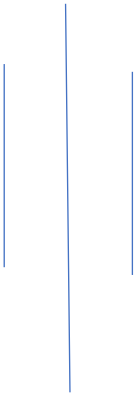
Project report on “A network design for Gecko Allied Health Services”



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MICT925 Strategic Network Design

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(In fulfillment of the master’s degree of information Technology)

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Executive Summary

1. Introduction

1.1 Background and Orientation

In the 21st century, as people live longer, and the prevalence of chronic diseases increases, the healthcare system becomes an important part of people's livelihood. More and more people are paying attention to how to get patient-centred, high-quality, continuous care from the community of health services (Strumpf et al., 2017). In the face of an ageing population and a growing number of morbid populations, drug treatment has become a growing demand and challenge (Garattini and Padula, 2018). This means that patients need to coordinate well between multiple health care providers (Strumpf et al., 2017). Therefore, Community health care is required to provide services coordinated by multidisciplinary doctors and full-time health care professionals.

In fact, the medical services that people can get are limited by their location. Geographically dispersed medical service sites are as difficult to co-operate as islands. In addition, there is literature showing that the module used by community health care and the approach to health services can affect the efficiency of healthcare delivery (Herwartz and Schley, 2018). This report addresses the above issues by design a network and a set of models which could be bringing dispersed General Practitioners together to provide patient-centred, better medical services.

The availability of integrated multidisciplinary health care services is facilitated by the spread of information and communication technology infrastructure. In this article, within the vast geographic area of the four locations of **Wollongong, Thirroul, Dapto and Kiama,** a network will be designed to unite the various GP offices. This combined community health care not only keeps its primary care services intact, but also provides more advanced integrated health care. Moreover, it can provide professional medical services such as pathology, imaging, tropical diseases, psychology, obesity treatment, plastic surgery, etc. And this comprehensive medical service practice is called as **Gecko Allied Health Services (GAMS)**.

Responsiveness to the healthcare consumers is identified by the World Health Organisation as one of three key elements for a quality health system. Providing continuous care involving person centred approach by integrating the health services is endorsed as the most efficient pathway in health systems reform (Grace, Bradbury et al. 2018). General practitioners in addition to treating the patients who visits them should also be sensitive to common health needs of the community as they are considered as frontline health workers (Vermeulen, Schäfer et al. 2018). There is a pressure for GPs in providing specialized healthcare services apart from their traditional routine “Monday to Friday, nine to five” opening hours. They realise that in order to improve the services to their patients they must join with other GPs who are experts in

different areas as well as allied healthcare professionals. Various applications in healthcare is offered by the growth of wireless technology in medical services.

1.2 Problem Statement

This report is to establish a service network that can provide high quality care and break the traditional “island” of health care services. However, there are some difficulties that cannot be ignored.

Firstly, considering the accessibility of Gecko Allied Health Services, non-working GP care has become a problem that has received widespread attention from patients, health care organizations, medical staff and decision makers in recent years, which also involves concerns about the quality and efficiency of the healthcare service (Pham and McRae, 2015).

Secondly, when patients were cared between multiple health care providers, there are some information exchange problems. The main problem is how to communicate the most basic information in a timely and safe manner, it in cloud patient privacy, the type of disease, procedure of diagnosis, the treatment process, results and recommendations for follow-up treatment (Erni et al., 2016).

Thirdly, the collaboration of general practitioners will face some communication problems. For example, the different profession medicals through video consultation and cooperation (Erni et al., 2016). It is necessary to consider the quality of the video, communication capabilities, stability and other issues.

In general, the main problem to be considered in this paper is to use network technology to build a model so that GAMS is no longer limited to geography.

1.3 Definition and Limitation

The definitions of terms used in this report include WAN, LAN, IP, RPC, SNMP and SDI.

WAN: it refers to the wide area network, which can provide long-distance communication in many areas covering a large physical range.

LAN: Local Area Network Connects to a computer network in a limited area.

IP: Internet Protocol is a protocol for packet switched data networks.

RPC: Remote Procedure Call is a computer communication protocol. In order to allow different clients to access the server, many standardized RPC systems have emerged. This protocol allows programs running on one computer to call subroutines of another computer without the programmer having to additionally program this interaction.

SNMP: A simple network management protocol consisting of a set of network-managed standards, including an application layer protocol, a database schema, and a set of resource objects. The protocol can support a network management system to monitor whether devices connected to the network have any management concerns.

