# Updating on Gigabit Ethernet Implementation: The Case of a Large New Zealand Organization

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**ABSTRACT**

Ethernet network technology is still one of the most popular LAN technologies in use today by many organizations and educational institutions worldwide. The throughput offered by the 10 and 100 Mbps Ethernet is inadequate for supporting high bandwidth applications such as real-time multimedia and web applications. Gigabit Ethernet (GigE) technology provides 1000 megabits per second (i.e., one gigabit per second) at reasonable cost than the other technologies of comparable speed and therefore it is a natural upgrade strategy for many legacy Ethernet networks. This chapter updates on our previous research on GigE that has been documented as case study of a large New Zealand organization. We focused on the level of GigE deployment, design, planning, implementation, network performance testing, problems encountered and future plans. Our research findings show the feasibility and practicability of deploying GigE technology in high-speed networking applications, such as campus- and corporate-wide local area networks.

***Keywords:*** bandwidth; channel access method; CSMA/CD; data link layer; delay; Gigabit Ethernet; local area network; throughput

## INTRODUCTION

To meet the growing demand for high-bandwidth networking applications, such as multimedia and web services, has challenged network researchers to design network architectures capable of delivering a quality of service to end users. The demand for high bandwidth to the desktop has also grown for many end users requiring for an even high-speed network technology at the backbone. The deployment of GigE at organizations will enable the development of many bandwidth-intensive interdisciplinary applications, standards-based quality of service features, fast routing, and ease of management makes GigE an ideal solution for the next generation network technology.

GigE is an evolution of the original Ethernet design which has been around for more than 30 years. The first ratification of the Ethernet standard is known as IEEE 802.3 Carrier Sense Multiple Access with Collision Detection (CSMA/CD) access method and Physical Layer Specifications (TechFest, 2001). This specification is for 10 Mbps (i.e., 10BASE 2) over thin coaxial cable of maximum length 185 meters. Since then the standard has improved to include new media systems for 10 Mbps (e.g. 10BASE-T), then 100 Mbps (i.e., Fast Ethernet), and now 1000 Mbps, known as GigE. The 10 GigE has also been standardised by the IEEE in June 2002 (802.3ae, 2002; Meirosu et al., 2005).

A detailed discussion of GigE technology including 1 and 10 GigE and their performance measurements can be found in many networking literature (Cheng, Yu, & Sincoskie, 2005; Hughes-Jones, Clarke, & Dallison, 2005; Intel Corporation, 2003a; McNamara, 2001; Stallings, 2007; Zeadally & Zhang, 2004). Bakes et al. (2003) described a case study of GigE technology and its applications at the NASA Glenn Research Center.

In this chapter we update our research on GigE that has been documented as case study of a large New Zealand organization considering upgrade to GigE focusing on the level and scope of GigE deployment, network design and implementation, network performance improvement, problems encountered, and future plans (Sarkar, Byrne, & Al-Qirim, 2006). This case study approach may be useful to other organizations interested in upgrading their current networks to GigE. Professionals interested in the GigE technology could benefit from the experience of the organization in this study in adopting and diffusing the GigE technology.

The remainder of this chapter is organized as follows. An overview of GigE is presented first. We then discuss the deployment considerations of GigE. A case study of a large New Zealand organization focusing on the level and scope of GigE deployment are described. The network performance and test results are presented followed by brief discussion and conclusion.

## OVERVIEW OF GIGABIT ETHERNET

GigE supports four different physical layer implementations, three to which are defined in the IEEE 802.3z standard (802.3, 1998). The fourth is defined in the IEEE 802.3ab standard (802.3ab, 1999). IEEE 802.3z provides the specifications for the 1000BASE-LX, 1000BASE-SX, and 1000BASE-CX physical layers which, together, are generally referred to as 1000BASE-X. 1000BASE-LX networks support three types of optical fibre and 1000BASE-SX networks support two types. 1000BASE-LX can operate over a pair of 10 μm (core diameter) single mode fibres, or 50 or 62.5 μm multimode fibres, and uses long-wavelength (1300 nm nominal) lasers.

An overview of various GigE standards is presented in Fig. 1. The frame format of a typical GigE is shown in Fig. 2.

