

PUBLIC SECTOR DATA CENTRE CONSOLIDATION (PSEDCC):
ENHANCING THE MANAGEMENT OF INFORMATION COMMUNICATION
TECHNOLOGY INFRASTRUCTURE IN NAMIBIA

A RESEARCH THESIS SUBMITTED IN PARTIAL FULFILMENT

OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE IN INFORMATION TECHNOLOGY

OF

THE UNIVERSITY OF NAMIBIA

BY

TOMAS KAMUKWEMA

200141147

MARCH 2016

Supervisor: Prof. Jameson Mbale

ABSTRACT

Inconsistencies in the design, security, storage, disaster controls, performance, management, budget allocations, and electricity consumption were some of the challenges faced by the Namibian Public Sector Data Centres. In addition, the above challenges had led many organizations to rationalize the way they design and manage their ICT infrastructure resources. In this study, the above challenges have led to the introduction of Public Sector Data Centre Consolidation (PSEDCC) architecture which is aimed at enhancing the design and management of Government ICT infrastructure resources in Namibia. Moreover, PSEDCC integrates all Government Data Centres into two sites only-one of which is a Disaster Recovery (DR) site for countering possible disasters in case they occur. This implies that all IT personnel, physical buildings, Information Systems and critical services such as email, storage, backup, and Internet would be centralized and comprehensively managed. As a result, the design and provisioning of ICT services would be standardized henceforth the technological gap between public institutions would be significantly narrowed and overall IT spending would be reduced. It further simplifies Data Centre administration and operation management through the use of Private Cloud and virtualization technologies.

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ACRONYMS

ACC	-	Anti-Corruption Commission
API	-	Application Programming Interface
AVG	-	Anti-Virus Guard
BMC	-	Baseboard Management Controller
CCTV	-	Closed-Circuit Television
CRAH	-	Computer Room Air-Handlers
DAS	-	Direct-Attached Storage
DBMS	-	Database Management System
DC	-	Data Centre
DCIM	-	Data Centre Infrastructure Management
DCIM	-	Data Centre Infrastructure Management
DR	-	Disaster Recovery
ECM	-	Enterprise Content Management
ECN	-	Electoral Commission of Namibia
GRN	-	Government of the Republic of Namibia
HCMS	-	Human Capital Management System
HP	-	Hewlett-Packard
HR	-	Human Resources
ICT	-	Information Communication Technology
IFMS	-	Integrated Financial Management System
IS	-	Information System
ISP	-	Internet Service Provider

IT	-	Information Technology
kW	-	kilo Watts
MAN	-	Metropolitan Area Network
MAWF	-	Ministry of Agriculture, Water and Forestry
MET	-	Ministry of Environment and Tourism
MFA	-	Ministry of Foreign Affairs
MFMR	-	Ministry of Fisheries and Marine Resources
MHA	-	Ministry of Home Affairs
MICT	-	Ministry of Information and Communication Technology
MLSW	-	Ministry of Labor and Social Welfare
MME	-	Ministry of Mines and Energy
MoE	-	Ministry of Education
MoF	-	Ministry of Finance
MoJ	-	Ministry of Justice
MRLGH	-	Ministry of Regional Local Government and Housing
MW	-	Mega Watts
NAS	-	Network Area Storage
NCAR	-	National Center for Atmospheric Research
NPC	-	National Planning Commission
OAG	-	Office of the Auditor General
OMA	-	Offices, Ministries and Agencies
OPM	-	Office of the Prime Minister
OS	-	Operating System
PSEDCC	-	Public Sector Data Centre Consolidation

PUE	-	Power Usage Effectiveness
ROI	-	Return of Investment
ROT	-	Returns of Investment
SAN	-	Storage Area Network
SQL	-	Structured Query Language
SRF	-	Service Request Filter
TN	-	Telecom Namibia
U. S	-	United States
UPS	-	Uninterrupted Power Supply
VM	-	Virtual Machine
WACS	-	Western Africa Cable System

ACKNOWLEDGEMENTS

My sincere gratitude goes to the Department of Computer Science at the University of Namibia for granting me the opportunity to study at this great institution of learning. I am specifically grateful to my mentor, Prof. Jameson Mbale for his dedication, guidance and encouragement during my time at the University of Namibia. He is the man who made this research possible and interesting from the start to the finishing line.

