokers get “up to the second”, integrated information. Value added to clients.</td>
</tr>
<tr>
<td>General Motors</td>
<td>Web services network connects various units with dealers. Aims at a build-to-order model, to cut inventory. Value added to dealers. System quickly locates specific cars in dealer’s inventory. Wider range of services to its dealers and customers.</td>
</tr>
<tr>
<td>Dell Computers</td>
<td>Web services network connecting assembly operations with suppliers. Also launching event management system. Dell automatically gets messages on inventory status for each hub. Reduced inventories and improved logistics.</td>
</tr>
<tr>
<td>Citibank</td>
<td>Offers competences as services to other companies e.g., the payment processing service. Sellers’ settlement time cut by 20-40%. Buyer costs down by up to 60%.</td>
</tr>
<tr>
<td>Entropia Inc</td>
<td>Entropia pays ordinary web users for their computers idle processing power, and then brokers those cycles both to commercial customers and non-profit research organisations. Innovative business model.</td>
</tr>
<tr>
<td>Juno Online Services</td>
<td>American free Internet Service provider is proposing that its customers leave their machines online for agreed periods. Innovative business model.</td>
</tr>
<tr>
<td>Sony Corporation</td>
<td>Using Sun’s Grid Technology to shorten design cycles and time to market for complex integrated circuits.</td>
</tr>
<tr>
<td>Intel</td>
<td>Saved $500m through its own internal “internet computing”.</td>
</tr>
<tr>
<td>Pratt &amp; Whitney</td>
<td>Cutting development time. Links with customers like NASA promote collaboration.</td>
</tr>
<tr>
<td>Boeing Company</td>
<td>Cutting development time. Boeing (BA) used a Grid to develop the 767-400 jet in the late 1990s.</td>
</tr>
<tr>
<td>SONY</td>
<td>Cutting development time.</td>
</tr>
<tr>
<td>Synopsis</td>
<td>Cutting development time.</td>
</tr>
<tr>
<td>Sydney Olympics</td>
<td>IBM UNIX clusters allowed huge numbers to access the Games website, viewing schedules and results.</td>
</tr>
<tr>
<td>Butterfly.net</td>
<td>Uses IBM’s Grid architecture to enable millions of game players to participate simultaneously. The system reduces the costs of developing and publishing games on the Web. For users, there is greater reliability.</td>
</tr>
<tr>
<td>IBM</td>
<td>Uses an internal Grid for research and development, and speeding time to market.</td>
</tr>
<tr>
<td>Oracle</td>
<td>Uses an internal Grid for research and development, and speeding time to market.</td>
</tr>
<tr>
<td>Bristol-Myers Squibb</td>
<td>The attraction was the low investment needed for a large increase in performance. This would also speed drug research.</td>
</tr>
<tr>
<td>Cereon Genomics</td>
<td>Achieved optimised use of hardware, thereby saving millions of dollars.</td>
</tr>
<tr>
<td>Texas Instruments</td>
<td>Adopted Grid technology in 1996, and reduced its data centres from 100 to 20.</td>
</tr>
</tbody>
</table>

Table 2: Commercial Applications of Grid Computing.

2.3.2 The Benefit Matrix

The information in Table 2 has been used to compile what the researcher calls the Benefit Matrix (Table 3), a cross-tabulation of the various benefits realised and the organisations that have achieved such benefits. These benefits represent the researcher’s interpretation of the information provided by the various sources referenced.

<table>
<thead>
<tr>
<th>Benefits Achieved To Date</th>
<th>Grid Computing Benefit Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inventory reduction</td>
</tr>
<tr>
<td>American Express</td>
<td></td>
</tr>
<tr>
<td>BEONIO</td>
<td>x</td>
</tr>
<tr>
<td>Bridgestone Squab</td>
<td>x</td>
</tr>
<tr>
<td>Citigroup</td>
<td></td>
</tr>
<tr>
<td>Coetec Genomics</td>
<td></td>
</tr>
<tr>
<td>CPBANK</td>
<td></td>
</tr>
<tr>
<td>Dell</td>
<td>x</td>
</tr>
<tr>
<td>Dow</td>
<td></td>
</tr>
<tr>
<td>ENTOFIA</td>
<td></td>
</tr>
<tr>
<td>Ford</td>
<td></td>
</tr>
<tr>
<td>GM</td>
<td></td>
</tr>
<tr>
<td>IBM</td>
<td></td>
</tr>
<tr>
<td>INTEL</td>
<td></td>
</tr>
<tr>
<td>JUNO ONLINE</td>
<td></td>
</tr>
<tr>
<td>Merrill Lynch</td>
<td></td>
</tr>
<tr>
<td>PRATT &amp; Whitney</td>
<td></td>
</tr>
<tr>
<td>Siemens/Cisco</td>
<td></td>
</tr>
<tr>
<td>SONY</td>
<td></td>
</tr>
<tr>
<td>Synaptics</td>
<td></td>
</tr>
<tr>
<td>Trader Instruments</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: The Benefit Matrix: Benefits Achieved To Date

The benefits tabulated in the Benefit Matrix are:

- **Inventory reduction**: where Grid Computing helped reduce inventories. With improved collaboration and relationships with suppliers, companies can minimise their inventories.
• **Reduced time to market**: where Grid Computing helped cut-down product development time;
• **Added value to clients**: where value was added to the goods and services provided;
• **Improved logistics**: where supply chain management was improved; this may or may not be accompanied by inventory reductions;
• **Value added to employees**: where employees benefited from Grid Computing initiatives;
• **Cost reduction**: where there were significant reductions in cost;
• **Added value to suppliers**: where suppliers benefited;
• **New revenue stream**: where new product lines were developed as a result of Grid Computing;
• **New business**: where new business models were developed using Grid technology;
• **Higher performance**: where the implementation of Grid Computing resulted in an increase in the utilisation and availability of computing resources.

An analysis of the *Benefit Matrix* confirms that there is a broad range of benefits that have actually been realised by the early adopters. The majority (50%) of the sample of the early adopters achieved **cost reduction** (e.g., DELL, Boeing, Butterfly.net and INTEL); whilst “**reduced time to market**” (e.g., Bristol-Myers Squib, Boeing), **improved logistics** (e.g., DELL, Pratt & Whatney) and **improved performance** (e.g., Synopsis), have been achieved by 30% of the companies analysed.

Arguably, the most important benefit is that of **“added value to clients”** (e.g., Butterfly.net, Entropia and CITIBANK), as this shifts the enterprise towards a more customer-centric model. Customer-centric strategies are vital for sustainable competitive advantage (Lynch, 2000).

A criticism of the above analysis is that the Internet sources, upon which the information is based, generally do not go into detail about the actual benefits achieved. The interpretation of the qualitative descriptions provided is also subjective. It should also be stated that the examples above only represent those the researcher managed to get from the Internet, and as such, are not necessarily representative of the entire population of organisations who have benefited from the use of Grid Computing. However, the *Benefit Matrix* represents the researcher’s attempt to
reduce the information sourced from the Internet into a form from which important lessons can be learnt.

The one important lesson learnt, here, is that Grid Computing does present some opportunities in the commercial arena. In fact, the opportunities could go beyond what has been discussed above, as the next section demonstrates.

2.3.3 Other Possible Benefits

In addition to the benefits discussed in the previous section, the literature survey revealed strong arguments for some benefits that could also be derived from the application of Grid technology in e-business. These include possible increases in Internet traffic, opportunities for service providers, and the development of a utility computing model:

i. Growth in Internet Traffic
Grid Computing could cause Internet traffic to grow more than 8 times current forecasts for the next decade, with peer-to-peer and server-to-server traffic accounting for 90% of all Internet traffic by 2008 (Shread, 2002c). This could result in an increase in the utilisation of bandwidth. Greater utilisation could lower the cost of bandwidth, which would in turn, lower the cost of service delivery through the Net.

ii. Capacity on Demand
A company could use Grid Computing to provide extra capacity on demand to its web servers when traffic to the company’s Internet traffic increases. Web server capacity needs are hard to predict (Goyal, 2002). Hoard (2000) gives the real-life example of Computer.com – a US-based company – that had to manage a massive spike of more than half-million people on their website, soon after an advertising campaign in 2000. Hoard (2000) argues that this would need a highly scalable system.
iii. **Ease of switching between service providers**

The use of the Internet and open standards for inter-organizational communications may obviate the need for expensive leased lines between the organizations, and could make switching from one service provider to another easier (Hagel and Brown, 2001).

iv. **More Efficient Networks**

The improved application interfaces will reduce the need for what Hagel and Brown (2001) call “swivel chair networks” - people behind websites manually transferring data from one application to another. This will be the result of improved integration.

v. **System Monitoring**

The monitoring systems that constantly check the workload on each machine, should improve system reliability, and increase the quality of service in information technology services (Lawson, 2002).

vi. **New Revenue Streams for Service Providers**

Adams and Couture (2002) suggest that service providers could be presented with a large number of opportunities, including the following:

- Development of Grid consulting services;
- Owning part of the Grid infrastructure;
- Development and management of private Grids;
- Brokering Grid-compute capacity; and
- Providing independent service level monitoring (Adams and Couture, 2002: 6).

vii. **Autonomic Systems**

Hirsh (2002) argues that Grid Computing could promote the development of self-diagnosing, self-managing, self-healing, or autonomic systems. The increasing complexity of the networks would make it difficult for “humans even to know that a problem has occurred” (Foroohar, 2002:
5). Such autonomic systems would result in a more stable, e-business environment. Recovery from hack attacks or outages would be quicker than otherwise. IBM’s “Project eLiza” (Hirsh, 2002), is given as an example of efforts towards the development of such self-managing systems.

viii. **Utility Computing**

Grid Computing could lead to the development of a utility computing model (Foroohar, 2002). Among the key drivers of this model, is the vision that, in future, organisations and individuals should be able to buy computing power on an as-needed basis (Berkman, 2002; Bonasia, 2002; Foroohar, 2002; Osadzinski, 2002; Neel, 2002). Companies would be able to purchase only the functionality they need, which should lower their investment costs, and increase return on investment.