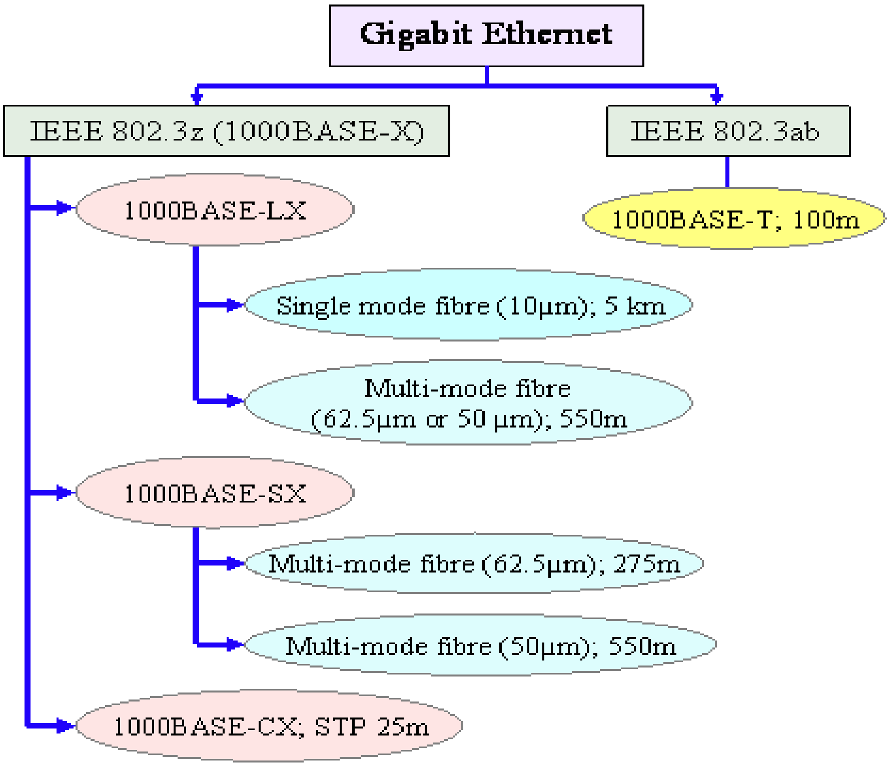


**Figure 1. Gigabit Ethernet standards.**

| byte → 8 | 6 | 6 | 2 | 46-1500 | 4 | 0-448 |
|---|---|---|---|---|---|---|
| Preamble +SFD | Destination address | Source address | Type/ Length | Payload + Pad | CRC | Carrier Extension |

← 512 byte minimum →

**Figure 2. Gigabit Ethernet frame format.**

## GIGABIT ETHERNET DEPLOYMENT CONSIDERATIONS

The three important factors (Intel Corporation, 2003b; Janowski, 2003; Serenbetz, 1998) that are necessary for the proper deployment of GigE are: (1) transmission media selection; (2) testing existing cabling; and (3) identifying potential bottlenecks.

For implementing a GigE, either UTP Cat 5 or better or fibre optic cables can be used. The choice of cables depends on factors such as distance coverage, physical location and environmental effects. The GigE has been approved for 550m and 5 km lengths for fibre optic and 100m for UTP Cat 5, Cat 5e and Cat 6 copper cables. So, if the distance between two devices is longer than 100m, then fibre optic cable will be more appropriate than the copper cables. However, the fibre optic cable may still be the better choice for applications requiring a short distance communication (less than 100m) because the fibre optic cable is not affected by electromagnetic interference, and is less vulnerable to security breaches. But, fibre optic cables are more expensive, difficult to install and since most organizations already have existing UTP Cat 5 or 5e, making copper cables often the most cost-effective choice for many companies upgrading to GigE (Janowski, 2003; Tan, 2000).

According to Tan (2000), GigE technology such as 1000BASE-T (i.e., 1Gbps over twisted-pair) will be the likely choice for many organizations. The question may arise as to whether copper cables (e.g., Cat 5e) or optical fibre cables are to be installed for upgrading to GigE. While many argue (Higgins, 2003; Hochmuth, 2003; Tolly, 2003) that using Cat 6 does not warrant the extra expense, others argue see e.g., (Corporation, 2003) that Cat 6 allows for 10 Gigabit use and should therefore be used for new installations to provide some future proofing. Although 10 GigE is not a standard for copper wiring, the industry community sees it as an important issue and an IEEE 802.3 Working Group has been established. However, Cat 6 cable has several advantages over Cat 5e, including tighter tolerance on impedance variations, higher bandwidth (250 MHz), and better performance.

Table 1 compares the performance of Cat 5, Cat 5e and Cat 6 cables (Anixter & Intel Corporation, 2003). The typical frame error rates in column 2 of Table 1 represent the transfer of 1 million 1518-byte packets over a 100BASE-T link using a marginal Ethernet adapter and switch port.

Table 1: Performance comparison of Cat 5, Cat 5e and Cat 6 twisted-pair cables

| *Cabling* | *Typical frame errors* | *Errors (%)* | *Improvement over Cat 5 (%)* |
|---|---|---|---|
| Cat 5 | 200,000 | 5 | |
| Cat 5e | 100,000 | 3.5 | 50 |
| Cat 6 | 17,000 | 0.4 | 92 |

If existing copper cable is to be used for GigE, then it is important that all cables must be tested to meet the performance criteria for GigE. As Janowski (2003) points out cable testing should include connectors, patch and fly leads. Testing for crosstalk and return loss is also required when using existing cabling, as these issues do not affect both 10BASE-T and 100BASE-T as the pairs used do not have bi-directional traffic (Sweeney, 2000; Vanderlaan, 1999). The test parameters are included in the TIA/EIA 568-B.1 standard, including the far-end crosstalk and return loss that were not included in the original Cat 5 standard.

According to Janowski (2003) and Chapin (2001), another issue is the standard 32-bit PCI architecture, as this only handles up to 133 megabytes per second, whereas 64-bit PCI-X buses can handle up to 1 gigabyte per second. There are several PCI-X buses available in the market (e.g. AMD 750, Intel Xeon and Itainuim2), but is not a common configuration for PC-based workstation. This is one of the bottlenecks that need to be considered when deploying GigE. Another potential bottleneck is that the devices connected to network such as printers are not to have Gigabit capabilities. The availability of PCI Express from Intel Corporation and the more widespread adoption of PCI-X may resolve some network bottlenecks.