Words alone will not be enough to express my sincere thanks to my fellow students in this program. You are the reason why this research work is strong. You have been there every step of the way and even when I wanted to weaver you never gave up on me, you kept encouraging and supporting me from the proposal writing all the way to the data analysis and report writing. I never saw an exceptional class like this in my life. It gave Prof. Jameson Mbale some headache at times but on the other hand he enjoyed working with this extra-ordinary class too.

Without the support of IT employees at various Governmental institutions, this study would not be possible. I thank them for providing me with the relevant data and directing me to the right respondents of the questions. Keep up the good work ladies and gentlemen; you understand the importance attached to an academic research. You provided me with some important and critical information. I would be indebted if I forget to thank the unyielding support of my family and friends for understanding the importance of this project and the difference it can bring to our society. I sacrificed the

time that I could have spent with you but you never questioned me because you knew how difficult and time consuming this project is.

Above all, my great thanks go to the Almighty God for guiding and protecting me every step of my life journey. You gave me the courage and strength to complete another important project. I know and believe that you will keep on paving my way for greater things in the future.

DEDICATIONS

Firstly, I dedicate this work to my grandmother who passed away while I was working on this project. She was an inspiration of my family and dedicated her little resources to the wellbeing of the family. She was not educated but believed that “Education is the greatest equalizer”. Secondly, I dedicate this piece of work to my biological mother, the rock of my family. She never believed in anything but education only.

DECLARATION

I, Tomas Kamukwema, hereby declare that this study “**Public Sector Data Centre Consolidation (PSEDCC): Enhancing the Management of ICT Infrastructure in Namibia**” is a true reflection of my own research, and that this work, or part thereof has not been submitted for a degree in any other institution of higher education.

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1. INTRODUCTION

This chapter introduces the study by providing an overview of the background, statement of the problem, research questions, significance and limitations of the study.

The chapter concludes with definitions of terms and Thesis outline.

1.1 Background

The advent of Data Centre Consolidation has brought efficiency both in the design and management of Information Communication Technology (ICT) infrastructure. It has also significantly reduced Data Centre Information Technology (IT) costs. According to the GAO Report (2013), the American Federal Government has witnessed an increasing demand for IT that has led to a dramatic rise in the number of its Data Centres. The report added that operating such a large number of Data Centres with heterogeneous devices was inefficient and expensive. However, the introduction of Data Centre consolidation in the Namibian Public Sector was inevitable. In addition, it represented one of the available solutions to most Data Centres challenges in the areas of design and management of ICT infrastructure. Hence this study introduced Public Sector Data Centre Consolidation (PSEDCC).

Computer Economics Report (2007) defined Data Centre Consolidation as a physical combination of two or more Data Centres into a single facility with the goal of reducing costs or improving performance. In addition, the report explained that consolidation may simply be a physical relocation of moving computer hardware and support personnel to a single location. Furthermore, the report indicated that it might be a more

aggressive effort with other types of consolidation which include servers, applications, databases, storage, networks and operating systems. Based on the above definition and the potential benefits that consolidation would bring, PSEDCC was exclusively customised for the Namibian Public Sector to enhance the design and management of ICT infrastructure. As a result, Data Centre performance would be improved and operational costs would be reduced.