This utility computing model would require the convergence of the autonomic systems, Grid Computing and “Web services”. Web services are tools and protocols that allow applications to be broken down into units that can be delivered over the Internet. Grid Computing would be providing the Web services with a reliable, dynamic infrastructure that would help coordinate disparate, heterogeneous resources. This would make it easier to integrate business processes, both within the enterprise, as well as with external business partners (Shread: 2002a: 2).

ix. **Electronic Marketing**

The increase in processing power, coupled with increases in broadband usage, could also have a positive impact on electronic marketing. The usage of such media as videos and three-dimensional images on websites could become more cost-effective (Hirsh, 2002).

Whilst it is possible that some of the benefits stated above will be realised, there exist several challenges that Grid Computing still faces. These challenges are explored in the next section.
2.3.4 Challenges to the implementation of Grid computing

“Several researchers and analysts warn (that) there are serious limits to what this (Grid) architecture can accomplish in a business environment, and from an IT standpoint, extremely serious—perhaps even terminal—obstacles may lie ahead” - Fixmer (2002:2).

Several challenges still need to be addressed. These include the need for open standards, the absence of reliable and robust Grid-enabled applications, security concerns and bandwidth limitations, and billing and cultural issues:

i. **Grid Infrastructure**: The infrastructure required e.g., Grid-enabled software, is not yet widely available. Ricadela (2002) reports that the early adopters of the technology (e.g., BMW, Charles Schwab, and Unilever), are still using largely in-house developed software, or software from relatively new companies like Entropia, Platinum Computing and Avaki Corporation. GlaxoSmithKline, reports encountering a high incidence of bugs in the software they use (Ricadela, 2002).

ii. **Security and bandwidth**: Fixmer (2002:5) cites security and bandwidth as two of the “often-cited drawbacks”. Though computation is increasing at a slower rate than bandwidth, plans for network extensions are lower than in the past (Kenyon and Cheliotis, 2002:223). Security and standardisation issues are the subject of major research efforts by such organisations as the Global Grid Forum and the New Productivity Initiative (NPI). The security problem is so significant that some companies, e.g., Structural Bioinformatics Inc. of San Diego, are building Grids and using virtual-private networks (VPN), which makes their Grids unavailable to outsiders (Ricadela, 2002).

iii. **Standards**: The definition of Grid standards is the “most critical” problem facing the Grid community (Foster, 2002:3). These standards are essential for enabling the various systems on the Grid to interact. It is also essential for all organisations to stick to the standards. The Global Grid Forum is working in conjunction with companies like IBM to develop such standards. The Globus Toolkit – a set of services and software libraries for
building Grid applications, is widely used, but is still being refined. The Open Grid Services Architecture (OGSA) is now being developed in order to bring together Grid Computing with web services (Foster, 2002).

iv. *Buyer Behaviour and Cultural Issues*: Osadzinski (2002) cautions about such cultural and governance issues as the traditional IT departments’ reluctance to surrender control over computing infrastructure, as key problems that could scupper the early adoption of the technology.

v. *Legal Issues*: Foroohah (2002) discusses the difficulty in determining who to apportion responsibility, if some process dependent on the Grid failed to work.

vi. *Billing issues*: A model for billing for the computing power used is yet to be developed.

vii. *Limitations of current tools*: As Grid jobs have to be split and distributed across multiple data centres, it is vital that robust systems for ensuring that the processing is coordinated are present. Current job management tools cannot handle multiple data centres effectively Ricadela (2002).

2.4 CONCLUSIONS FROM THE LITERATURE SURVEY

A large number of sources have written about Grid Computing, describing the development of this technology within the scientific and academic communities, and tracing its progression into the commercial environment. The leading information technology providers, such as IBM, now visualise a future where Grid Computing will merge with web services to create an environment where information technology can be provided via the World Wide Web, as a service, just as electricity is delivered as a service.

Whilst the literature survey reveals a lot of theory about the benefits or potential benefits of the technology, as well as the various hurdles that the technology faces, the next section describes the methodology that was used in an attempt to gather more information about the real benefits and hurdles of Grid Computing.
3. RESEARCH METHODOLOGY

The research was carried out in two phases. The first phase was exploratory, and involved both informal interviews, and the submission of questionnaires to some South African companies involved in E-Business. This phase was aimed at establishing some of the key issues affecting e-business, while offering an opportunity to refine the questionnaire and the hypotheses for the next phase.

The second phase involved attendance at the Global Grid Forum 5 Conference in Edinburgh, Scotland, from 21 to 24 July 2002. This conference brought together over 900 Grid-computing enthusiasts, who included researchers, information technology providers and some of the early adopters of Grid technologies. Through informal interviews, attendance at various plenary sessions, and a structured questionnaire, the researcher was able to collate a significant amount of data. This data is analysed in detail in subsequent sections.

In addition to data from the Global Grid Forum Conference, extensive use of the World Wide Web was made. This later source of information was to prove an invaluable source of information, especially due to the shortage of hardcopy documentation and empirical research on this emerging technology in South Africa. It was, however, essential to ensure that data collected on the Web, came from reputable sites. The key websites utilised are those of the Global Grid Forum and the Grid Computing Planet.

The use of a mixture of data collecting methods was to “allow a broader … complimentary view of the research problem”, as well as to minimise the “potential bias and sterility of a single-method approach” (Hussey and Hussey, 1997: 72). Because different approaches were used to collect data from different sources in a study of a common phenomenon, this approach is a form of data triangulation (Hussey and Hussey, 1997).
A key disadvantage of the triangulation approach is the difficulty in replicating data, and that it is time-consuming and expensive. Fortunately, the researcher managed to obtain sponsorship for his trip to Edinburgh.

### 3.1 PHASE I: EXPLORATORY RESEARCH

This phase was aimed at helping the researcher gain a better understanding of the main issues and challenges facing E-Business. Exploratory studies are considered a valuable means of finding out “what is happening; to seek new insights; to ask questions, and to assess phenomena in a new light” (Saunders, Lewis and Thornhill, 1997:78). The objective of such studies is to identify “patterns, ideas or hypotheses, rather than testing and confirming a hypothesis” (Hussey and Hussey, 1997:10).

This approach was selected because the researcher, at this stage of the research, was seeking to gain a better appreciation of the E-Business context. This understanding would then be used to try to draw important conclusions about the areas where Grid Computing could really be useful, particularly in a South African context. The exploratory research was also aimed at fine-tuning the hypothesis to be tested in the main research phase.

A key limitation of exploratory research is that interpretation of the results is generally subjective, and that the sample selected is not representative of the entire population. This makes it difficult to generalise the results (Zikmund, 1984: 125).

### 3.2 PHASE II: PRIMARY RESEARCH

#### 3.2.1 Objectives of Primary Phase

The aim of this phase of the research was to:

- Establish what the suppliers of this technology, the early adopters, as well as Grid technology researchers, identify as the benefits of Grid Computing;
Identify the key challenges that could slow down the widespread adoption of Grid Computing in e-business; and

Assess to what extent the “actual benefits” will help meet the challenges identified in the first phase of the research.

3.2.2 Research Approach

The research approach for the primary research phase was positivist. This approach entails generating some hypotheses, testing the hypotheses, and modifying the theory in view of the findings (Saunders, Lewis and Thornhill, 1997:71).

The hypotheses to be tested are listed below, together with the significance of these hypotheses:

i. **Significant obstacles must be cleared before Grid Computing can become a commercial reality.**
   **Significance:** If the obstacles are too big, the adoption of this technology could be limited.

ii. **Grid Computing is not just for research and science communities.**
   **Significance:** The impression among some people (Berkman, 2002) is that Grid Computing is just for the large compute-intensive operations like the SETI@home, and “Fight Aids @home” research projects. The statement below would seem to corroborate this view:

   “The technology best serves problems that are computationally intensive using algorithms that developers can break down into discrete computational units, such as genetics where scientists must mathematically analyze thousands of genes in combination to find matches. And that’s not a task most corporations face” (Berkman, 2002:3).
iii. Grid Computing will change the competitive landscape quite quickly.

Significance: If this is true, then companies must start adopting strategies that must ensure that they will remain competitive when this technology is adopted. Companies should thus seek ways and means of taking advantage of this technology.

iv. South African businesses do not need to currently concern themselves with this technology.

Significance: This would be true if this technology is likely to face too many obstacles in South Africa for it to be commercially viable. This, among other reasons, could be a result of bandwidth limitations, and security concerns in South Africa. In this case, South Africa could be a proxy for many emerging markets with comparable problems.

3.2.2.1 Subjective Nature of Research Approach

Whilst all the above hypotheses were subjective in nature, and difficult to test objectively, an effort was made to source information to confirm or refute the hypotheses. Subjectivity is one of the disadvantages of qualitative research, as “much of the measurement process is at the discretion of the researcher, and it does not include rigorous mathematical analysis” (Zikmund, 1984:125)

The qualitative and subjective nature of the research, as well as the inability to employ any controls for hypothesis testing, justified a departure from conventional, scientific positivist approaches (Saunders, Lewis and Thornhill, 1997). In addition, the use of open-ended questions necessitated in the questionnaires, made it necessary to avoid a highly structured methodology, which would otherwise facilitate replication (Saunders, Lewis and Thornhill, 1997:71).

3.2.3 Data Collection Methods

The questionnaire used for South African businesses is shown in Appendix 1. A key attraction of questionnaires is that they are “relatively cheap, and easy to administer” (Raymond, 1993: 67).
In addition, a questionnaire makes it easier to gain access into companies, as one does not need to negotiate to be allowed into the companies of interest. A disadvantage is that an incentive may be needed for the recipient to sacrifice time and effort to fill in the questionnaire (Raymond, 1993). Other than offering to give the respondent a copy of the final research report, the researcher could not offer any incentives for the questionnaires to be filled in.