**Deployment steps**

The industry best practice for deploying GigE as outlined in (Gigabit Ethernet Alliance, 1998; Intel Corporation, 2003a; McNamara, 2001) seems to be that the deployment is carried out in the following order:

- **Switch-to-switch and switch-to-router connections:** This requires a decision on whether layer 2 or layer 3 switches are to be used. Layer 3 switches allow for the linking of subnets without the use of a router.
- **Switch-to-server connections:** All servers on the GigE switch should have Gigabit capable network interface cards (NICs).
- **Switch-to-high performance workgroups**: Whether this step is carried out depends on the company requirements. If a company requires Gigabit performance to desktop then, according to GigE Alliance (Gigabit Ethernet Alliance, 1998) and McNamara (McNamara, 2001), the first area that needs to be upgraded is the groups/departments that requires connection between high performance workstations and switches.
- **Switch-to-other users**: If this were going to be done, it would be the last step in the implementation.

Figure 3 shows an example of a best practice implementation of a GigE network for a large organization.

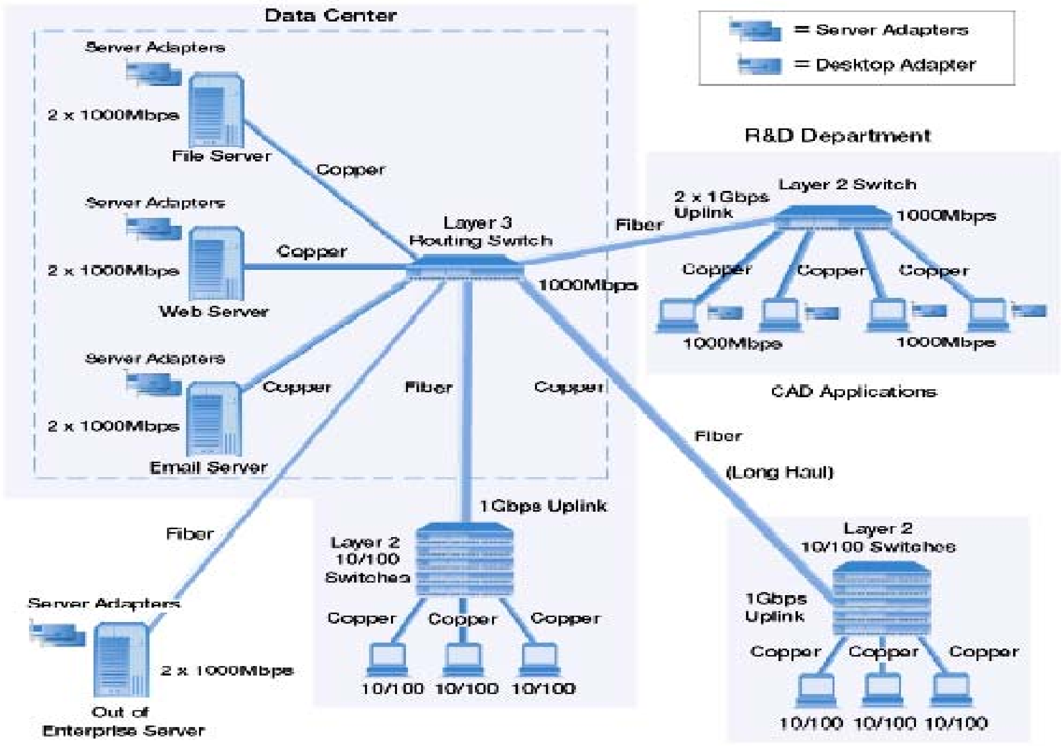


**Figure 3. A typical corporate Gigabit Ethernet infrastructure.**

## CASE STUDY

This research is exploratory in the sense that there was no prior research in New Zealand to guide this research endeavour. Therefore, this research adopted the case study methodology proposed by Yin (1994). Yin's (1994) views are that case studies are the preferred research strategy to answer how and why type questions and using interviews would also be acceptable by the interpretivist school (Walsham, 1995). The strength of case studies is the ability to capture a greater number of variables than is possible with any of the other strategies. The case study approach is important to this study in exploring the application of this novel GigE technology in organizations.

In summary, this research adopts Yin's (1994) case study design in studying one single case (holistic) represented here by a large environmental and engineering consultancy firm (unit of analysis) that has been in business for more than 45 years.

As requested by the management of this company, the real name of the company and the interviewee was suppressed. Closed-ended and open-ended questions were used during the in-depth interview with the IT manager of the company.

**Case background**

The company in this study has 10 regional offices in New Zealand with a headquarters in Auckland. The company has also affiliated companies in Malaysia and Philippines. This company specialises in environmental, geotechnical, water resources and civil infrastructure work such as tunnelling, storm water, waste management and roading.

Currently there are 325 employees in New Zealand consisting of 287 consultants and 38 support staff. All staff members are highly computer literate and most of them are very sophisticated users. The nature of the business requires a robust and responsive IT infrastructure with flexibility to meet the fluctuating demands of project work.