Marston et al. (2011) stated that as computing becomes more pervasive within the organisation, the increasing complexity of managing the whole Data Centre infrastructure of disparate information architecture and distributed data has made computing more expensive than ever before. In support of their observation, it is also true that the increasing complexity of managing Data Centre infrastructures in the Namibia Public Sector has made daily operations more expensive to the Government. Subsequently, some Namibian Public Sector Data Centres have been in a state of disarray which is attributed to poor design standards, low performance and inefficient management of ICT infrastructure resources.

Over the past few years, leading companies had begun revising the way they design, maintain, and monitor their Data Centres, from the physical building all the way down to the hardware doing the computation (Mone, 2012). Similar to other building types, Data Centre infrastructures are designed to meet local, state and federal building codes, as well as design standards and guidelines set forth by industry organizations (Lui, 2010). Therefore, the Namibian Government needed to revise the way its Data Centre infrastructure was designed in order to meet building codes, standards and guidelines

set forth by industry organizations. Maintenance and monitoring techniques also needed to be upgraded and updated in order to optimize Data Centre infrastructure operational management.

Lim (2009) stated that securing the Data Centre against vulnerabilities and attacks had grown in importance in the past several years. However, he reported that many Data Centre modernisation initiatives had missed on the opportunity to improve security and reliability while pursuing cost-reducing IT objectives. In this view, it is true that securing a Data Centre against any potential threat is an important precaution required in the organization. On the other hand, current Data Centre practices in the Namibian Public Sector had missed the opportunity to improve security and reliability without increasing IT spending. This implies that there was no proper initiative in the public sector that could improve Data Centre security, consistency and reduce IT expenditure simultaneously.

Although Data Centre Consolidation initiative is a step in the right direction to stop infrastructure sprawl, the public sector faced a number of challenges preventing the initiative from being the game changing program it is intended to be (Nacke, 2011). According to Nacke (2011), these challenges need to be addressed or discussed before consolidation can take place. Based on the above arguments, the emergence of PSEDCC represents a fundamental change in the way IT services are designed and managed. However, PSEDCC processes require extensive and thorough planning to ensure that consolidation best practices such as integrated and standardized security,

design standards, power utilization, cooling infrastructures, cabling techniques and management tools are taken into account before implementation.

Chandra and Prasad (2010) stated that one of the biggest challenges that Data Centres face today is increased demand in strategic operations management. They further established that adopting and implementing the best practices in Data Centres is essential to attaining world-class performance. Similarly, the Namibian Public Sector Data Centres faced the same challenges of increased demand in critical operational areas. However, in order to reach outstanding performances these challenges needed to be addressed through adopting best practices as mentioned in the above paragraph. Hence, there was a need to conduct a research on how PSEDCC could enhance the design and management of Government ICT infrastructure resources.

1.2 Statement of the problem

According to the Namibian Public Service e-Government Strategic Action Plan Report (2012), poor Data Centre infrastructure design and inefficient management of ICT resources are some of the biggest challenges faced by the Namibian Public Sector. This observation was supported by Computer Economics Report (2007) which stated that many organizations had multiple Data Centres, even though a smaller number of Data Centres would be sufficient. Correspondingly, the Namibian Public Sector had fragmented Data Centres in O/M/As, even though one unified Data Centre shared by all institutions would be enough for the whole Government. In addition, there were many applications across the public sector with similar functions and supported by

various IT vendors. As a result, there was a duplication of some resources, a significant increase in energy consumption, floor utilization, storage, software licences, manpower and operational costs.

Hassell (2012) stated that Data Centre Managers have been challenged to maintain or increase availability, utilization, and efficiency in the face of rising costs and demands. He further stated that despite the large investments in today’s Data Centres, significant inefficiencies still exist. Data Centre Managers in the Namibian Public Sector have also been under pressure to maintain or increase availability, utilization and efficiency at their respective O/M/As. On the other hand, some IT departments were not allocated adequate funds by their institutions to invest in their Data Centres infrastructure development projects resulting in the ineffective delivery of services.