TCP: Transmission Control Protocol is a connection-oriented, reliable, byte stream-based transport layer communication protocol.

SDI: SDI is the digital component serial interface, while the HD-SDI interface is a broadcast-grade high-definition digital input and output port, where HD stands for high-definition signals. Since the SDI interface cannot directly transmit compressed digital signals, the compressed signals recorded by devices such as digital video recorders and hard disks must be decompressed and output via the SDI interface to enter the SDI system. Repeated decompression and compression will inevitably lead to image degradation and increased latency. For this reason, digital video recorders and non-linear editing systems of various formats specify their own interfaces for direct transmission of compressed digital signals. SDI is widely used, and it is an interface specification that transmits under the signal rate of 1.485Gb/s or 1.485/1.001Gb/s according to SMPTE292M. This specification specifies the data format, channel coding method, signal specifications for the coaxial cable interface, connectors and cable types, and fiber interfaces. The HD-SDI interface uses a coaxial cable with a BNC interface as the cable standard. Effective distance is 100M.

CMOT: CMIS/ CMIP Over TCP/IP, TCP/IP-based public management information services and protocols. The Common Management Information Protocol (CMIP) is an ISO protocol used to monitor different networks simultaneously with the Common Management Information Service(CMIS). CMIS defines a network management information service system. The goal of CMIP is to replace the simple network management protocol. CMOT defines a network management architecture that supports the use of the Common Management Information Service/Common Management Information Protocol (CMIS/CMIP) defined by the International Organization for Standardization (ISO) in the Internet. In addition, the architecture provides a means of exchanging monitoring information between the manager and the remote network unit.

Entry label: The limitations of this project network include:

1. the cost from a geographically dispersed location.
2. Secure Database requires 99.999% reliability.
3. Video Conference require HD quality and the service outage should be resolved in 10minutes.
4. Bandwidth prerequisite is additionally high to trade data amongst the four locations.

2. Analysis and Specification Document:

According to McCabe, the first step in designing the network is analysing the requirements by gathering and deriving the information from the management, users and applications. This information provides an understanding of the network system and its characteristics. Once the requirements are gathered, the performance for the services can be determined by applying the concepts of best-effort, predictable and guaranteed networks (McCabe 2007).

2.1 Initial conditions:

The initial conditions are the basis to develop a network design by gathering the requirements from the GAMS (Geeky Allied Medical Services) Chief Information Office. With this information, we develop a requirement map and flow analysis that can be implemented in GAMS offices. The key requirements are listed below.

1. The network design is to be implemented in four locations (**Wollongong, Kiama, Dapto and Thirroul**) in Illawarra.
2. All the locations are separated by 10 kilometres.
3. The network should be available for use **24/7**.
4. Each location must have five offices with same level of service metrics.
5. All the locations should have access to all the services with an exception of staff web access.
6. Secure database server must be installed in Wollongong location.
7. Back-up archive server should be installed in one of the four locations.

2.2 Requirements Map:

Requirement Map refers to the diagram that demonstrate the location dependencies between applications and devices. Such diagram will be used for flow analysis of the project.