To get some insights about the level of deployment of GigE, we conducted an interview with an IT manager of the organization under study. The interview questionnaire used in this study consists of three sections with a total of 32 questions (see Appendix for interview questionnaire).

The first section (questions 1 to 16) of the interview questionnaire was designed to get an insight into the existing network infrastructure of the company under study. This was supported by asking about the number of PCs and laptops and the operating systems they used in questions 2 to 5; number of servers on the LAN and server OS, in questions 8, and 9; network topology and cabling in questions 14 and 15. The second section (questions 17 to 26) of the interview questionnaire was designed to gather some information about the upgrade to GigE. This was supported by asking about what is being upgraded to GigE, in question 17; whether the existing wiring system is going to be used for GigE, in questions 18 to 20; and the networking devices including routers and switches that need to be upgraded, in questions 21 to 22. The third section (questions 27 to 32) of the interview questionnaire was designed to get information about GigE design, planning and implementation. This was supported by asking about reasons for upgrade, in question 27; what services will use GigE and planned implementation, in questions 28 and 29; and the overall cost for upgrade and data rate after upgrade to GigE, in questions 31 and 32.

**Existing network infrastructure**

The existing network infrastructure (before upgrade to GigE) is an extended star physical topology with a star Intermediate Distribution Frame (IDF) on each floor of the building, joined to a central star Main Distribution Frame (MDF). Each star IDF uses a mixture of 3Com Ethernet 3 switches (24-port 10/100 Mbps) and 10 Mbps Hubs. A D-Link DES-5024 24-port 10/100 Mbps switch serves the central star. The cabling for all parts of the topology consists of either Cat 5 or Cat 5e. There is no record of where each type is used and none of the cabling has been certified. The protocols used on the network are TCP/IP and IPX/SPX.

Each of the organization’s offices runs a LAN which is connected to head office via a VPN running over Fibre, Wireless and DSL. These links are also used for the Internet access for the company. However in the head office a separate 4Mbps fibre line is also being used for the Internet connectivity (*Telecom NZ Links*, 2004). Mako Systems are used as routers, firewalls and VPN access end points. Microsoft’s ISA Server is used for VPN services for mobile users and for publishing Internet facing servers.

At the head office, there are twenty servers in total of which 19 are Windows 2003 servers, and one Windows 2008 server. Table 2 lists the 20 servers: (1) fifteen servers as shown in column 1 are linked to company LANs; (2) two servers are connected to both the company's LANs and externally is shown in column 2; and (3) the remaining three servers are external to the company LANs and are used for communication and accessing PMCRS (Project Management and Communication Reporting System)(see column 3).

**Table 2. Sixteen servers currently operating at the head office**

| *Server connected to LAN* | *Server connected to LAN and externally* | *External server* |
|---|---|---|
| SQL server (2) | VPN server | Web server |
| File server (2) | ISA server | Mail server |
| Print server (1) | | SQL server |
| Domain Controllers (2) | | |
| Application Servers (5) | | |
| Intranet server (1) | | |
| Archival storage server (1) | | |
| Legacy financial server (1) | | |

At the head office there are 220 PC-based workstations and 54 laptops. All computers are operating under MS Windows XP, The configuration for each workstation ranges from Intel P4 3.0 MHz to Core 2 Duo, with 1GB to 2GB of RAM. Hard disk drives are 120GB with a speed of 7,200 rpm. All computers have DVDs, sound cards and 1GB Marvel network cards.

All computers in the organization are configured with MS Windows XP via a scripted install and a standard set of software via Microsoft Installer (MSI) and group policies. Then through the use of further group policies computers are installed with the specialist software required by the users. Basically the bulk of installations are covered by four further group policies as follows:

- ArcGIS
- Geotechnical software (about 12 applications by different vendors)
- Administrative assistants (software required by the administrative support staff in each Group).
- Accounts software (applications required only be the accounts staff)

With the use of Active Directory Services and distributed file systems, the distribution of new and upgraded applications is controlled by MSIs and group policies across all offices via the VPN. While not a 24/7 operation, users do have requirements and expectations of having the system available 7 days a week and for most of the evening. Administrative activities are run from midnight to 4am in the morning, so there is little time available for planned down time.

### Reasons for upgrade

According to the IT Manager of the organization under study, there are three main reasons for upgrading to GigE.

- **Relocation of offices:** The IT Group had moved to a new location about three years ago but the central switches stayed at the old location. To cope with company's current growth, servers are splitted over both locations. The re-wiring would allow all servers and the switches on the star MDF to move to one location.
- **High bandwidth applications:** Due to increased use of images with design packages such as ArcGIS, Land Development, AutoCAD, 12D and MOSS, as well as photographs in reports, has led to the requirement for more bandwidth.
- **Replacement of hubs and switches**: Wanted to install more Ethernet Switches to replace all the Hubs and 10 Mbps switches.