The best practices in Data Centre design are constantly evolving (Wilson, 2012). On the contrary, best practices in some Namibian Public Sector Data Centres are not constantly changing in line with modern building codes and design standards. For instance, some of the O/M/As infrastructures were not purposely-designed hence they lack the basic characteristics of an ordinary Data Centre. In addition, they are vulnerable to security attacks, have inadequate floor space and are ill-equipped for expansion. Furthermore, some of this Data Centre infrastructure was occupied by hardware devices which could not withstand certain temperature levels.

In view of the above, there is a need to consolidate fragmented Data Centre location by O/M/As in Namibia. Therefore, this study assessed the disparate IT facilities in the

Namibian Public Sector and further presented the PSEDCC architecture as a solution to overcome the current Data Centre conditions. This study further provided a list of consolidation best practices that could be followed when implementing PSEDCC.

1.3 Research questions

1.3.1 How does consolidation of Data Centres enhance the management of Government ICT infrastructure in Namibia?

1.3.1.1 What is the current state of Data Centres in the Namibian Public Sector?

1.3.1.2 What can be done to improve Data Centre design in the Namibian Public Sector?

1.3.1.3 What are the best practices of Data Centre consolidation and management of ICT resources?

1.4 Significance of the study

The study would greatly assist the Namibian Government in reviewing its current Data Centre operations by incorporating consolidation techniques in its design models. The consolidation process could reduce the cost of Data Centre hardware, software and operations. Furthermore, it would improve performance and the overall service delivery. On the other hand, it would increase the overall Data Centre security measures of the Government and shift IT investment to more efficient computing platforms and technologies. The study would contribute to the literature on Data Centre Consolidation, which can be useful to other researchers who may have interest in exploring on the same topic.

1.5 Limitation of the study

The topic of Data Centre consolidation is relatively new, and there is a resultant lack of discussion in the mainstream of IT literature (Chandra & Prasad, 2010). Therefore, it was difficult for the researcher to obtain adequate information on the ICT literature in relation to Data Centre consolidation in the Namibian context. Furthermore, finding the right people who possess the knowledge on the subject matter was also a limitation for this study. The response rate was also one of the limitations because potential respondents could not be reached easily while some felt that they do not possess the right knowledge in the subject matter. As a result, they delegated their subordinates to complete the questionnaire on their behalf.

1.6 Research methodology

The study used a mixed-method research approach, where both qualitative and quantitative methods were used. Quantitatively, a structured questionnaire and self-observation checklist were used to explore the current state of Data Centre best practices in the Namibian Public Sector. Qualitatively, an interview schedule was used to find in-depth information on the operations, designs and management of Data Centre ICT infrastructure in the public sector.

1.7 Definition of terms

The following is a list of the definitions of terms which are most frequently used in the study.

Private Cloud: Private Cloud is a term used to refer to a computing architecture providing hosted services on private networks (Khalid & Shahbaz, 2013)

Power Usage Effectiveness (PUE): PUE is the total energy used to operate a Data Centre divided by the amount that is dedicated to actual computing (Mone, 2012)

Virtualization: Virtualization is a technique that allows one physical server to run multiple virtual machines (VMs), whereby each VM can operate different applications at the same time (Shuja et al., 2012).

Cloud Computing: Cloud Computing can be defined as an IT service model, which delivers a set of convenient, on-demand, and configurable computing services and resources to clients over a network in a self-service fashion, independent of devices and location and with minimal internal IT effort and service provider interaction (Dutta, Alex & Choudhary, 2013)

Data Centre: Data Centre is a physical location where computer servers are located and maintained or operated by full time computer operators and network support personnel (Computer Economics Report, 2007).

Data Centre Consolidation: Data Centre Consolidation is the physical combination of two or more Data Centres into a single facility with the goal of reducing costs or improving performance (Computer Economics Report, 2014).

1.8 Outline of the thesis

The thesis is organized into five chapters as follows:

Chapter 1 introduces Public Sector Data Centre Consolidation (PSEDCC) based on statement of the problem, research questions, significance and limitations of the study.