The questionnaire was designed to capture the following information:

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Information Sought</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Identity of organisation</td>
</tr>
<tr>
<td>2</td>
<td>Business Sector</td>
</tr>
<tr>
<td>3</td>
<td>E-Business Initiatives in the organisation</td>
</tr>
<tr>
<td>4</td>
<td>Importance of business initiatives in the organisation</td>
</tr>
<tr>
<td>5</td>
<td>Problems facing e-business</td>
</tr>
<tr>
<td>6</td>
<td>Level of awareness about Grid Computing</td>
</tr>
<tr>
<td>7</td>
<td>Opinion about possible role of Grid Computing in e-business</td>
</tr>
<tr>
<td>8</td>
<td>Assessment of applications as barrier to Grid adoption</td>
</tr>
<tr>
<td>9</td>
<td>How Grid Computing could help respondent’s organisation</td>
</tr>
<tr>
<td>10</td>
<td>Assessment of security as barrier to Grid adoption</td>
</tr>
<tr>
<td>11</td>
<td>Assessment of bandwidth as barrier to Grid adoption</td>
</tr>
</tbody>
</table>

Table 4: Questionnaire Design: Information Sought

This questionnaire was sent to a carefully chosen list of companies known to be involved in e-business, e.g., SAPAfrica, NEDCOR and SHELL. The criterion used was “any company involved in e-business activities”. The companies would have to come from different industrial sectors for the researcher to get a more balanced view. The target respondents were Chief Information Officers (CIO’s) or their equivalent. The researcher was making the assumption that CIO’s would have a closer appreciation of the issues surrounding e-business than the more distantly placed Chief Executive Officers (CEO’s).
3.2.3.1 Collection of Data from the World Wide Web

Internet research was chosen because of the relative unavailability in South Africa, of hardcopy documentation on this new technology (the researcher did, however, manage to get two publications on Grid Computing through South African online library, SABINET, in November 2002). A major attraction was the low cost of accessing some of this information. Internet research is inexpensive, relative to such other forms of data collection as direct interviews. Some potentially good sources of information, however, would require payment of subscription fees. An example was the Gartner Dataquest website. Many institutions carrying out Grid Computing research are government funded, and because of rising publication costs, “many government documents are now most easily available in online form “ (Lovewell, 2000:1).

Internet research enables the researcher to reach geographic segments that would otherwise be difficult to access. A further reason for using Internet research was that of data currency, as online sources are likely to be more up-to-date than printed sources (Hussey and Hussey, 1997). The Internet research included data from media sources. Zikmund (1984) argues that even data from the media can be valuable, though he cautions against over-reliance on it, as it might be limited in scope.

3.2.3.2 Limitations of Internet Research

Internet-based research, however, has its own limitations. One such limitation is the researcher’s inability to cross-validate proprietary information. A further disadvantage of Internet research is that “information found may be difficult to retrieve again” (Lovewell, 2000:1). This data will also be, of necessity, distorted by the communication channels it passes through. The extent of distortion will depend on, among other factors, the author’s writing skills and the researcher’s reading skills, as well as “the inability of language to reproduce every nuance of detail that a firsthand observation can provide” (Leedy, 1993:117). The data can also be biased to suit the vested interest of the source (Zikmund, 1984:145).
3.2.4 Data Collection at the Global Grid Forum Conference

The researcher attended the Global Grid Forum (GGF5) conference held in Edinburgh, Scotland from the 21st – 26th July 2002. The 950 conference attendants would constitute the population of the research project. These were people actively involved in the development, research into, or use of Grid technology. This population was considered appropriate, on the assumption that the participants at the conference would have a superior insight into Grid Computing than ordinary members of the public. A further justification for choosing this population was availability—these people were there at the conference, which the researcher, with assistance from the Global Grid Forum, was able to attend.

A further assumption was that the participants themselves would be representative of the entire Grid community in the world.

The following methods of data collection were used:

- A total of 110 questionnaires were issued, at random, to participants at the conference. Selecting the respondents at random was done in order to minimise bias. A copy of the questionnaire is displayed in Appendix 2. The questionnaire was designed to capture information on country of origin, sector of industry, and the respondents’ assessment of the various challenges faced by grid computing. It would also give the opportunity for the respondent to highlight what benefits, if any his or her organisation has realised to date from the use of Grid Computing. The pros and cons of using a questionnaire have been highlighted in previous sections;

- The researcher took an amateur video of some of the key speeches made;
- A substantial number of brochures relating to Grid Computing were collected, and
- Informal interviews were carried out with persons involved in Grid technology
3.2.5 Ethical Issues

Ethical issues must be taken into account in all research (Davitz and Davitz, 1996:14). Care has been taken to ensure that every aspect of the methodology employed is ethical.

Most of the respondents indicated that they did not wish to be personally identified in the final report. This research will, accordingly, not reveal the identities of these respondents.

The researcher took an amateur video of some of the key speeches delivered at the conference. However, this dissertation will not reference any one of those speeches, as the speakers had not been made aware that a recording was taking place at the time. The speeches, however, have helped broaden the researcher’s appreciation of Grid technology.
4. FINDINGS, DISCUSSIONS AND ANALYSIS

4.1 RESULTS FROM EXPLORATORY RESEARCH

4.1.1 PROFILE OF RESPONDENTS

A total of 11 responses (out of 30 questionnaires sent out to South African companies), were received. The research proposal required 5-10 organisations involved in e-business in South Africa. The researcher felt that this number would be adequate to highlight the main issues affecting e-business in South Africa.

Table 4 profiles the participating organisations in terms of the e-business activities taking place within these organisations. The industrial sectors represented are Finance (Nedcor); IT Services (SAP Africa, MasecoBytes, Unipro Enterprise Systems, APT Projects/E-Business Support, Business Unusual Group Holdings, Arivia.kom); Education (GSB) and the Mining/Oil and Gas (PetroSA- Cape Town, PetroSA- Mossel Bay).

Table 4 also shows the designation of the respondent in each one of the participating organisations. The respondents’ designation ranges from Chief Information Officer (CIO), Chief Executive Officer (CEO) to Technical Specialist (TS). The original intention was to target CIO’s, but the researcher was often referred to technical specialists, who were said to be more involved in e-business activities.

The response from Old Mutual has been excluded from the analysis because it was difficult to establish the authenticity of the response.
Table 5: E-Business Activities In Participating Organisations

4.1.2 SUMMARY OF RESULTS FROM EXPLORATORY SURVEY

Table 5 summarises the key issues emerging from the responses from the various respondents. More details on the results, including key quotes from the respondents, are to be found in Appendix 3. It was not intended to perform any rigorous analysis of these issues, but merely to identify and understand the issues, and then use that understanding to:

- Fine tune the hypotheses for the primary phase of the study; and
- Gain an appreciation of the South African e-business context, and then use this appreciation as input in subsequent analysis. The primary research phase includes a hypothesis that questions the relevance of Grid Computing in the South African e-business environment.
<table>
<thead>
<tr>
<th>Question Number</th>
<th>Information Sought</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Identity of organisation</td>
<td>PetroSA, SAP Africa, Arivia.kom, GSB, Unipro.</td>
</tr>
<tr>
<td>2</td>
<td>Business Sector</td>
<td>Education, Finance, IT, Oil &amp; Gas.</td>
</tr>
<tr>
<td>3</td>
<td>E-Business Initiatives in the organisation (Covered elsewhere in this dissertation)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Importance of business initiatives in the organisation as % of total revenue.</td>
<td>Mostly 20-70% of total business.</td>
</tr>
<tr>
<td>5</td>
<td>Problems facing e-business.</td>
<td>In order of decreasing importance: Bandwidth, security, infrastructure costs, low return on investment, skills shortage, low internet usage</td>
</tr>
<tr>
<td>6</td>
<td>Level of awareness about Grid Computing.</td>
<td>50% had never heard of Grid Computing.</td>
</tr>
<tr>
<td>8</td>
<td>Assessment of applications as barrier to Grid adoption.</td>
<td>Low barrier. Applications can always adapt.</td>
</tr>
<tr>
<td>9</td>
<td>How Grid Computing could help respondent’s organisation.</td>
<td>Cost reduction, improved customer service, inventory reduction and improved collaboration with external partners. Most respondents, however, not sure.</td>
</tr>
<tr>
<td>10</td>
<td>Assessment of security as barrier to Grid adoption.</td>
<td>High barrier. As for normal Internet business.</td>
</tr>
<tr>
<td>11</td>
<td>Assessment of bandwidth as barrier to Grid adoption.</td>
<td>High barrier, affects speed. In SA bandwidth is expensive, inadequate and unreliable. Monopoly by Telkom seen as counterproductive.</td>
</tr>
</tbody>
</table>

Table 6: Results from Exploratory Survey

4.1.3 CONCLUSIONS FROM EXPLORATORY RESEARCH

The exploratory research managed to solicit responses from a small selection of South African organisations involved in e-business. These responses highlighted the following key e-business issues:

Bandwidth

Bandwidth was regarded as the most important problem facing e-business in South Africa. Bandwidth was seen as being more expensive than in the developed world. The capacity was
also seen as being inadequate, resulting in low network transmission speeds, and a generally low service quality.

The issue of Telkom’s monopoly, as a provider of bandwidth, was seen as a major factor contributing to the bandwidth problem. In South Africa, only Telkom is currently allowed to provide fixed landline bandwidth. It was felt that there would only be a significant increase in bandwidth, with associated reductions in cost, if competition among bandwidth providers were introduced. This view was succinctly made by R. Fereira of Nedcor, who said: “As long as free enterprise is not permitted and governments insist on monopolising bandwidth providers like Telkom, bandwidth will continue to be a problem”.

Security concerns

Security was also regarded, as a major problem that e-business has to contend with. Concern was raised that there appears to be an increase in Internet-related crime, and it was felt that this would impact negatively on Grid Computing:

Cyber crime is fast becoming the newly adopted profession of the sometimes unemployed and experimental young adult; there is always someone out there trying to be “smarter” than his or her predecessor- R. Fereira (Nedcor).