### Goals and requirements

The overall goals for upgrading to GigE are: (1) streamline the wiring from the star MDF to the star IDFS; and (2) provide, in the first instance, more bandwidth on the backbone and gradually to users. To achieve successful rollover to GigE, the organization undertook the following three phases:

- Deciding on a design
- Implementation
- Testing

The factors influencing the process revolved around past experience, budget constraints and newness of the technology. The reason the organization has not replaced all hubs with switches is because of the problems that they have had getting good support in New Zealand for their current switches. So this is an important factor in the choosing of new switches. The switch supplier has to have a strong presence in New Zealand – not just for selling but for ad-hoc support as well. However budget constraints means that cost has to be taken into account in this decision. The decision to use a consultant to design the upgrade has been made despite the organization usually doing design work themselves. The reason for this is based on two issues: (1) time is a factor since all IT staff members are heavily committed to other projects for several months; and (2) newness is another factor – use of GigE technology is still new, so the company wanted another view.

As the IT Manager stated “even if they only endorse the design we have in place already, it would be worth the piece of mind”. As the star MDF’s location is being shifted, re-wiring will be necessary. Given this and the fact that no further plans for relocation are likely to occur in the foreseeable future, the decision was made to plan for future bandwidth growth requirements. As discussed earlier, both Cat 5 and Cat 5e would be capable of running Gigabit. Fibre optic cable was considered but the benefits versus the cost were not warranted according to both the consultants and the IT Manager.

The specification requirements for the servers had been investigated and although the current servers only have 32-bit bus PCI capability, the IT Manager had already decided that even though this would cause a bottleneck, access speeds would still be faster than fast Ethernet and upgrades to a higher speed PCI bus can be done as the technology becomes available. So the design mandate given to the consultants was to design a system that in the first instance provided switch-to-switch Gigabit connections, allowing however the ability to extend to the desktop when and if required in the future. The other requirement was for the heavy demand servers (total six servers) to have Gigabit connection to the switches on the star MDF.

**Design and planning**

The consultants were asked to assess the entire current topology as well as replacing the main star. The design they submitted did not change the topology in any significant way. The only difference was the addition of extra cables between the star MDF and star IDFS, where currently there are two; the new design had four cables. The use of the four cables allows for redundancy as well as for growth. The consultant's recommendation for switches met the organization's requirements of a strong New Zealand presence and budget constraints.

All floors would have their 10/100 switches and/or hubs replaced with one 10/100 switches which also have two Gigabit ports, with an option for two more. One of these ports would be used for the connection to the backbone. In the future a Gigabit switch can be added at each of the star IDFS for any group of users that require GigE to the desktop. These switches will use one of the remaining three cables at each star.

The use of two switches at the main star allows for redundancy and for increased bandwidth for server access. The connection configurations for these switches are shown in Fig. 4. These switches are layer-3 switches, which allows for any expansion of the network in the future. The high usage servers will connect directly to these switches.

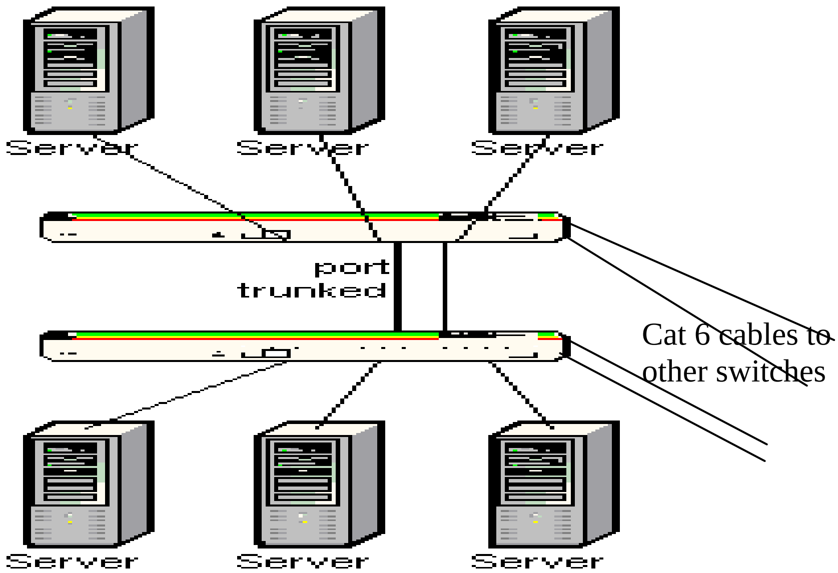


**Figure 4. Connection configuration for the main switches.**

The rest of the switches are layer-2 switches as the cost of layer-3 switches is not warranted. The total cost of the switches and installation was in the 40 to 60 thousand-dollar range.

**Implementation**

The implementation requires new wiring to be run between all floors to the star MDF in the computer room. This can all be done without disruption to the existing network. However the wiring ducts between the floors has been concreted in, apparently for fire safety reasons, so this will have to be drilled through out of work hours because of the noise disruption. The switch at each star IDF can be placed in the existing frame and connected to the new backbone cable before cutover. However this will require some reorganization of the current frame configuration so that the new switches can be patched tidily from the patch panel. This work will be done on a Sunday, after a week's notification, to minimise impact on the users. The new frame for the star MDF will be installed and all switches and panels transferred at the same time.

Prior to cutover to the new wiring and switches, the network cards in the servers will have to be replaced with 100/1000 NICs. This is scheduled to be done as part of the routine maintenance over the month prior to cutover. The cutover was scheduled for one Saturday. Testing the new star topology had been completed but the unknown was the new main star interacting with the existing cabling of the other stars. So although one evening should have been enough time, doing the cutover on a Saturday gave all weekend before lack of system caused by any problems would impact on the business.