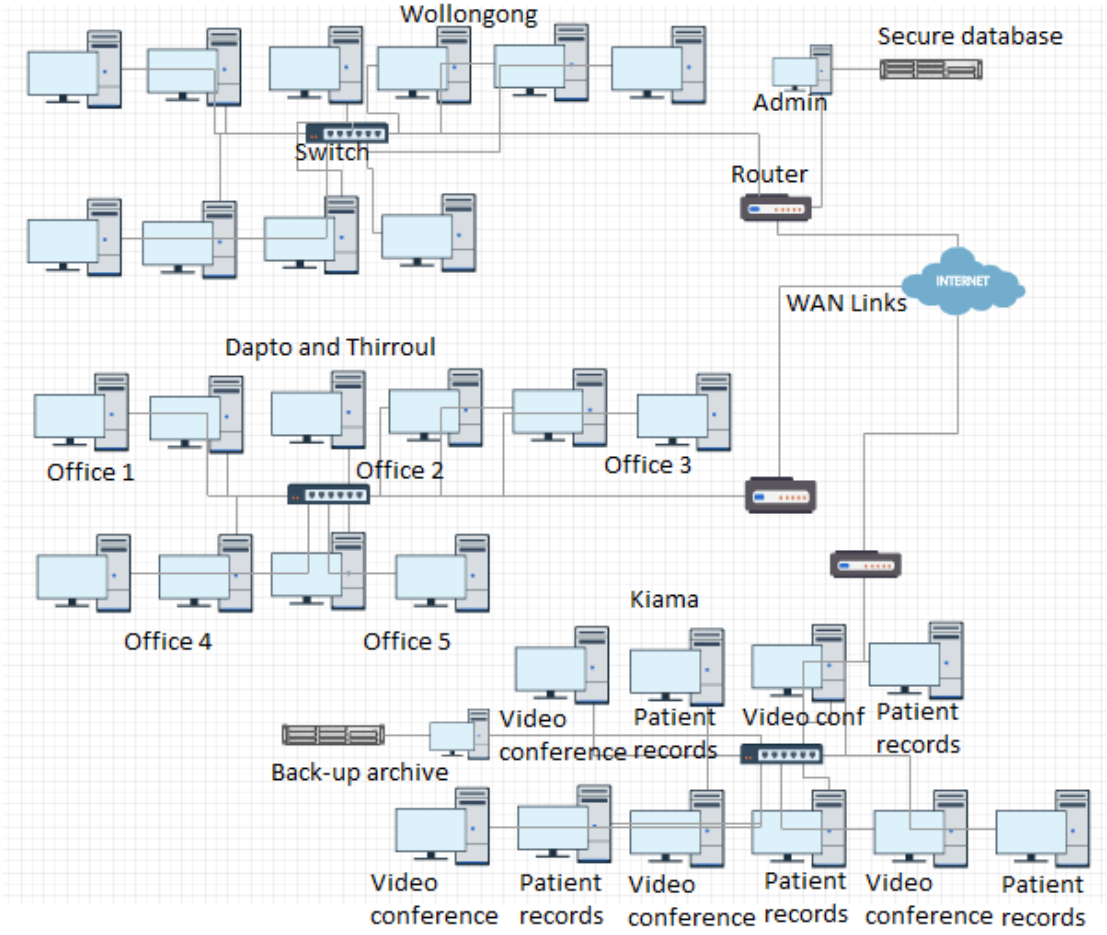


Figure 1: Requirements Map

2.3 Requirements Specifications:

The basic requirements in the below table are gathered from the GAMS case study. The location, status and priorities for each network and application are determined.

All the network, application and performance requirements are shown in detail in the tables Table 1 and Table 2.

ID	TYPE	DESCRIPTION	GATHERED/ DERIVED	LOCATIONS	STATUS	PRIORITY
1	Network	The network should be available for use 24/7.	Gathered from management	TBD	Info	TBD
2	Network	Four office locations – Wollongong, Thirroul, Dapto and Kiama	Gathered from management	Four locations in Illawarra	Info	TBD
3	Application - Secure Database	The database should securely keep patients' records. Availability must be 99.999%	Gathered from management	Wollongong	Core	TBD

4	Application - Video Conference	The video conference should be of HD quality. The service outage should be resolved in 10minutes	Gathered from management	All offices	Core	TBD
5	Application - Back up archiving	The backup archive should be updated every 5mins.	Gathered from management	See the map /TBD	core	TBD
6	Application - Staff use	The staff may access personal email, social media accounts or other web-based applications.	Gathered from management	All offices	Feature	TBD

Table 1: Requirements Specification

Application Set	Performance Requirements				
	Model	Capacity	Reliability	Delay	Priority
Secure Database	c-s	3.2Mb/s download; 1 Mb/s upload	99.999%	5 secs	1
Video conference	p-p	5.2 Mb/s download/upload	99.5%	100ms	2
Back-up archiving	d-c	100kb/s download/upload	99.7%	N/A	3
Staff use	c-s	3.2 Mb/s download; 1 Mb/s upload	N/A	N/A	4

Table 2: Performance Requirements for Application Set

2.4 Flow Analysis:

Flow Analysis is carried out to determine the direction of flows between the source and sinks, type of flow and performance requirements of individual and composite flows (McCabe 2007). It is a process that collect information about the possible set of values for different opinion in a computer. In general sense, flows in network simply refer to the moment in which information is transferred from one source to another sink or vice-versa. They are the result of merging different services such as requirement services in the network. In more essence flow analysis delivers an end-to-end perspective on requirements and their interactions. Here we have applied distributed computing flow model. Distributed system flow model is the most specialized software system in which components located on different networked computers communicate and coordinate their actions by passing messages. Generally, in this flow model messages are passing through RPC mechanism and message queuing mechanism between server to its computing devices.