Shortage of skills

This was seen to be a problem, especially in the Enterprise Resource Planning (ERP) area, with D. Prytz of Arivia.kom, saying:

“Our most pressing problem is sourcing high calibre ERP consultants to service an increasing client base at the service levels we are accustomed to delivering”.

Low Internet Usage

The low Internet usage in South Africa was regarded as less important than bandwidth and security constraints.
Awareness of Grid Computing

A low level of awareness of Grid Computing initiatives was evident, with about 50% of the respondents admitting that they had never heard of Grid Computing. Those who had heard about Grid Computing could not confidently identify any real benefits that Grid Computing could have on e-business.

Finally, the researcher felt that these results were not inconsistent with the hypotheses that had been formulated for the next phase of the project. These hypotheses were therefore left unchanged. The questionnaire, however, had to be modified slightly, to improve readability, as well as to improve clarity among the questions asked.

4.2 RESULTS FROM PRIMARY RESEARCH PHASE

This phase of the research goes into much more detail than the exploratory survey. The major difference is that this (second) phase involves information from persons and organisations that were actually involved in the development and use of Grid Computing.

First, a statistical description of the sample demographics is made. This is followed by a detailed analysis for each of the key questions addressed in the questionnaire is made, with both the justification for each question, and the analysis of the responses thereto given. Analysis of the individual comments, backing the respondents’ various positions, is made. The commercial implication of the various positions taken by the respondents is described, with the researcher drawing from additional Internet research, as well as personal insights.

Finally, conclusions are drawn from this analysis, and recommendations for further research made.
4.2.1 DESCRIPTIVE STATISTICS

A total of 111 questionnaires were issued to the participants at the Global Grid Forum conference. Total attendance was about 950, according to the Global Grid Forum website. Of the 111 questionnaires issued, 37 were completely filled in, giving a 33% response rate. The respondents came from a wide range of industrial sectors, namely government, education, manufacturing, oil and gas, engineering, finance and aerospace industries.

Important institutions represented, among the respondents, include NASA, which is one of the agencies that “fuelled” the evolution of Grid Computing (Foroohar, 2002:2), and the Argonne National Laboratory, where the Global Grid Forum is based.

These results are summarised in Appendix 4.

4.2.1.1 BREAKDOWN BY COUNTRY OF ORIGIN

The respondents came from 10 different countries, which can be divided into 3 groups, distributed as depicted in the Table 7.

<table>
<thead>
<tr>
<th>Country of Origin</th>
<th>Number of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>11</td>
</tr>
<tr>
<td>UK</td>
<td>13</td>
</tr>
</tbody>
</table>
| Rest of the World:  
  (Germany, Italy, France, Holland,  
  Canada, Spain, South Korea, Poland)      | 13                    |
| **Total**                                 | **37**                |

Table 7: Respondents’ Countries Of Origin

The geographic spread would, hopefully, minimise any bias that could result from differences in the countries of origin of the respondents. Countries may differ in terms of the level of technological development, and the level of support for research efforts in such areas as Grid Computing. Furthermore, this geographic spread would help highlight significant differences, if any, in Grid Computing experiences and opinions, across the different geographical regions.
The venue of the conference- Scotland, may have contributed to the relatively high percentage of UK respondents. The absence of South African respondents may have been due to the low level of awareness (about Grid Computing) indicated in the exploratory survey. The relatively large US fraction may reflect a high level of interest in Grid Computing in the USA.

4.2.1.2 Analysis Of Respondents By Sector

The respondents were asked to identify the industrial sector from which they came. Subsequent analysis would highlight whether there were any differences in opinions and experiences about Grid Computing across the different sectors.

Results:

Some 37.8% of the respondents came from educational institutions, whilst 32% were from government institutions, with the rest coming from manufacturing (8%), oil and gas (3%), engineering (11%), finance (3%) and aerospace (3%) industries (see Figure 2). This means that 70% of the respondents were either from Government or educational institutions. This statistic would be in line with expectations, as Grid technology evolved from, and is still largely, within government agencies (Foroohar, 2002).
Commercial Implications of the results:

The involvement of a broad range of industrial sectors implies that interest in the technology goes beyond the confines of academia and scientific research. The involvement of multiple sectors should help in developing consensus on common standards, as well as helping develop a robust architecture capable of meeting the needs and challenges applicable to the different sectors.

4.2.2 Grid Computing Usage

Question: Have you personally used Grid technology?

Respondents were asked to answer “Yes” or “No”, and also to make comments on the areas in which they had used Grid technology.

Reason for asking question: This would determine what percentage of the respondents had had hands-on experience of Grid Computing, and highlight whether those with direct usage experience differed in opinions from those without.
Results:

75% of the respondents said they had used Grid Computing, whilst the remainder (25%) had not used Grid Computing. The majority of the responses were, therefore, from people with hands-on experience with Grid Computing, and hence, should be a more credible source of information on this technology.

The Grid Computing usage variable is categorical, which limits the statistical analysis possible to just counting the observations, and calculating proportions in each category (Keller and Warrack, 2000:19). However, the resulting groups can be used to assess whether there are any differences in opinions among the respondents from the two groups.

Here we attempt to answer the following question:

- Is there evidence to suggest that those who have used Grid Computing differ in their optimism about the future role of Grid Computing on e-business?

We can use a Chi-Squared Test of a Contingency Table (Keller and Warrack, 2000:553) to test whether opinions about the possible importance of Grid Computing in E-Business, are related to whether a respondent has direct experience with Grid Computing, or not. In Table 7, the vertical columns split the respondents into those who “Strongly Agreed”, and those who “Agreed” that Grid Computing would play a significant role in e-business. The rows split the sample into those who claimed direct Grid Computing experience (“Yes”), and those without (“No”).
Table 8: Contingency Table: Grid Usage and E-Business Role

Null hypothesis: The two variables are unrelated.
Alternative Hypothesis: The two variables are related.
Result of the test: $p$-value = 0.017

From the analysis of the data, it can be concluded that there is strong evidence to reject the null hypothesis. In other words, opinions will about Grid Computing’s role in e-business will vary depending on whether the respondent has actually used Grid Computing or not. From Table 8, we can see that those without direct Grid Computing experience tend to be more optimistic about Grid Computing’s role than those with direct experience. This could indicate some form of unrealistic expectations on the part of those who have not used Grid Computing!

The following section explores the role of Grid technology in e-business in greater detail.

4.2.3 THE IMPORTANCE OF GRID TECHNOLOGY IN E-BUSINESS

Question: Do you believe that Grid Computing will play an important role in e-business?

Respondents were asked to indicate whether they “Strongly Disagree”, “Do not agree”, “Agree” or “Strongly agree”. They were also asked to give additional comments justifying their responses.
Results:

Of the 35\% of the respondents “Strongly agreed”, with an additional 62\% just “Agreeing”, that Grid Computing would play an important role in E-Business (Figure 3). Only one person did not believe that Grid Computing would play a significant role in E-Business (The one dissenting voice was an American, who has used Grid Computing, but is “not clear” what business need Grid Computing can serve). A large majority (97\%) of the respondents were optimistic that Grid Computing would play an important role in e-business. However, it is necessary to establish exactly what role they felt Grid Computing would play.

Table 9 shows the various areas in which the respondents felt Grid Computing would play a part. Table 9 also shows some of the supporting comments made by the respondents. For each area, an indication is made whether the literature survey, in earlier sections of this dissertation has covered that area. Where the answer is “No”, an attempt will be made to explain the significance of that area in e-business.
Table 9: Analysis Of Comments On E-Business Role

Most of the areas in which Grid Computing is expected to play a role, as can be seen in Table 9, have been explored in the literature survey, largely constituting part of the Benefit Matrix.

The outstanding areas – alluded to by the respondents, but not explicitly addressed earlier are:

- **Collaboration between business and research:** But, why would it be of significance to have this closer co-operation? The researcher’s opinion is that increases in co-operation between business and research would:
  - Minimise the need for organisations to have their own departments for research and development for new products;
  - Enable business to better leverage the expertise currently available within the research communities;
• Bring more convergence between academia and business, and make curricula more relevant to the needs of business;
• Reduce the time it takes for new products to move from academia to business. This could result in new products being brought onto the market quicker; and
• Improve chances of research projects getting funding from business. This too should stimulate more research.

- Support for Virtual Organisations: Virtual organisations are defined as “ever-changing groups of individuals or institutions sharing the resources of the Grid, for a variety of purposes” (Goyal, 2002:2). Such sharing would be highly controlled, with rules clearly defining the resources to be shared and identifying who is allowed to share them (Foster, 2001b). The virtual organisation can comprise geographically dispersed components, which might not even comply with normal organisational structures. The ability to form virtual organisations would give enterprises flexibility to create dynamic groups of resources, services and people. This could help organisations quickly upscale or downscale their services, and achieve a higher quality of service (Foster, Kesselman, Nick and Tuecke, 2002).

The importance of Grid Computing in e-business can be summed up by this quote from one of the respondents:

Routine e-business will increasingly span multiple organisations across cities, regions, countries, and continents. This will require communication facilities that rival the communication bandwidth of face-to-face meetings. It will also require efficient management of geographically distributed complex data (such as CAD models of cars and buildings, subsurface models of oil reservoirs, etc). Grid computing is the only way to achieve this. -Dr C. Ramshorn, Schlumberger Cambridge Research.

4.2.4 ANALYSIS OF BENEFITS ACHIEVED TO DATE

Question asked: How has Grid Computing helped your organization?

Justification for asking the question:
It was necessary to establish how the respondents had actually benefited from Grid Computing. This would confirm, or otherwise, some of the claims made by the technology providers about the benefits of the technology, several of which have been covered in the literature survey.

The results:

Only 10 respondents, or 27% of the respondents indicated that their organisations had actually benefited from the technology. The benefits declared, as having been realised, ranged from improved external (9 responses), and internal collaboration (8), to improved customer service (4), the creation of a new revenue stream (2), as well as reductions in cost (2). These results are summarised in Figure 4.