The cutover consisted of changing the patch leads from the existing switches and hubs at each IDF to the new switches and of connecting the high usage servers to the switches at the MDF. This was all carried out successfully and workstations in each star were used to run various applications with speeds compared to similar tests done before cutover. An increase in speed was not necessarily expected in this low load situation but was a check that there was not a decreased performance indicating some problem. However the following morning the network went down and testing showed that a particular star was the problem. Resetting the switch restarted the network but the consultants decided that a “loopback” problem existed, that is one of the stars somewhere had two routes to the servers that were on the problem star. The cabling was again checked and completely re-patched but the problem re-occurred within 24 hours. Resetting fixed the problem again but the consultants were adamant that it could not be the switch as all the switches had undergone testing in their lab for a week before installation. However after more testing by the organizations IT staff and several more outages (impact reduced by taking all servers off the problem star), the

IT Manager insisted on replacing the switch. No further problems occurred once the switch was replaced. The network performance is described next.

## PERFORMANCE TEST RESULTS

The organization under study was particularly interested in the network throughput performance improvement operating under high traffic conditions, as this was one of the main reasons for upgrading to GigE.

The workstation-to-server configurations before and after upgrading to GigE are shown in Fig. 5 and 6, respectively.

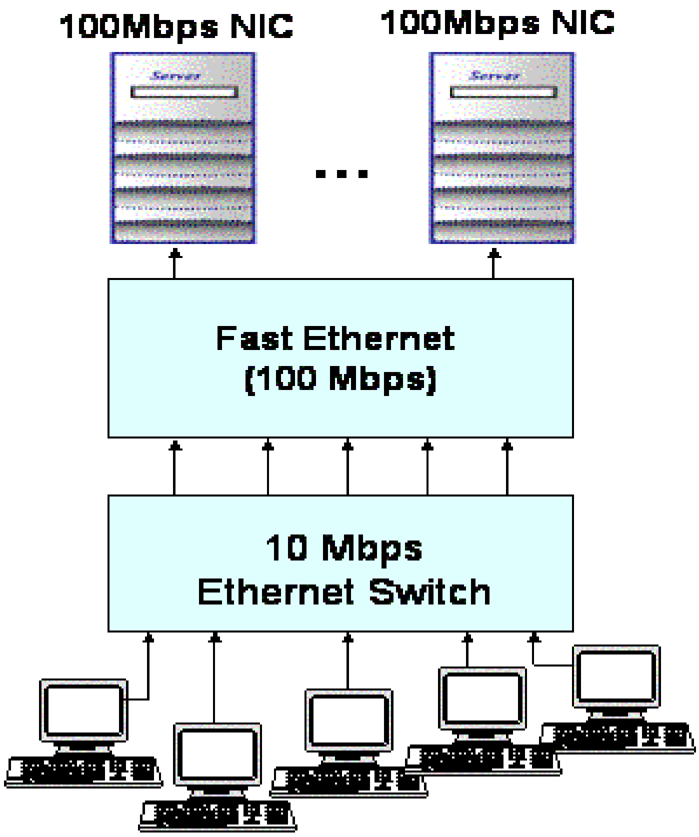


**Figure 5. Workstation-to-server configuration before upgrade to GigE**

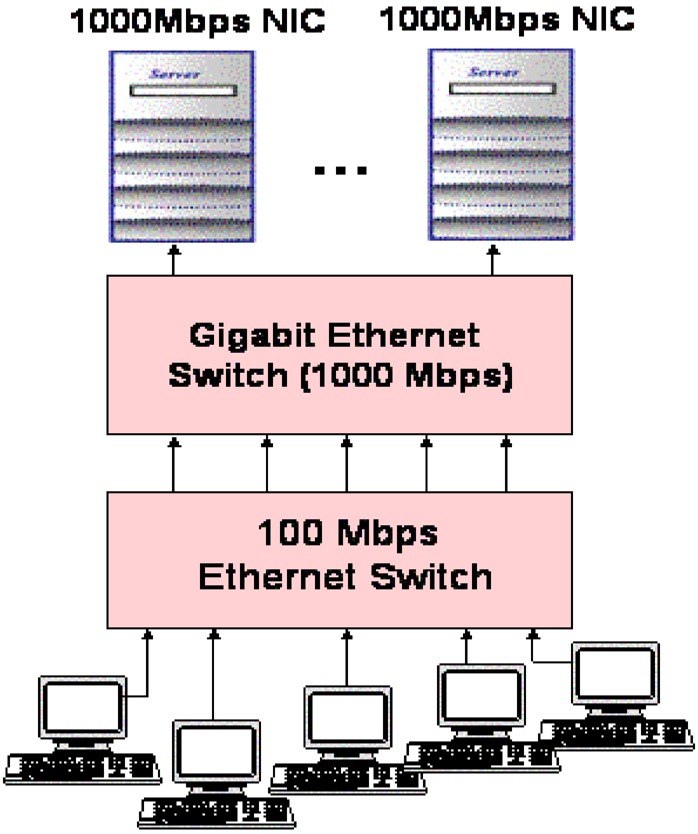


**Figure 6. Workstation-to-server configuration after upgrade to GigE**

The network performance was tested by transferring a 596 MB file under the following network configurations: (1) workstation-to-server; and (2) server-to-server. In the first configuration, two or more servers (with identical configuration including 1000 Mbps NIC) were connected to a GigE switch and all workstations were communicating with the servers via 100 Mbps Ethernet switch (Fig. 6). In the second configuration, two servers (with identical configuration including 1000 Mbps NIC) were linked to a GigE switch. In each case, the file transmission time was recorded and the network throughput was computed by dividing the file size by the transmission time.