Chapter 2 addresses the literature review carried out for the purpose of the study. It includes the design, practices and management of Data Centres.

Chapter 3 discusses the research methodologies used in the study.

Chapter 4 presents the findings of the data collected through the distribution of questionnaires and semi-structured interviews. The findings are presented in the form of graphs, tables and pie charts.

Chapter 5 presents and discusses the components of the Public Sector Data Centre Consolidation (PSEDCC) architecture that addresses the problem statement.

Chapter 6 analyses and discusses the findings of the data analysis in relation to the research questions posed in the study. Furthermore, it presents the conclusion and recommendation for the research.

Chapter 7 Presents recommendations based on the research findings. It further presented the conclusion of the study.

2. LITERATURE REVIEW

This section presents the advanced works which were carried out by different role players when it comes to Data Centre consolidation. It has also provided an overview on the general states of Data Centres, common methodologies applied by private and public organizations, challenges and best practices which improve the design and management of ICT infrastructure resources.

2.1 Introduction

Data Centre can be defined as a building block of any IT business organisation, providing capabilities of centralised storage, backups, management, networking and dissemination of data in which the mechanical, lighting, electrical and computing systems are designed for maximum energy efficiency and minimum environmental impact (Uddin & Rahman, 2010). In agreement with the above, in this study Data Centre was defined in the same terms as those presented above by Uddin and Rahman.

McNamara (2009) stated that Data Centre has become the heart and soul of many organizations. He added that it provides far more than just the technology aspect of a business. However, he acknowledged that the average Data Centre has grown extremely complex. As a result, he said new technologies, fast growth, acquisitions, the online data explosion, and increased security concerns have driven complexity up and utilization rates down. The author further indicated that in recent years there have been an increasing number of threats like attacks, power outages, and natural disasters that have exacerbated the challenges facing Data Centres. Based on the above analysis,

the author observed that the Namibian Public Sector was also reliant on the operations of Data Centres in order to provide quality services to the citizens. However, like other organizations it was never spared from the challenges such as power outages, security concerns, handling of massive data and possible disaster threats. As a result, a study was conducted to assess the states of public sector Data Centres in Namibia and to find a reliable solution to the challenges facing these fragmented facilities with diverse devices.

In this study, the literature was reviewed under three areas, namely:

- Current states of Data Centre infrastructures
- Different Data Centre consolidation approaches and challenges
- Data Centre consolidation best practices in terms of: design and management of ICT infrastructure.

Reviews for each of the above mentioned areas of the literature are explained in the following corresponding sections:

2.2 Current states of Data Centre infrastructures

Many organizations had multiple Data Centres, even though a smaller number would be sufficient (Computer Economics Report, 2007). In addition, the report elaborated that the costs for maintaining those additional Data Centres could be significant because each must be staffed with operational staff and heterogeneous devices. Furthermore, it established that many organizations had multiple Data Centres that exist, not for reasons of business continuity, but because efforts had not been taken to

rationalize their numbers. In support of the report, the researcher observed that most O/M/As in the Namibian Public Sector had two or more Data Centres that were redundant and operating autonomously. In addition, there were many applications across the public sector, many with similar functions and supported by various IT vendors. As a result, there was a duplication of resources, a significant increase in energy consumption, floor utilization, storage, software licences, manpower and operational costs.

Lim (2009) stated that securing the Data Centre against vulnerabilities and attacks had grown in importance in the past several years. However, he said many Data Centre modernisation initiatives had missed on the opportunity to improve security and reliability while pursuing cost-reducing IT objectives. Varcoe (2012) added that security ranks highly on any Data Centre Manager's list of priorities especially when considering the devastating impact that downtime or data theft can have on a business. In support of the above authors, the researcher established that there were security challenges due to thousands of diverse ICT resources such as servers, switches, routers, networks, storage devices and applications hosted at various Government Data Centres in Namibia. As a result, it was difficult for IT Managers and Administrators to manage and secure Data Centres with heterogeneous devices. In addition, the complexity at various Data Centres has led to slow internet connections, downtime and loss of critical data. In other words, the current security situation has negatively affected resources availability at various O/M/As.