![Grid Computing Benefits](image)

*Figure 4: Grid Computing Benefits*
4.2.5 APPLICATIONS AS A BARRIER TO THE ADOPTION OF GRID TECHNOLOGY

**Question:** Do you believe that applications will be a major barrier to the adoption of Grid technology?

Respondents were asked to indicate their opinion on a rating scale ranging from “Do not agree” to “Strongly Agree”. They were also asked to give additional comments as necessary.

Why the question was asked:

Some sources (Ricadela, 2002; Slater, 2002) believe that applications are going to scupper the progression of Grid Computing, as has been discussed in the literature survey. The major reasons cited are the lag between infrastructure and applications, and the shortage of Grid-enabled software (Ricadela, 2002; Slater, 2002).

The researcher wanted to find out to what extent applications would actually be a hindrance, if at all. It was also hoped that additional insights would emerge from the comments from the respondents.

The results:

The results can be depicted as in Figure 5.
Responses on Applications as Barrier To Grid Adoption

<table>
<thead>
<tr>
<th>Strongly agree</th>
<th>Do not agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>11%</td>
<td>36%</td>
</tr>
</tbody>
</table>

Figure 5: Respondent Views On Applications.

Clearly, opinions vary widely, but with a slight majority (53%) believing that applications will be a major obstacle. To find out the basis upon which the views vary, we have to analyse the comments (see Appendix 5). The reasons given for regarding applications as a major hindrance included the fact that the technology is currently difficult to use, that the Grid represents a new infrastructure that applications must adapt to, and that there is, currently, a shortage of Grid-enabled software. This would be in agreement with issues covered in the literature survey section of this dissertation.

It is also important, however, to look at what the very significant percentage (47%) of the respondents gave as justification for a less pessimistic view about applications. The key justification was that, though applications would need modification to become Grid-enabled, this modification would happen once there were incentives to do so. It was also argued that Grid-enabled applications actually do exist, and that, the Grid itself, would actually promote the development of applications. In defence of this view, one of the respondents argues:

\[
\text{The crux of successful Grid Computing is distributed systems and Grid middleware. Applications will relatively easily adapt to a Grid environment once it is stable and reasonably simple to exploit. - Dr C. Ramshorn, Shlumberger Cambridge Research}
\]

A further justification, for those feeling that applications might not be a major barrier, would be the fact that some organisations, e.g., the Max Planck Institute in Potsdam, have been able to use
standard applications, without any modification, but only using the application in conjunction
with a Grid-enabled interface (The Globus Project, 2002). If some standard applications can,
indeed, be used in a Grid environment with minimal adaptation, then the cost of the transition to
a Grid infrastructure would be significantly reduced. The transition would also be quicker.

4.2.6 SECURITY AS A HINDRANCE TO GRID COMPUTING

Question: To what extent do you think security will be a hindrance to the wide adoption of Grid
Technology in e-business?
Respondents were asked to indicate their opinion, on a rating scale ranging from “Very Low” to
“Very High”. They were also asked to give additional comments.

Why the question was asked:

The exploratory phase of this research project highlighted security as one of the major issues
affecting e-business. In fact all the respondents (in the exploratory phase) rated security as
“High” to “Very High” among the potential constraints to Grid Computing. In addition, many
sources cite Grid security as a major hurdle (Slater, 2002). Users of Grid Computing will need
assurance that any confidential information on the system will not be accessible to unauthorised
persons. The researcher wanted to find out how the respondents would rate security as a barrier
to the adoption of Grid technology. Would their responses mirror those from the exploratory
survey? Could there be some new insights from the respondent’s comments? Or, had this issue
been addressed already?

The results:

Some 13% of the respondents felt that security posed a “moderate” to “low” barrier. One of the
respondents, William Johnston (NASA and Lawrence Berkeley National Laboratory), dismissed
security as a barrier, describing Grid Computing as having an “excellent security model”.
Another respondent, Thomas Hinke (incidentally, also of NASA), even went so far as to suggest
that businesses could actually benefit from the security model offered by Grid Computing (see Appendix 4).

This view (that security will not be a major hindrance), also finds support from some of Grid technology providers. Steve Armentrot, Chief Executive Officer at Parabon Computation, argues that, in time, security will be just a “small consideration for users”, predicting that Grid Computing usage to follow the course of credit card usage on the Internet (Shread, 2002b: 1).

The majority (87%) of the respondents, however, rated security as a “high”, to “very high”, barrier. This is in line with discussions in the literature survey, and will not be discussed here. This essentially suggests that the majority of respondents in the Grid community do not have confidence in the current Grid security model.

4.2.7 BANDWIDTH AS A CONSTRAINT TO THE ADOPTION OF GRID TECHNOLOGY

Question: Do you agree that bandwidth constraints will slow down the adoption of Grid technology in e-business?

Respondents were asked to indicate their opinion on a five-point rating scale ranging from “Strongly Disagree” to “Strongly Agree”. They were also asked to give additional comments, as necessary.

Why the question was asked:

The exploratory phase of this project has identified bandwidth constraints as one of the key factors affecting e-business. Bandwidth is a measure of the speed at which data is transported in a network. The higher the bandwidth, the faster the data transmission speed. Grid Computing relies on the movement across the network of a large amount of resources. One would think that any constraints on the bandwidth would adversely affect Grid Computing. However, opinions on the extent to which the adoption of Grid technologies in e-business could be hindered, differ.
The responses to this question would, hopefully, help clarify the nature, extent and reasons for this difference.

**Results obtained:**

The responses shows almost an even split between those that "agree", to “strongly agree” (total 55%), that bandwidth is a major constraint, with those who “disagree” (45%) (See Figure 6).

**Figure 6: Views of Bandwidth As A Constraint to Grid Computing**

The respondents who “disagreed” highlighted the following to justify their viewpoint:

- The “high” rate at which bandwidth has been developing, with the leisure market being seen as one of the key drivers cited (Foster (2001b) estimates that network capacity doubles every nine months, whilst computing power doubles every 18 months);
- One of the respondents, Thomas Sandholme of the Argonne National Laboratory in Chicago, argues that Grid applications can always be adapted to the available bandwidth.
- E-business transactions are relatively lightweight with respect to their bandwidth demands. Further support for this view comes from some of the technology providers, e.g., Platform Computing, where Ian Baird, their chief business architecture and corporate strategist, argues that Grid technology splits jobs into packets so small that bandwidth “becomes a non-issue” (Fixmer, 2002: 5).
Those respondents who cited bandwidth as a significant drawback, raised the following key issues:

There is a need to improve the “last mile” bandwidth. This relates to the connection from homes and (local area networks) LANS to local service providers, which are still largely dependent on copper, rather than optical fibre (Onfibre, 2002). Copper-based lines are not as scalable, cost effective and as reliable as optical fibre lines, and that, for Europe and the US, bandwidth is adequate. For the rest of the world, however, the respondents viewed bandwidth as inadequate. This view is shared by one of the key respondents in the earlier, exploratory survey:

“Bandwidth capacity constraints are mainly a problem in Africa and other underdeveloped countries. Europe and the USA have a huge advantage over us as their infrastructures are far more advanced, and services are available at fractions of the cost here in Africa. Therefore Grid-computing adoption should not be a problem in the developed world, here however it is a different story. Bandwidth costs more in South Africa than in the USA or Europe- R. Afonso, MasecoBytes, Cape Town.

- Users must find it easy to access Grid resources, and the availability of adequate bandwidth will be vital. The following quotation from one of the respondents, supports this view:

  Easy access to Grid computing is crucial in order for people to use Grid resources. Easy access includes high bandwidth to be available when needed. This applies in particular to immense telepresence applications where high bandwidth, with low latency and guaranteed quality of service are a must- Dr C. Ramshorn, Shlumberger Cambridge Research.

### 4.2.7.1 Differences across regions

Here we seek to establish whether opinions about the significance of bandwidth as a barrier to the adoption of Grid Computing, are related to the region from which the respondents came. In other words, are there any differences in opinions about bandwidth across regions?
The table below is a cross-tabulation of the variables “region” and “the opinion whether bandwidth will be a major barrier to Grid Computing”.

<table>
<thead>
<tr>
<th></th>
<th>Agree</th>
<th>Do Not Agree</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>4</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>UK</td>
<td>8</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>World</td>
<td>8</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>17</td>
<td>37</td>
</tr>
</tbody>
</table>

Table 10: Contingency Table on Bandwidth.

Here we use a *Chi-Squared test of a Contingency Table*, using these hypotheses:

*Null Hypothesis*: The two variables are not related, i.e., where the respondent comes from has no bearing on his or her opinion on about bandwidth.

*Alternative Hypothesis*: The two variables are related.

The test yielded a *p-value* of 0.43. This means there is no statistical evidence at a significance level of 5% to reject the hypothesis that opinions differ depending on where the respondent comes from. However, a Box & Whisker plot showing the ratings of bandwidth, as a barrier to Grid Computing, for the three regions, clearly shows more optimism among the USA respondents (Figure 7). The rating *median* for USA (3) is higher than for the rest of the world (2). This is a valid analysis, because the responses “Strongly Agree”, “Agree” and “Do Not Agree” have been ordered, to form ordinal data. A comparison of the medians of ordinal data is a valid way of analysing this type of data (Keller and Warrack, 2000).
The USA respondents appear to be more optimistic about the likelihood of bandwidth being a hindrance to the adoption of Grid Computing in e-business, than their UK and World counterparts. An explanation for this would be the relative abundance of bandwidth in the USA, where “too many carriers built too much (bandwidth) capacity during the go-go 1990s” (Kessler, 2002:1). Gartner Dataquest suggests that, “only a fraction of the bandwidth available in North America is utilised at any given moment” (Adams and Couture, 2002:3).

A possible explanation for the low optimism in the UK is one given by one of the respondents: that in the UK there is “no fibre to the door” policy- that the government is not promoting bandwidth development, as much as is the case in the USA.
4.3 HYPOTHESIS TESTING

The various hypotheses this research project sought to test can be rejected or accepted, based on the findings from the responses to the questionnaires, as well as the substantial Internet research that was also part of the data collection methodology. Each hypothesis is assessed below.