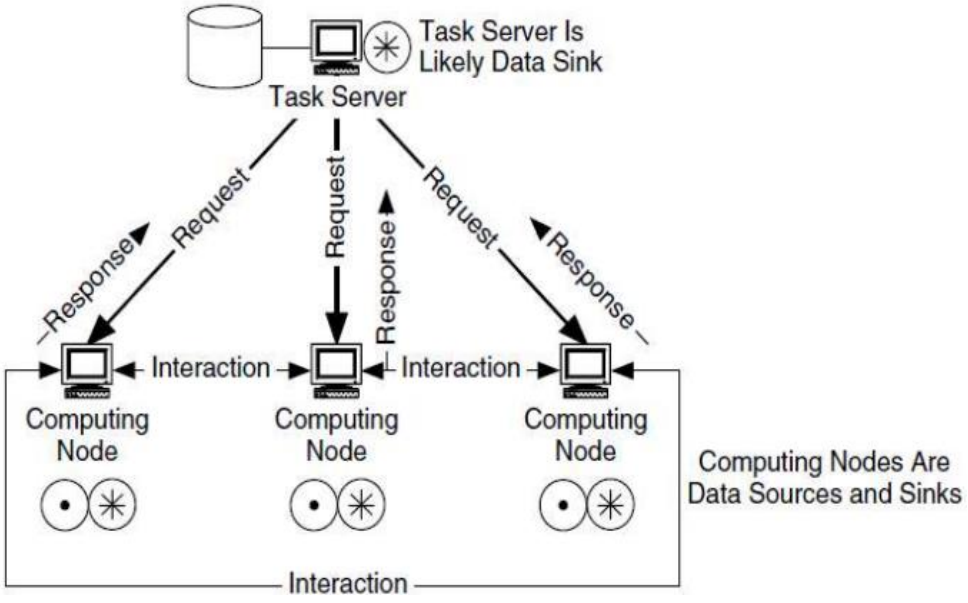


Figure2: Flow analysis model

3. Reference Architecture

A reference architecture is the representation of one entire network architecture which combines the functions of each individual component architecture with the internal and external relationships between them. Each component architecture functions are based on the mechanism, location and interaction within the component. After developing the component architecture for a network, all the components are combined, and their external relationship is determined based on their interaction between each component, trade-offs, dependencies and constraints (McCabe 2007).

3.1 Architectural model

3.2 Addressing and Routing Architecture justification

This component architecture deals with the connectivity of the network to the devices. Addressing mechanism is basically done at the physical and link layers. Routing is done at the physical, link and network layers. Addressing is responsible for assigning network addresses to the devices whereas routing is responsible for sending the data packets to the destination.

Addressing is done using the address identifier and its mask which is available from any IP address. For GAMS, we have two addresses i.e. global/external and local/internal addresses to establish a connection with WAN and LAN. Classful addressing is used to determine the class for the given IP address with the first octet of the address. Subnet masks are identified with the class. Following are the external and internal addresses with the subnet masks.

External range: 203.2.144.0/20

Subnet mask: 255.255.255.0

As there are four locations for GAMS, 4 subnets are needed for which we borrow 2 bits from the host portion of IP address.

Locations	IP Address	Network mask
Wollongong		
Network address	203.2.144.0	22
1st useable IP address	203.2.144.1	22
Last useable IP address	203.2.147.254	22
Broadcast address	203.2.147.255	22
Kiama		
Network address	203.2.148.0	22
1st useable IP address	203.2.148.1	22
Last useable IP address	203.2.151.254	22
Broadcast address	203.2.151.255	22
Dapto		
Network address	203.2.152.0	22
1st useable IP address	203.2.152.1	22
Last useable IP address	203.2.155.254	22
Broadcast address	203.2.155.255	22
Thirroul		
Network address	203.2.156.0	22
1st useable IP address	203.2.156.1	22
Last useable IP address	203.2.159.254	22
Broadcast address	203.2.159.255	22

Internal IP range: 10.0.0.0/8

Subnet mask: 255.0.0.0

We need to borrow 2 bits from the host to create subnets for LAN connections across 5 offices in each location.