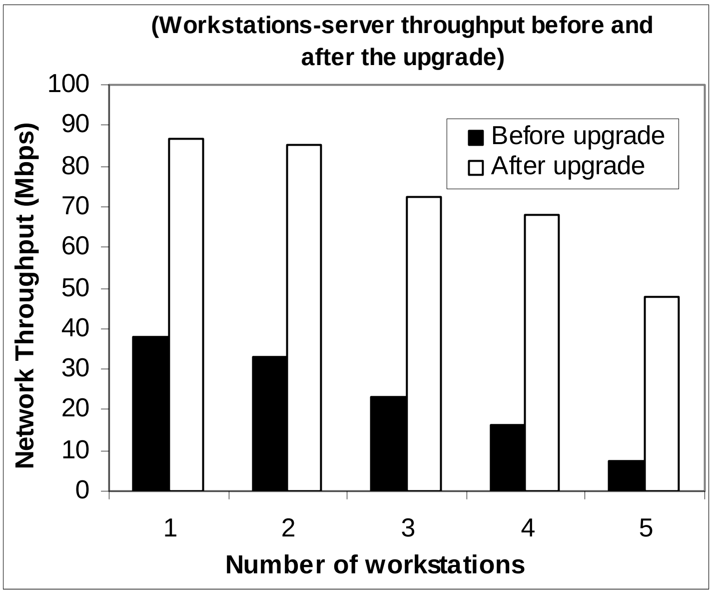


**Figure 7. Comparison of network throughput performance before and after upgrade to GigE under workstation-server configuration.**

Figure 7 compares network throughput performance before and after upgrade to GigE under workstation-to-server configuration. We observed that the network throughput performance has increased significantly after the network upgrade to GigE. The network throughput performance improvement is even more significant as the number of workstation communicating with servers increased. For example, when five workstations are communicating with the servers on the GigE, the network throughput is around six times larger than the existing 10/100 Mbps network (i.e., before upgrade to GigE).

In Fig. 8, we compare network throughput performance before and after the network upgrade to GigE under a server-to-server configuration.

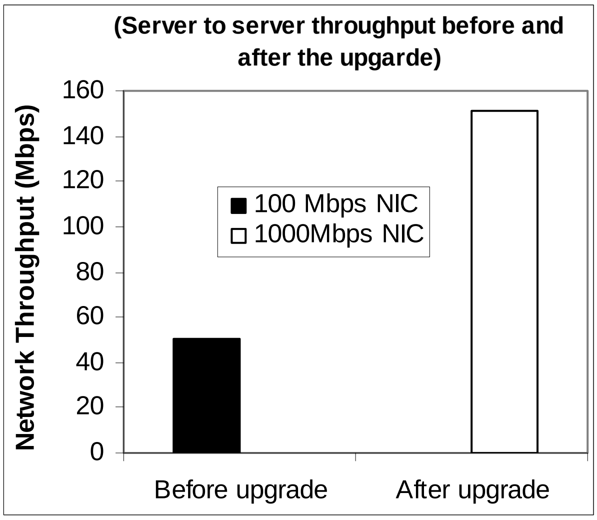


**Figure 8. Comparison of network throughput performance before and after upgrade to GigE under server-server configuration.**

When first implemented we observed that the network throughput under the GigE was approximately three times faster than the existing 10/100 Mbps network. While the improvement in data transmission rate, even though it was not ten times faster than the fast Ethernet, was still acceptable to the company's operation because it provided an increased productivity. However, it was considered that much of this limitation to the overall network throughput was due to the low-end PC-based servers and associated hardware including bus architecture, RAM, and GigE cards. It was found that with faster server hardware (the biggest improvement to speed was when network cards became integrated on the motherboard's chipset). The overall network throughput especially at server-to-server configuration increased to nearly 1 Gbps.

Included in the performance testing was a P4 3GHz machine with hyperthreading enabled and an onboard GigE NIC. This computer was the fastest in all the tests, even though it was running over Cat 5e. The onboard network card must have been the difference and further studies showed this to be true. The third party consultant tested the cables using a Fluke Networks DSP-4100 cable tester, and all the cables passed the requirements.

## DISCUSSION AND CONCLUSION

Gigabit Ethernet technology is a viable option for campus- and corporate-wide backbone networks, as well as for desktops, workgroups and server connections where legacy Ethernet LAN technologies are no longer able to provide adequate bandwidth and services.

This chapter described a case study of a large New Zealand organization about the company's level and scope of Gigabit Ethernet (GigE) deployment, the problems the company encountered, network performance and test results. While the use of fibre optic cable for switch-to-switch connections may have some obvious benefits such as longer distance coverage, less electromagnetic interference, and high noise immunity than the copper cables. The most common low-cost Cat 5e UTP cable can be used as an alternative option to deliver 1 Gbps (i.e. 1000BASE-T) over 100 meters.