**Hypothesis 1: Significant obstacles must be cleared before Grid Computing can become a commercial reality.**

There is strong evidence that this hypothesis is correct. The research has highlighted security and bandwidth as the major obstacles that need to be addressed. Eighty-seven percent of all respondents indicated that security would be a major barrier.

While there were differences across regions about how bandwidth constraints are viewed, there were some 54% of the respondents who indicated that bandwidth was a major constraint. Further constraints highlighted include the shortage of Grid-enabled applications and the need to development of Grid management tools.

**Hypothesis 2: Grid Computing is not just for research and science communities.**

There is strong evidence to support this hypothesis. The needs that Grid Computing has helped address in science and research do extend into other areas, including E-business. These needs include the ability to integrate heterogeneous systems across remote locations. There is also the need to expedite computation, e.g., in product development.

The research has shown that some early adopters of the Grid have actually derived commercial benefits from the technology. The early commercial adopters have replicated some of the successes of Grid Computing in science.

These successes are (examples are in brackets):

- Improvements in intra- and inter-organisational collaboration (Pratt & Whitney, Merrill Lynch);
• Inventory reduction, through improved supply-chain management (DELL);
• Faster delivery of products to market (Sony, Oracle, Pratt & Whitney);
• Creation of new revenue streams (Citibank, Butterfly.net) and
• Data aggregation (Texas Instruments).

The above list clearly shows that Grid Computing does have potential outside the science and research communities.

**Hypothesis 3: Grid Computing will change the competitive landscape quite quickly.**

*If a single major factor is the critical factor, then the competitive equilibrium is unstable.*  
Bruce Henderson (Kotler, 2000:228).

In E-business, it can be argued that the single major factor that determines the competitiveness of an organisation is its technology- its reliability, simplicity, availability, capacity to meet customer needs, as well as the cost implications of running that technology. If an organisation could adopt a technology that would enable it to achieve a cost breakthrough, while maintaining a high level of service and reliability, the organisation could reduce its prices, and gain market share, at the expense of its competitors (Kotler, 2000). On the basis of the findings from this research, it is difficult to conclude with certainty, that Grid Computing will be one such technology. Grid computing has been described as inexpensive, simple to deploy, and not requiring the replacement of existing systems (Leone, 2002:20. However, the key difficulty is the lack of detail regarding the benefits actually obtained to date. It is difficult to ascertain the sustainability of the benefits that the various organisations and individuals have achieved.

Secondly, the large number of significant obstacles (see **Hypothesis 1**) makes it difficult to predict how the commercial adoption of Grid Computing will progress. What is clear is that security concerns, for instance, are likely to slow down the adoption of Grid technology. Organisations are unlikely to move onto an architecture that could expose their proprietary information to competitors. The slow uptake of the technology will prevent organisations from fully benefiting from the technology at the early stages.
On the other hand, some organisations might see the benefits of introducing Grid technology within the enterprise, within the protection of their firewalls. These organisations, could deploy this technology with minimal cost, since, theoretically at least, Grid technology should be able to run on existing platforms, and is not complex not operate.

**Hypothesis 4: South African businesses do not need to currently concern themselves with this technology.**

South African enterprises, just like their counterparts in the developed world, need to be competitive in order to survive. They need to be able to bring products to the market quickly. They need to collaborate more with their internal and external partners, in order to optimise their value chains, and deliver more value, more cost-effectively than their competitors. They also need computer infrastructures that give the organisations the flexibility to easily scale up and down, with changing business needs. Like their overseas counterparts, South African businesses do need stable and reliable infrastructures that will enable them to meet the quality of service required by their customers. These are all issues where Grid Computing could help. It would, hence, be unwise for South African businesses to ignore the development of Grid Computing.
5. LIMITATIONS OF THIS PROJECT

A limitation represents potential weaknesses in the research- Hussey and Hussey (1997:129). The following is a list of the potential weaknesses of this research:

5.1 SAMPLE SIZE AND COMPOSITION

The number of respondents was only 37, most of who were from academic and scientific backgrounds. It is possible that their appreciation of the real demands of e-business was limited. Their responses might therefore not give an entirely accurate picture of the impact of Grid Computing on e-business. It is possible that a larger sample, with a more different composition would have yielded significantly different results.

5.2 DISTANCE PROBLEMS

All the respondents in the primary research phase were based overseas. Whilst an effort was made to conduct e-mail follow-ups, in order to increase the number of responses, very few additional responses were received. Telephonic follow-up was too costly an option to pursue.

5.3 VERIFICATION

It was not possible to verify the claims made by the respondents, largely because of the cost of doing so, and also because some of the forms did not bear the names and contact details of the respondents.

5.4 THE NEWNESS OF THE TECHNOLOGY

The absence of an established body of knowledge, locally, made it necessary for the researcher to invest a large amount of time in background research. Whilst this helped the researcher acquire a very good appreciation of the technology, it left little time to explore some of the more exciting areas like resource virtualisation, which could have enriched this research significantly.

In spite of the above limitations, the researcher is confident that this research project has demonstrated that Grid Computing does have potential to play a significant role in e-business.
While the real capacity of the technology to upset the competitive equilibrium in e-business is subject to debate, it is hoped that this research will get some businesses thinking of ways to make this technology work for them.
6. FURTHER RESEARCH

The following topic is suggested for research:


This will help investigate the various ways and means by which South African companies could exploit this technology. They could start building their own Grids and brokering compute power. Would this work? What would the problems be? Could the Butterfly.net business model work in South Africa? How about giving computers cheaply to poor communities in South Africa, then entering into a contract with these communities such that, all they have to do is to keep the machines up and running, and connected to the Internet. One would then broker the compute cycles made available on these machines, and sell them to enterprises needing extra computing resources.
7. CONCLUSIONS

It can be concluded that Grid Computing is likely to have a significant impact on e-business. The respondents to the primary survey have shown strong optimism in the role of Grid Computing, with 97% of the respondents “Agreeing”, to “Strongly Agreeing”, that Grid Computing would play a significant role in e-business. Most of these respondents are actively involved in the development and use of the technology, with 75% of them having personally used the technology. Their views should, therefore, be based on a good appreciation of the opportunities the technology presents, as well as the challenges it faces. In addition, the research has been able to complement the insights from the respondents, with relevant information from a wide range of authoritative Internet sources, all of which points to a very significant commercial role for Grid Computing.

This research has been able to explore those benefits achieved by more than twenty early adopters, from a broad range of industrial sectors. These benefits range from cost cutting (largely due to inventory reduction, resulting from improved collaboration with suppliers); performance enhancements (resulting in expedited product development), improved customer service (due to a more robust and reliable system architecture), to greater collaboration both within the enterprise, as well as with external partners. This greater collaboration has been largely due to the ease with which resource sharing can be effected.

The research has also discussed how Grid Computing can give rise to opportunities for new revenue streams, with real-life examples presented (e.g., Butterfly.net). The possibility of forming virtual organisations for greater flexibility and scalability was also discussed, this having been raised by some of the respondents.

This research, however, also reveals how the full commercial adoption is still fraught with challenges. Key among these challenges is the need for a robust and dependable security model. Other issues relate to bandwidth, which is particularly poignant in the South African context, where the absence of competition in the provision of bandwidth has been identified as a major
handicap. The USA seems to be better placed than the rest of the world, as far as bandwidth constraints are concerned. Other than the “last mile” bandwidth problem, Grid Computing is not expected to encounter as many bandwidth related problems in the USA as in the rest of the world. Interestingly, it also emerged that the UK was not in such a good a position as the USA, as far as bandwidth constraints were concerned, with the perceived lack of governmental support for a “fibre-to the door policy” in the UK being highlighted.

The shortage of robust Grid-enabled applications and universal, open Grid standards continue to be a problem, but significant efforts are being made by both, big business, and the Grid community, to address these. There appeared to be confidence in the fact that a large community was working on the establishment of Grid standards like the Open Grid Services Architecture (OGSA).

Finally, the fact that some early adopters have actually benefited from Grid Computing should be a clarion call for all enterprises to seriously start looking into the many opportunities that this emerging technology could offer them. It will be necessary, though, to be pragmatic, and recognise that the technology does face some major hurdles.
8. BIBLIOGRAPHY


2. April, K.A. and Cradock, J. (2000), e or be@ten: E-Business Redefining the Corporate Landscape in South Africa, Durban: Butterworths.


33. IBM, URL: http://www-916.ibm.com; (accessed on Wednesday, 8th May 2002).


9. APPENDICES

9.1 APPENDIX 1: QUESTIONNAIRE FOR SOUTH AFRICAN BUSINESSES

1.0 Name of organization

2.0 Sector of Industry:

<table>
<thead>
<tr>
<th>Government</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering</td>
</tr>
<tr>
<td>Finance</td>
</tr>
<tr>
<td>Education</td>
</tr>
<tr>
<td>Forestry/Mining/Oil</td>
</tr>
<tr>
<td>Retail</td>
</tr>
<tr>
<td>Manufacturing</td>
</tr>
<tr>
<td>Other- specify</td>
</tr>
</tbody>
</table>

3.0 What e-business activities occur in your organization? (Please tick)

<table>
<thead>
<tr>
<th>Internet access and e-mail</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Corporate website</td>
<td></td>
</tr>
<tr>
<td>E-commerce enabled</td>
<td></td>
</tr>
<tr>
<td>Electronic links</td>
<td></td>
</tr>
<tr>
<td>Electronic link</td>
<td></td>
</tr>
<tr>
<td>We have an intranet</td>
<td></td>
</tr>
<tr>
<td>We have an extranet</td>
<td></td>
</tr>
<tr>
<td>Electronic Data Interchange (EDI)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>

Other, please specify: ________________________________________________________________

4.0 What percentage of your business is conducted electronically? 


5.0 How would you rate the following factors as problems facing e-business in your company? (Please give them a rating of 1-5, where 1 is for least severe):

<table>
<thead>
<tr>
<th>Security concerns</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth constraints</td>
<td></td>
</tr>
<tr>
<td>Low Internet usage</td>
<td></td>
</tr>
<tr>
<td>Low return on Investment</td>
<td></td>
</tr>
<tr>
<td>Infrastructure costs too high</td>
<td></td>
</tr>
<tr>
<td>IT Skills shortage</td>
<td></td>
</tr>
</tbody>
</table>
6.0 Please list other key problems faced by your organisation:  
-----------------------------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------------------------

7.0 Have you heard of Grid Computing?  
Yes  No

8.0 Do you believe that Grid Computing will play an important role in e-business?

<table>
<thead>
<tr>
<th>I Strongly Disagree</th>
<th>Do Not Agree</th>
<th>I Agree</th>
<th>I Strongly Agree</th>
</tr>
</thead>
</table>

Please explain your answer to the above:

-----------------------------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------------------------

9.0 Do you believe that applications will be a major barrier to the adoption of the Grid technology?

<table>
<thead>
<tr>
<th>I Strongly Disagree</th>
<th>Do Not Agree</th>
<th>I Agree</th>
<th>I Strongly Agree</th>
</tr>
</thead>
</table>

Please explain your answer to the above:

-----------------------------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------------------------

10.0 How do you think Grid Computing could help your organization?

Please tick the appropriate box. Also, please indicate what the one or two key stumbling blocks for each of the categories could be e.g., security, applications, and bandwidth.