Locations	IP Address	Network mask
Wollongong		
Network address	10.0.0.0	10
1st useable IP address	10.0.0.1	10

Last useable IP address	10.63.255.254	10
Broadcast address	10.63.255.255	10
Dapto		
Network address	10.64.0.0	10
1st useable IP address	10.64.0.1	10
Last useable IP address	10.127.255.254	10
Broadcast address	10.127.255.255	10
Thirroul		
Network address	10.128.0.0	10
1st useable IP address	10.128.0.1	10
Last useable IP address	10.191.255.254	10
Broadcast address	10.191.255.255	10
Kiama		
Network address	10.192.0.0	10
1st useable IP address	10.192.0.1	10
Last useable IP address	10.255.255.254	10
Broadcast address	10.255.255.255	10

From the Subnet calculation, we found that we can allocate the IP address for each office LAN ranging from 10.0.0.0 to 10.255.255.255 in four locations. Separate IP address for 5 offices across 4 locations are shown below:

- Five offices in Wollongong share the IP address ranging from 10.0.0.1 to 10.63.255.254
- Five offices in Dapto share the IP address ranging from 10.64.0.1 to 10.127.255.254
- Five offices in Thirroul share the IP address ranging from 10.128.0.1 to 10.191.255.254
- Five offices in Kiama share the IP address ranging from 10.192.0.1 to 10.255.255.254

It can be seen that each office can accommodate a maximum of 253 hosts.

3.3 Network management Architectural Justification

Network management is a set of functions that control, assign, plan, implement, and observe the working network. The network management is usually done at the end of the network architecture and design. In this report, it is important to consider the following during analysis process:

1. The protocol type to be applied.
2. High level asset management Implementation.
3. Reconfiguring the network at various times according to the needs.
4. The ability to monitor the system from one place or using only one device
5. Discovering the problems in the system before it affects any user or component
6. Requirements for dedicated channels that allows trusted boundaries while accessing the management functions.

Network management has a list of multiple layers which follows a top-down approach. Abstract components such as Business management at the top and lower concrete elements such as Network-element Management are at the bottom. The structure consists of the following:

- Business management: business related elements which include the cost, planning and designing and business agreements area managed.

- Service Management: Service providers side of management that includes managing Data storage, bandwidth, access and application.

- Network management: Managing all the devices in the network including networking devices.

- Element management: Management of similar network devices (e.g.) access routers.

- Network element management: Managing the individual network devices (e.g.) router, switch or hub.

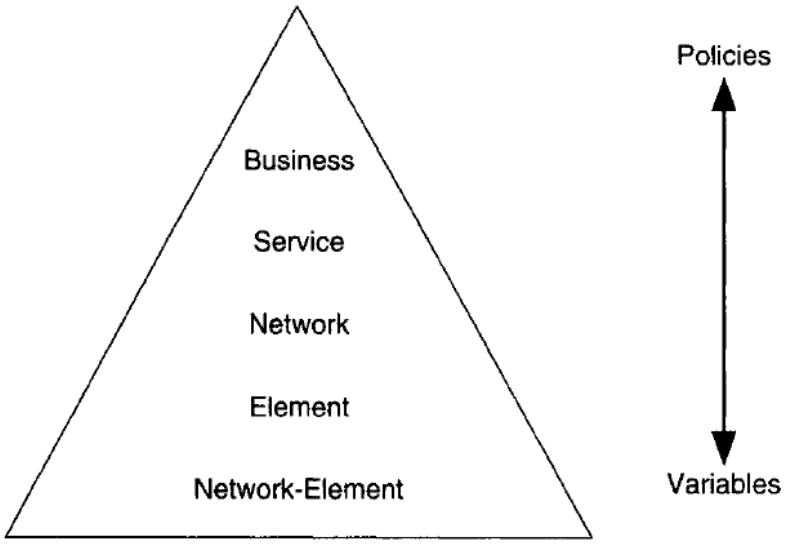


Figure 3: Network management architecture

The above figure shows the top end of the hierarchy is more of policy related functions such as cost and budgeting and towards the lower end network-Elements are variables elements which could be any networking devices such as routers, switches or hubs.

Network management mechanism and network protocols together constitutes network management functions. Simple network management protocol (SNMP) and common management information protocol (CIMP) are the two main protocol in network management. These protocol helps in recovering, altering and transporting the network management data to various networks. CIMP/CMOT is responsible for the collection and setting of parameters just like SNMP but SNMP is capable of performing other operations such as monitoring, instrumentation and configuration mechanism.