Our findings show that the organization under study first achieved around 300 Mbps after the network upgraded to GigE. This limitation of the overall network throughput was mainly due to the low-end PC-based servers and the associated hardware. However, as expected with faster server hardware the overall network throughput especially at server-to-server configuration was nearly up to 1 Gbps. Originally, while the improvement in data transmission rate was not ten times faster than the fast Ethernet, it was still acceptable to the company's operation since it provided an increased productivity. However with the better server configurations and faster server hardware that has been introduced full advantage of GigE capacity has been achieved.

Our analysis and findings reported in this chapter serve two main purposes. Firstly, we believe that our findings, as reported in this chapter, can be a useful resource, aiding managers to make an informed decision about the deployment of GigE technology to upgrade their campus and/or corporate LAN infrastructure. Secondly, this case study can be used in the classroom as a real-world example, when teaching high-speed networking courses. We believe that this chapter also contributes to filling a research gap in how a large New Zealand organization and similar organizations elsewhere upgrade their networks to GigE to meet the current and future needs of high-speed networking requirements. A survey with a larger number of organizations is planned as an extension of the present study.

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# Appendix

## Interview Questionnaire

**Section 1: Existing system**

1. Each of your offices operates a LAN. Are they joined by a WAN? Y/N
   If Yes, briefly describe how this is configured and what equipment/software is used.
2. How many workstations are on the LAN being investigated for upgrading to Gigabit Ethernet?
3. How many laptops (not already included in the above figures)?
4. What OS is used in workstations? Please give number for each OS (Tick all that apply).

☐ Win98 ☐ WinNT ☐ Win 2000
☐ WinXp ☐ Unix/Linux ☐ Other (please specify)

5. What OS is used in laptops (if not included in Q4 above)? Please give number for each OS.

☐ Win98 ☐ WinNT ☐ Win 2000
☐ WinXp ☐ Unix/Linux ☐ Other (please specify)

6. Are the Win98 computers going to have their OS changed? Y/N
7. In general what are the specifications of workstations that will use Gigabit Ethernet?

☐ PCI Bus (MHz) ☐ RAM (type e.g. DDR & size)
☐ HDD transfer rate ☐ CPU speed ☐ CPU type

8. How many servers are on the company LAN?
9. What OS is used for file servers? Please give number for each OS

☐ WinNT ☐ Win 2000
☐ UNIX ☐ LINUX ☐ NetWare

10. What are the specifications of servers that will use Gigabit Ethernet?

☐ PCI Bus (MHz) ☐ RAM (type e.g. DDR & size)
☐ HDD transfer rate ☐ CPU speed & type

11. What protocols are used on the LAN?

☐ TCP/IP ☐ IPX/SPX
☐ NetBui ☐ Other (please specify)

12. Which of the following are used on the current network? Please specify brand/model and how many.

☐ Routers ☐ Ethernet switches ☐ Hubs
☐ Repeaters ☐ Bridges

13. Are VLANs used? Y/N

14. What wiring topology is used?

☐ Star ☐ Bus ☐ Ring

☐ Tree ☐ Other _______________

15. What kind of cabling is currently used? Have they been certified?

☐ Cat 3 Certified Y/N ☐ Cat 5 Certified Y/N

☐ Cat 5e Certified Y/N ☐ Cat 6 Certified Y/N

☐ Fibre optic Certified Y/N ☐ Coax Certified Y/N

16. Define the LAN backbone – please describe or provide a diagram.

**Section 2: What is being upgraded?**

17. What is being upgraded to Gigabit Ethernet?

- Entire LAN Y/N
- Segment(s) Y/N

If segment(s), please specify (i.e. backbone plus one department)

18. Is the existing wiring going to be used? Y/N

19. If No to Q18 please specify why.

20. If Yes to Q18 has it been tested to check that it will meet Gigabit Ethernet requirements? Y/N

21. Is any of the equipment listed in Q12 being replaced? Y/N

22. If Yes to Q21 please list the new equipment – brand/models and numbers

☐ Routers ☐ Ethernet switches ☐ Hubs

☐ Repeaters ☐ Bridges

23. Is there any other equipment being installed not mentioned in Q22 above? Y/N

If yes, please specify

24. What changes will be required for the servers?

25. Will any redundancy be built into the network topology? Y/N
If so where and how?

26. What will the structure of the network be once the installation has been completed? Please describe or provide a diagram.

**Section 3: Planning and implementation**

27. What are the reasons for upgrading to Gigabit Ethernet?

28. What services/applications will use Gigabit Ethernet and why?

29. What are the planned implementation steps?

30. How is the cutover being planned?

31. What was the cost of the upgrade?

☐ < $20,000 ☐ $20,001-$40,000 ☐ $40,001 - $60,000
☐ $60,001 - $80,000 ☐ $80,001-$100,000 ☐ >$100,001

32. What were the bandwidth/data rate, before and after the upgrade to Gigabit Ethernet:

Server level: Before: ________ After: ________

User level: Before: ________ After: ________

Backbone: Before: ________ After: ________