<table>
<thead>
<tr>
<th></th>
<th>x</th>
<th>Stumbling blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inventory reduction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greater collaboration with external partners</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greater collaboration within the organisation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Helped generate new revenue stream</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved customer service</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost reduction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced staffing requirements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increased Return on Investment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced product time to market</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If there are other benefits, please specify:

-----------------------------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------------------------

11.0 To what extent do you think security will be a hindrance to the wide adoption of Grid
Technology in e-business?

<table>
<thead>
<tr>
<th>Very Low</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
<th>Very high</th>
</tr>
</thead>
</table>

Please explain your answer to the above:

----------------------------------------------------------------------------------------------------------------------------------
----------------------------------------------------------------------------------------------------------------------------------
----------------------------------------------------------------------------------------------------------------------------------

12.0 Do you agree that bandwidth constraints will slow-down the adoption of Grid Technology in e-business?

<table>
<thead>
<tr>
<th>I Strongly Disagree</th>
<th>Do Not Agree</th>
<th>I Agree</th>
<th>I Strongly Agree</th>
</tr>
</thead>
</table>

Please explain your answer to the above. Could you also indicate what you think the future holds for bandwidth in the next 3-5 years, say?

----------------------------------------------------------------------------------------------------------------------------------
----------------------------------------------------------------------------------------------------------------------------------

13.0 Your name (optional): -------------------------------

14.0 Designation (optional): -------------------------------

15.0 E-mail Address (optional): -------------------------------

16.0 Telephone Number (optional): -------------------------------
APPENDIX 2: QUESTIONNAIRE FOR GLOBAL GRID FORUM

1.0 Your name: -----------------------------------------------------------------------------------------------

2.0 Title: -----------------------------------------------------------------------------------------------------

3.0 Designation:---------------------------------------------------------------------------------------------

4.0 E-mail Address: ------------------------------------------------------------------------------------------

5.0 Telephone Number: ---------------------------------------------------------------------------------------

6.0 Name of organization? ------------------------------------------------------------------------------------

7.0 Sector of Industry:

<table>
<thead>
<tr>
<th>Government</th>
<th>Engineering</th>
<th>Finance</th>
<th>Education</th>
<th>Forestry/Mining</th>
<th>Retail</th>
<th>Manufacturing</th>
<th>Other - specify</th>
</tr>
</thead>
</table>

8.0 Country  -----------------------------------------------------------------------------------------------

9.0 What e-business activities occur in your organization?

<table>
<thead>
<tr>
<th>Internet access and e-mail</th>
<th>Corporate website with company information</th>
<th>E-commerce enabled corporate website</th>
<th>Electronic links to suppliers</th>
<th>Electronic link to clients</th>
<th>We have an intranet</th>
<th>We have an extranet</th>
<th>Electronic Data Interchange</th>
<th>Other</th>
</tr>
</thead>
</table>

10.0 Do you believe that Grid Computing will play an important role in e-business?

I strongly disagree  Do not agree  I agree  I strongly agree

Please explain your answer to the above:

-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

11.0 Do you believe that applications will be a major barrier to the adoption of Grid technology?

I strongly disagree  Do not agree  I agree  I strongly agree

Please explain your answer to the above:
12.0 Have you personally used Grid technology? (Yes/No)

If yes, please specify in which area this technology was used.

13.0 How has Grid Computing helped your organization?

Please tick the appropriate box. Also please indicate what the one or two key stumbling blocks for each of the categories were e.g., security, applications, and bandwidth.

<table>
<thead>
<tr>
<th>Stumbling blocks</th>
<th>x</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inventory reduction</td>
<td></td>
</tr>
<tr>
<td>Greater collaboration with external partners</td>
<td></td>
</tr>
<tr>
<td>Greater collaboration within the organisation</td>
<td></td>
</tr>
<tr>
<td>Helped generate new revenue stream</td>
<td></td>
</tr>
<tr>
<td>Improved customer service</td>
<td></td>
</tr>
<tr>
<td>Cost reduction (State % reduction)</td>
<td></td>
</tr>
<tr>
<td>Reduced staffing requirements (State % reduction)</td>
<td></td>
</tr>
<tr>
<td>Increased Return on Investment (State % reduction)</td>
<td></td>
</tr>
<tr>
<td>Reduced product time to market (State % Reduction)</td>
<td></td>
</tr>
</tbody>
</table>

If there are other benefits, please specify:

14.0 To what extent do you think security will be a hindrance to the wide adoption of Grid Technology in e-business?

<table>
<thead>
<tr>
<th>Very Low</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
<th>Very high</th>
</tr>
</thead>
</table>

Please explain your answer to the above:

15.0 Do you agree that bandwidth constraints will slow-down the adoption of Grid Technology in e-business?

<table>
<thead>
<tr>
<th>I strongly disagree</th>
<th>Do not agree</th>
<th>I agree</th>
<th>I strongly agree</th>
</tr>
</thead>
</table>
Please explain your answer to the above. Could you also indicate what you think the future holds for bandwidth in the next 3-5 years, say?
9.3 APPENDIX 3: RESULTS FROM EXPLORATORY SURVEY

<table>
<thead>
<tr>
<th>Country of origin</th>
<th>Is Grid Computing to play a major role in e-business? *</th>
<th>Applications to be a barrier to Grid Computing?</th>
<th>Have you heard of Grid technology?</th>
<th>Is security a barrier to Grid adoption?</th>
<th>Is bandwidth a barrier to Grid adoption?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Old Mutual</td>
<td>SD=1,DNA=2,A=3,SA=4</td>
<td>SD=4,DNA=3,A=2,SA=1</td>
<td>Y=2,N=1</td>
<td>Y=2,L=4,M=3</td>
<td>SA=1,A=2,DNA=3,SA=4</td>
</tr>
<tr>
<td>Arivia.kom</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>PetroSA (CT)</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>PetroSA (MB)</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GSB</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>SAP Africa</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nedcor</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>APT-E-business Support</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BUG Holdings</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BTN</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Unipro Enterprise systems</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 11: Exploratory Surveys: Results

*SD= Strongly Disagree; DNA= Do Not Agree; A= Agree; SA= Strongly Agree; Y= Yes, N= No; VL= Very Low; L= Low; M= Medium; H= High, VH= Very High.

9.3.1 QUOTES FROM EXPLORATORY SURVEY

9.3.1.1 SHORTAGE OF SKILLS

Our most pressing problem is sourcing high calibre ERP consultants to service an increasing client base at the service levels we are accustomed to delivering- D. Prytz, Arivia.kom.

9.3.1.2 GRID COMPUTING ROLE IN E-BUSINESS:

Grid Computing could help organisations achieve cost reductions (assuming the entire Grid is under your control), and increased return on investment (assuming that the billing models are available for charging for resource usage)- R. Fereira (Nedcor).

I do not agree that Grid computing will play an important role in e-business. I do not see that in the medium term Grid Computing can overcome security, bandwidth issues- C. Van Den Berg, PetroSA (Cape Town).
Current focus is the massing of computer power to solve complex problems and utilize under-utilised resources more efficiently. I don’t know of any particular e-business scenarios, where Grid Computing would be beneficial, however as business and technology changes and new access methods, new ways of doing business and new business cycles appear the application of Grid computing may well become very important to e-business - R. Afonso (MasecoBytes).

Depending on applications being available, Grid computing could be very useful in design / simulation work to optimize / streamline the process, a lot faster than can currently be done on standalone machines - R. Afonso.


I do not agree that Grid Computing will play an important role in e-business. E-business and company linkages require robust, predictable, secure infrastructure (sometimes proprietary, e.g., VANs), and Grid is too open - Lance Stringer (Graduate School of Business, University of Cape Town).

9.3.1.3 APPLICATIONS

Applications, by their very nature, are fluid expressions of present day system possibilities, and their development will flow into the opportunities presented to meet future needs.
Applications can be modified for use in a Grid-computing environment, as they are modified for use in a multiprocessor environment - R. Afonso.

9.3.1.4 SECURITY

Just as Internet nerve centres are potential targets for terrorist attacks, so will Grid Computing centres be - D. Prytz (Arivia.kom).

With appropriate operating systems, adequate data security should be possible - T. Hoake, (E-Business Support).

Cyber crime is fast becoming the newly adopted profession of the sometimes unemployed and experimental young adult; there is always someone out there trying to be “smarter” than his or her predecessor - R. Fereira (Nedcor).

By it’s very nature – Grid Computing is distributed, when utilizing this technology in a corporate / business environment it is very important to ensure that only relevant
individuals / companies have access to the Grid – to prevent competitors gaining a competitive advantage from utilizing your information- R. Afonso.

9.3.1.5 Bandwidth

If a customer experiences waiting times beyond certain tolerances, the customer goes elsewhere- D. Prytz.