Configuration the network devices for operation and control by using parameters configuration mechanism allows access to devices directly, indirectly or remotely and also download this configuration information. Instrumentation involves the tools and utilities which are required to monitor the network's data. Instrumentation mechanism allows access to network management data. Monitoring involves collection of data on various characteristics such as end-to-end, per-link, and per-elements. The processed data is displayed and archived as subset of data.

Network work management is nothing but a set of functions that helps to monitor and maintain the network. It is important to know what to be monitored and managed and the relevant network management function to be implemented. Only by understanding this we can develop a proper network management architecture which meets the customer requirement.

3.4 Performance Architecture Justification

Performance of a network can be optimized by capacity, delay and availability. These optimization can be done for one or more traffic flows depending on the number of users, applications and devices (McCabe 2007).

According to (McCabe 2007) performance of the network has the following functions:

- Controlling traffic inputs to the network.
- Controlling network for delivery of specific services.
- Feedback from users and network management.

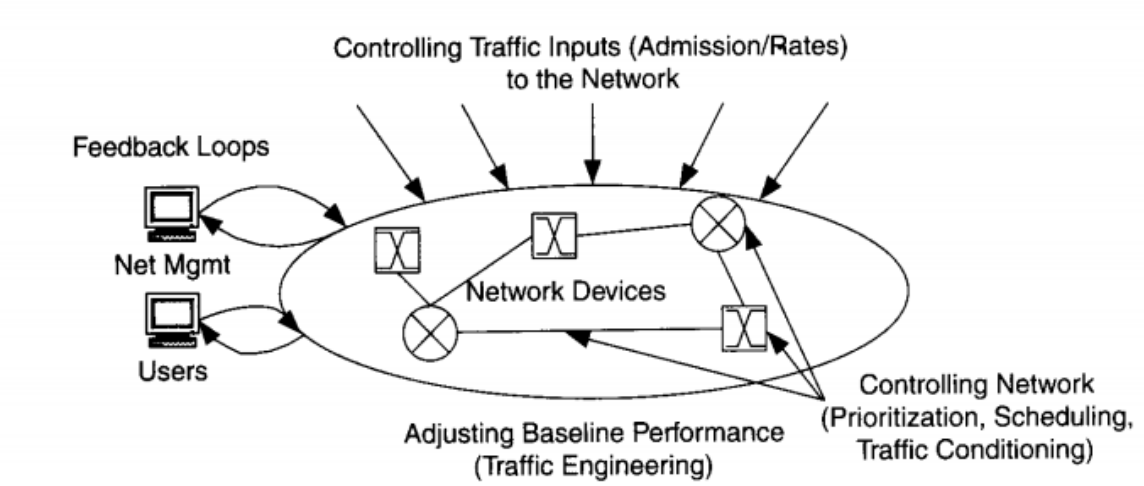


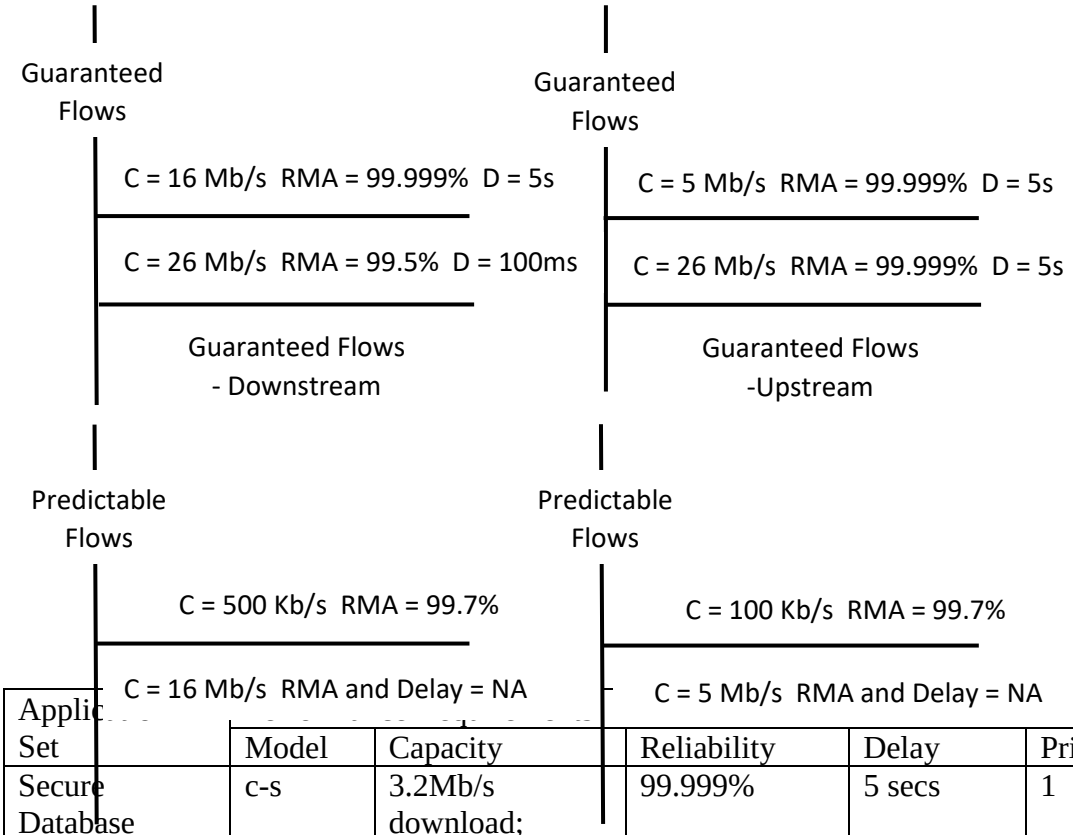
Figure 4: General Performance mechanism

Prioritization, traffic management, scheduling and queuing are the mechanisms of the performance in a network. Prioritization is one of the main requirements of the performance in GAMS. We prioritize the applications based on its importance and urgency.

The secure Database and video conference applications are guaranteed

Backup archiving and Staff web applications are predictable.

The flows are calculated for 5 offices in each location.



Application Set	Model	Capacity	Reliability	Delay	Priority
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Back-up archiving	d-c	100kb/s download/upload	99.7%	N/A	3
Staff web use	c-s	3.2 Mb/s download; 1 Mb/s upload	N/A	N/A	4

Predictable Flows - Downstream

Predictable Flows - Upstream

3.5 Security and Privacy Plan

To implement a high security and privacy plan, it is important to understand how each function is required for the particular network in order to develop each component architecture. Security strength for a network is based on the security mechanism implemented into the architecture to satisfy the requirements for that network. To develop a security architecture, two questions should be kept in mind