According to the Public CIO Special Report (2012), Federal Data Centres multiplied from four hundred and thirty four (432) to two thousand and ninety four (2 094) between 1998 and 2010 however they were using only twenty seven (27) percent of the computing power, wasting money on unused IT infrastructure. As a result, the Report indicated that the Federal CIO acknowledged the inefficiency of this Data Centre sprawl. In support of the above Report, Computer Economics Report (2007) stated that hardware assets such as servers were most likely underutilized. Correspondingly, Uddin et al. (2012) established that in an average server environment, 30% of these servers are “dead” only consuming energy without being properly utilized. Similarly, the researcher recognized that the Namibian Government was spending millions of dollars in Data Centre acquisitions, yet some of those purchased resources were not being used to their full capacity. Furthermore, O/M/As did not know how many or where exactly their hardware and software resources were deployed. In addition, he observed that some resources and their impact on Data Centres were not properly accounted for. Moreover, some IT Managers did not know how much power their Data Centres consume every month or how many devices they were hosting and supporting. Hence there was a need to optimize the underutilization of hardware and software resources through PSEDCC.

According to McNamara (2009) outdated approaches have left a gap between the management of data and the management of storage. Further, he stated that this has resulted in inefficient operations, with considerable duplication of effort and with frequent interruptions to the activities of highly interdependent administrative groups. In favour of the author, outdated methods in the operations of Data Centres have also

left a gap which resulted in the inefficient management of ICT resources and regular disturbances to critical services in the Namibian Public Sector. Therefore, introducing PSEDCC would consider replacing outdated methods with new and efficient methods. As result, frequent interruptions would decrease.

Nacke (2012) stated that most public sector Data Centres collect, store and manipulate data. Further, he stated that these critical facilities were designed to be flexible so they can grow based on capacity and availability needs, customer demands and Return on Investment (ROI). On the contrary, some Data Centres in the Namibian Public Sector were not designed to be flexible or scalable. Hence they could not grow based on capacity and availability neither on customer demands nor on ROI. Based on the above, PSEDCC would consider a flexible and scalable designed facility.

On the other hand, Nacke (2012) described decision-making process within the public sector as one of the challenges that hinder most Governments from stopping Data Centre infrastructure sprawl. He argued that this is because the decision-making process can be complicated and lengthy. He further added that in many agencies it was not unusual to have up to fifteen (15) or twenty (20) people signing off on a decision. In support of the author, the researcher observed that the situation is exactly the same in Namibia where the decision-making process on anything related to ICT management and operation projects is lengthy and complicated. In other words, it was difficult to participants in the Government decision-making process. As a result, time and game changing opportunities that could transform Data Centre management and operations would be frequently missed.

Historically, Data Centres and Storage Area Networks (SANs) have often been constructed without full consideration of the implications of frequent capacity expansions and the resultant moves, additions, and changes that occur over their lifecycle (Struhara, 2006). He further stated that some systems may be installed and cabled by a manufacturer's own technicians, while these crews were likely to be competent with their own systems, the Data Centre may contain a mix of disparate technologies. He further warned that using such practices would inevitably lead to cabling system without the manageability critical for rapid maintenance, upgrades and the introduction of new products and technologies. In support of Struhara, some public sector Data Centres in Namibia had been constructed without full consideration of future cabling changes. As a result, Data Centre expansions and changes to accommodate new technologies were improbable and costly.