Seconds, and no longer minutes, are the measurement used for customer satisfaction, and any customer who experiences long waiting times will be inclined to go elsewhere for the fulfilment of his needs- Arivia.kom.

In South Africa, bandwidth is extremely expensive, and perhaps not sufficiently reliable- C. van den Berg, PetroSA (Cape Town).

As long as free enterprise is not permitted and governments insist on monopolising bandwidth providers like Telkom, bandwidth will continue to be a problem- R. Ferreira (Nedcor).

Bandwidth limitations in Africa:

“Bandwidth capacity constraints are mainly a problem in Africa and other underdeveloped countries. Europe and the USA have a huge advantage over us as their infrastructures are far more advanced, and services are available at fractions of the cost here in Africa. Therefore Grid-computing adoption should not be a problem in the developed world, here however it is a different story. Bandwidth costs more in South Africa than in the USA or Europe. The cost of bandwidth is one of the biggest factors affecting us; in the USA and Europe it is possible for small companies to have access to T3 (45Mb/s) lines for not much more than we pay for 64Kb and 128Kb leased lines. Even home users in these countries have access to bandwidths far in excess of what most of corporate South Africa enjoys.

“On the upside – our telecoms environments are just starting to deregulate, allowing for competition, the appearance of new technologies means that in some instances we can leapfrog our more developed counterparts and take advantage of new technologies and much higher bandwidths without going through the intermediate stages that they went through. Although these technologies come at a massive cost – particularly due to our poor exchange rates with the major currencies. Newer technologies such as Dense Wavelength Division Multiplexing (DWDM), Optical routing, unbounded optical systems, broadband wireless, etc., mean that bandwidth is becoming less and less of an issue. These newer systems promise huge bandwidth using existing infrastructures (fibre optic
cabling, etc.,) and utilizing lasers or wireless equipment over alternative media such as ‘thin air’.

“Current technologies such as Digital Subscriber line (DSL) will have an impact in the next 3-5 years although the current Telkom model will need to change. Aiming DSL at small businesses will result in competition with Telkom’s own leased line services, while delivering a service which is actually designed more for home users than business.

“Deregulation should mean competition for Telkom in provision of services to end-users, although this will be difficult for the competitor unless the “local loop” – last mile copper cabling is deregulated along with the market. If this is not done then competitors to Telkom will have to deploy wireless local loop technologies (fixed wireless) such as Local Multipoint Distribution Service (LMDS) – which although it works well will have a significant price premium, as the equipment required is expensive and priced in hard currencies.

“The existing GSM cellular networks will become more utilized for data services, particularly in remote areas and increasingly so as they implement third Generation (3G) Universal Mobile Telephone System (UMTS) technology, which provides for much higher bandwidths. This will still be expensive as 3G technologies are priced in hard currency and are expensive – even in developed countries” - R. Afonso, MasecoBytes.
### 9.4 APPENDIX 4: RESPONSES FROM THE GLOBAL GRID FORUM (GGF)

<table>
<thead>
<tr>
<th>Case Number</th>
<th>Country of origin</th>
<th>Is Grid Computing to play a major role in e-business?</th>
<th>Applications to be a barrier to Grid Computing?</th>
<th>Have you used Grid technology?</th>
<th>Is security a barrier to Grid adoption?</th>
<th>Is bandwidth a barrier to Grid adoption?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>USA</td>
<td>4</td>
<td>4</td>
<td>Y</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>USA</td>
<td>2</td>
<td>2</td>
<td>Y</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Netherlands</td>
<td>3</td>
<td>3</td>
<td>Y</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>USA</td>
<td>4</td>
<td>2</td>
<td>Y</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>UK</td>
<td>4</td>
<td>3</td>
<td>Y</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>USA</td>
<td>4</td>
<td>1</td>
<td>Y</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>Spain</td>
<td>3</td>
<td>2</td>
<td>Y</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>UK</td>
<td>3</td>
<td>4</td>
<td>Y</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>Poland</td>
<td>3</td>
<td>3</td>
<td>Y</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>UK</td>
<td>3</td>
<td>3</td>
<td>N</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>UK</td>
<td>3</td>
<td>2</td>
<td>Y</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>South Korea</td>
<td>3</td>
<td>2</td>
<td>Y</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>13</td>
<td>UK</td>
<td>4</td>
<td>3</td>
<td>N</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>14</td>
<td>USA</td>
<td>3</td>
<td>3</td>
<td>N</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>15</td>
<td>USA</td>
<td>4</td>
<td>2</td>
<td>N</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>16</td>
<td>South Korea</td>
<td>3</td>
<td>3</td>
<td>Y</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>17</td>
<td>UK</td>
<td>3</td>
<td>1</td>
<td>Y</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>18</td>
<td>Germany</td>
<td>4</td>
<td>2</td>
<td>N</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>19</td>
<td>USA</td>
<td>3</td>
<td>2</td>
<td>Y</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>20</td>
<td>UK</td>
<td>3</td>
<td>2</td>
<td>Y</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>21</td>
<td>Netherlands</td>
<td>3</td>
<td>2</td>
<td>Y</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>22</td>
<td>Canada</td>
<td>3</td>
<td>3</td>
<td>Y</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>23</td>
<td>France</td>
<td>3</td>
<td>3</td>
<td>Y</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>24</td>
<td>Germany</td>
<td>4</td>
<td>2</td>
<td>N</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>25</td>
<td>Italy</td>
<td>3</td>
<td>2</td>
<td>Y</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>26</td>
<td>Netherlands</td>
<td>3</td>
<td>3</td>
<td>Y</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>27</td>
<td>Germany</td>
<td>3</td>
<td>2</td>
<td>Y</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>28</td>
<td>USA</td>
<td>3</td>
<td>3</td>
<td>Y</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>29</td>
<td>UK</td>
<td>4</td>
<td>3</td>
<td>Y</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>30</td>
<td>UK</td>
<td>3</td>
<td>4</td>
<td>N</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>31</td>
<td>UK</td>
<td>4</td>
<td>2</td>
<td>N</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>32</td>
<td>USA</td>
<td>3</td>
<td>4</td>
<td>Y</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>33</td>
<td>UK</td>
<td>4</td>
<td>3</td>
<td>N</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>34</td>
<td>UK</td>
<td>3</td>
<td>1</td>
<td>Y</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>35</td>
<td>USA</td>
<td>4</td>
<td>2</td>
<td>Y</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>36</td>
<td>USA</td>
<td>4</td>
<td>1</td>
<td>Y</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>37</td>
<td>UK</td>
<td>4</td>
<td>3</td>
<td>N</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 12: Responses to GGF Questionnaire
9.4.1 RESPONSES TO OPEN-ENDED QUESTIONS

9.4.1.1 WHAT WAS SAID ABOUT BANDWIDTH

- For the US and Europe, I believe that the bandwidth will be there for other parts of the world bandwidth can be a problem. However, it is not the Grid that requires high bandwidth, but many of the applications that are on as the Grid. As an infrastructure the Grid can support applications that do not require the movement of large amounts of data and thus which do not have high bandwidth requirements - Thomas Hinke, NASA.
- For e-business bandwidth is no problem. For e-science it is, but bandwidth is increasing very fast, so in 3 years this is not going to be a big problem anymore.
- There is currently no evidence that bandwidth will be a problem. The leisure market is driving bandwidth upgrades, e.g., ADSL.
- Generally networking (capacity) is coming on faster than compute power. As long as the "last mile" problem is solved, bandwidth will not be a problem. Subsidies for broadband will help this problem.
- The last mile problem - both to homes and business is crucial. In the UK, the government is only partially trying to improve this. There is no "(optic) fibre to the door" programme.
- Level 3 (technology) has the network and bandwidth to support Grid bandwidth.
- E-business itself is lightweight transaction processing. The content may require lots of bandwidth, but the transactions themselves not.
- If several customers begin using Grid at same time it causes a bottleneck and slows things down. It all depends on the number of customers on the Grid.

9.4.1.2 QUOTATIONS RELATING TO SECURITY

- A significant Grid problem is that organisations have open ports through the firewalls protecting must organizations. On the positive side, the Grid provides security, which will be welcomed by organizations- T. Hinke, NASA.
- Grids have an excellent security model (This quotation is from a well-known Grid technology authority working for NASA).
- New security models (will be) needed for more complex collaborations- Thomas Sandholme, Argonne National Laboratory, Chicago.
- Security is always a top priority, but a large community is developing this.
- Uptake by major corporations will only occur with proven security.
- Today Internet business is most concerned about security. Grid will be same.
• Grid is about management of resources owned by organisations and individuals. You want to have a secure protected environment.

9.4.1.3 Quotations relating to Grid Computing’s role in E-business.

• Grid will play a role in e-business, but not as large as is e-science.
• Grid Computing will provide a way to seamlessly couple data, instruments and computation —T. Hinke, NASA.
• Grids provide resource management for Web Services.
• Grids enable "active services", and remote data collection, computation and control.
• Web services are strongly supported by business - I hope Grid services will bring business & research together.
• Grid Computing will improve utilization of resources (e.g., computers) and support teams working in Virtual Organisations.
• Grid Computing will help in product/service and development.
• Grid Computing will enable a better infrastructure.
• Grid Computing will enable access to remote sites.
• Computer resources as a commodity will provide new revenue.

9.4.1.4 Quotations on applications as a barrier to Grid Computing.

• It is applications that will benefit from the Grid since the Grid will help the development of applications.
• Grids represent a new infrastructure that application must adapt to.
• Many parametric screening and security analysis applications exist already.
• I think there are many applications already waiting for a Grid infrastructure.
• The technology is difficult to use at present.
• Applications may need some modification to become Grid enabled, but that will happen once the incentive is there to do it.
• There will be need for the development of middleware to enable collaboration.
• Applications are fundamental to take-up of Grid Computing.
• A lot of research (into applications) is still necessary.
• There are not many (Grid-enabled) applications at present.
• Yes, adaptation (of applications) to the Grid is not trivial.