- What are we trying to solve or changing while incorporating security mechanism in the network?
- If the security mechanism sufficient for the network?

It is important to have threat analysis information which will help us decide the level of security for the network. It is not advisable to implement security mechanism every time when a new one is updated. It is important to keep in mind the following:

1.The resource need to be protected
2. The types of problems we are protecting against
3. The character of each problem.

The above list will provide the information for security and privacy plan for the network

Threat analysis

Helps to analyse which component needs protection and types of risk they should be guarded from. This information will give the efficacy and reason to implement the security and estimating the threats. Some of the assets include user hardware, software and data. While threats include data corruption, virus attacks, physical damage and authorization violation and denial. The threat analysis worksheet will help to determine the intensity of the threat and could be eradicated or managed while implementing the security and privacy

The threat analysis for GAMS (gecko allied health service) is tabulated below.

Effect/Likelihood	User Hardware	Servers	Devices	Services	Data	Software
Unauthorized Access	B/A	B/B	C/B	B/C	A/B	A/B
Unauthorized Disclosure	B/C	B/B	C/C	B/C	A/B	A/B
Theft	C/B	B/D	B/D	C/C	A/B	A/B
Corruption	B/A					
Viruses	B/B	B/B	B/B	B/C	D/D	B/B
Physical Damage	B/C	B/C	C/C	D/D	D/D	D/D

Effect:	/	**Likelihood:**
A: Destructive B: Disabling		A: Certain B: Likely
C: Disruptive D: No Impact		C: Unlikely D: Impossible

Figure: Threat Analysis Worksheet for Gecko Allied Health Services

Firewall

Firewall is used at each location for network security purpose, Wollongong and Kiama are the two locations which has database and backup database respectively. To enhance the security for both the database we have implement two more firewall that will protect the data against threats such as corruption, unauthorized access, attacks and controls the flow of traffic in and out of the network. The two firewalls for both the database is an internal firewall and four network firewalls are external firewall.

4. Design Document

The design simply refers to the adding of location, vendor, product and set-up all details to the architecture which makes the design process reproducible and well documented. The design document helps to connect all the components and make an overall layout of the network design.