Many Data Centre initiatives had been driven by the ever-growing demand for server and storage capacity, and the resulting escalation of hardware costs and operating expenses for electricity, floor space, and administrative labour (Lim, 2009). Similarly, PSEDCC initiative was driven by the current deteriorating states of public sector Data Centres in Namibia which resulted in the escalation of above said elements, including administrative complications, application redundancies, security and cabling issues. In short, the initiative was aimed at solving the current states of public sector Data Centres in relation to design and management of ICT resources.

2.3 Different Data Centre consolidation approaches and challenges

Computer Economics Report (2007) established that the costs for maintaining additional data centres can be significant. Each must be staffed with computer operators, production control personnel, system administrators, facilities engineers, and other operational specialists. In addition, hardware assets are most likely underutilized, as excess capacity must be maintained to handle spikes in demand for each individual data center. Some level of management personnel duplication probably occurs, as data centres may be in different time zones, or different parts of the world. The report further stated that additional software licenses need to be maintained and many other costs can be found to be duplicative among the various data centres. As a result of the above challenges, some international organizations and Governments chose to cut the physical and logical layout of their infrastructure through consolidation. The list of such organizations and Governments and their consolidation approaches are enumerated below as follows:

Hewlett Packard (HP) has cut its eighty-five (85) global Data Centres down to six (6), three (3) of which would be mirrored Disaster Recovery sites. HP expected this physical move to save the company one (1) billion dollars annually. Although the Namibian Public Sector does not have as many Data Centres as HP, the ultimate aim of PSEDCC was also to cut its multiple physical Data Centres to two (2), one (1) of which would be a mirrored Disaster Recovery site.

International Business Machines (IBM) has consolidated three thousand nine hundred (3900) servers into thirty (30) virtualised mainframes running under Linux. The

company anticipated an eighty percent (80%) reduction in energy usage while significantly shrinking its current eight (8) million square feet of Data Centre space. On the other hand, Microsoft was well along in its Data Centre consolidation efforts. The company produced a saving of twenty-three million two hundred thousand dollars (\$23.2 million) – a forty percent (40%) cut in its pre-consolidation spending levels. Similarly, PSEDCC is expected to reduce the current energy consumption by at least fifty percent (50%) through virtualization of some servers.

Williams-Sonoma, Inc. has moved one hundred (100) stand- alone servers into five (5) IBM Regatta Unix servers. This effort eliminated the need to add fifty (50) more stand-alone servers to handle increased processing demands. Similarly, Thibodeau (2007) stated that West Virginia is one of the states that had embraced Data Centre and server consolidation in its Government IT operations. He further said that it had replaced eight five (85) e-mail servers that run a half-dozen different applications with four (4) Exchange-based systems- two (2) for production and two (2) for backup. Furthermore, Thibodeau revealed that Michigan had closed twenty-one (21) Data Centres over two (2) years in its consolidation effort. He established that such a move had saved the state nine million and five hundred thousand dollars (\$9.5 million) thus far and its officials expected the savings to amount to as much as twenty million dollars (\$20 million) over five (5) years.

In addition, he documented that the state of Michigan had avoided seven million and three hundred thousand dollars (\$7.3 million) in capital costs that it would have incurred to upgrade its Data Centres and computer rooms. As a result, it had regained

more than twenty-nine thousand (29 000 f²) square feet of floor space. The Namibian Public Sector had multiple physical Data Centres and e-mail servers that run different applications in various O/M/As. However, this practice could be changed by following in the consolidation paths of West Virginia and Michigan states as stated above.

According to Wood (2012), the Canadian Government had created a centralized IT agency, Shared Services Canada. The agency comprised of personnel taken from forty-four (44) Federal IT Departments. It had reduced the number of Government-run Data Centres from three hundred (300) to just twenty (20) and combined about hundred (100) email systems into one (1), while serving as the sole IT provider for the Federal Government. The Canadian Government had saved four billion dollars (\$4 billion) out of an eighty billion dollars (\$80 billion) program budget by following such a path. Similarly, the Namibian Public Sector could also reduce the number of its Data Centres by incorporating PSEDCC. Furthermore, it could combine its multiple email systems into one. In this way, the Namibia public sector could save millions of dollars to be used for other important developmental projects such as building new schools and hospitals.