4.1 Topological diagram

There are two types of models for topological diagram. The first one is LAN/MAN/WAN model which is simple and based on the topological separation of networks. The second one is Access/Distribution/Core model which focus on function instead of location. Both types of models represent the degree of hierarchy for the network architecture, as both are easy and convenient to apply in network design.

4.2 Design traceability

Design traceability is one of the significant parts for architecture and design process. The overall decisions about network design should be traceable on the basis of needed things, problem statements and architecture decisions because each design decision give direction to one or more architecture then plan to the needed thing and then map to the problem statements. Therefore, without design traceability, it is a bit difficult to know whether all the needed things, architecture and problem statements of the project are matched or not.

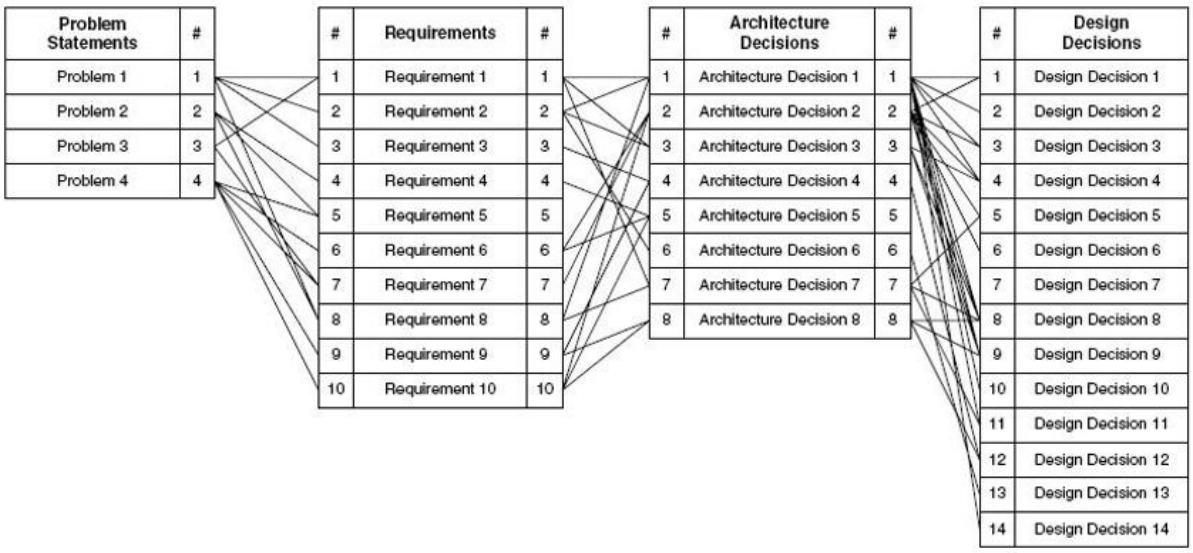

Figure: Design Traceability

Problem statements	• Video streaming • Duplicate network • Expensive
Requirements	• Give direct streaming to IP cloud
Architecture Decision	• AS routers and SID should be detached
Design Decision	• Install SDI and use it to establish IP converters

4.3 Design Metrics:

Design Metrics is an important part of the project, it can measure whether the project is successful. In the part of Requirements Specifications, where capacity, delay, and RMA are used as metrics to determine if the network meets the requirements. Design Metrics is similar to these requirements-related metrics, which are measures of performance and service delivery. Personalized design according to customer needs, the SLAs are used in this project to summarize important performance metrics that are associated with measures of network availability, reliability and performance requirements for service delivery.

A service level agreement (SLA) is a formal contract between a service provider and a customer. The service provider and the customer agree on the content of the service to be provided. It will describe the quality of service, the type of service, and the scope of the service， and make the service quantifiable through quality, availability, and responsibility. Moreover, the SLAS can also monitor services at runtime (zhang and song, 2010).

This project is to build a high-quality network for GAMS, which provides an all-day network services for the four locations (Wollongong, Kama, Dapto and Thirroul) located in Illawarra. In the case of an IP network connection, the service will include a secure database, video conferencing, backup archiving, employee usage, network maintenance, and more. In addition to describing the service types and functions described above, the SLA also includes the level of performance required for the service, such as the reliability of Secure Database is defined as 99.999%.

In general, the SLA guarantees the benefits of GMAS, and which supervises the project team to complete all the requirements of the agreement.

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