Wood further described that the United States (U.S.) Government consolidation efforts had targeted a large set of equipment. He added that the U.S. Federal Government had more than three thousand (3, 000) Data Centres that ranged in size from a couple of computers sitting in a closet to a one hundred and ninety-five thousand (195, 000 f²)-square-foot departments. He further stated that the U.S. Data Centre consolidation initiative, launched in early 2010 by the Office of Management and Budget had closed

more than seven hundred and forty (740) Data Centres by the end of 2012. In addition, some estimates put their Data Centre energy savings at five billion dollars (\$5 000 000 000). In view of the above, energy savings would be one (1) of the benefits that could be achieved through the deployment of PSEDCC. For instance, the consumption of power by servers and other devices in all public sector Data Centres could be reduced significantly through PSEDCC implementation initiative.

On the other hand, Brandel (2009) said the state of Indiana had consolidated seven (7) Data Centres into one, plus a second for disaster recovery, while also reducing server count by one-third through virtualization. In addition, he stated that since many of the state's Personal Computers (PCs) were older models, it also upgraded thirty thousand (30 000) desktops to Dell machines using Intel Corp.'s vPro chip. He further found that the initiative resulted in four hundred thousand dollars (\$ 400 000) in savings from a reduction in electricity use and an increase in productivity. Brandel argued that vPro enables IT to manage PCs over the network, eliminating the need to travel to the 800 sites the office serves. Similarly, PSEDCC would need to upgrade older public desktop computers using vPro. As a result, the need for IT support staff to travel to remote sites in order to fix a network related problem would be completely eliminated and money in travel allowances can be saved.

In general, consolidation efforts in most organizations were aimed at cutting operating costs and improving quality of service, which they did by reducing duplication and increasing hardware optimization. Efforts to eliminate acres of superfluous Data

Centres and email networks are moved towards embracing industry trends, such as server virtualization and cloud computing. Consolidation plans also point to reduced energy consumption and real estate costs. On the other hand, PSEDCC could also be aimed at enhancing the quality of service in the Namibian Public Sector.

2.4 Data Centre consolidation best practices

Chu (2003) described the following best practices that organizations should consider when adopting application consolidation:

- 2.4.1 Choose mainstream operating systems and databases- consolidate around operating systems and databases that would run as large percentage of your application set as possible.
- 2.4.2 Use portable APIs and generic SQL- ANSI C with POSIX, Java, web scripting languages, perl and .Net Framework languages all provide portability insurance.
- 2.4.3 Modularize applications- web applications and other three-tier designs cost less and are easier to consolidate than monolithic designs because parts of the application can be consolidated without affecting other application tiers.
- 2.4.4 Use single sign-on and distributed directories- avoid build-in application directories and turn to single sign-on or directory synchronization tools to make application consolidation easier without disrupting existing user names or passwords.

- 2.4.5 Design for high availability- running multiple mission-critical applications on a single server or server partition means that uptime is much more critical. Well thought-out failover systems and disaster recovery plans are an absolute must.
- 2.4.6 Pursue vertical (scale up) and horizontal (scale out) scalability- Horizontal scaling (through the use of multi-machine clustering) is much cheaper in terms of initial investment and provides the best price/performance ratio for consolidation, but it is also much more restrictive in the types of application supported.
- 2.4.7 Delegate administrative domains- this is the biggest technical challenge in application consolidation and a major reason for server sprawl in the first place. Many packaged applications do not support the concept of administrative domains or delegation. Therefore, server partition or system virtualization techniques may be the only viable approach to properly partition some applications. Similarly, PSEDCC would follow the above listed application consolidation best practices that were defined by Chu. Application consolidation would eventually reduce the number of similar applications in the public sector and eliminate repetitions and inconsistency associated with Namibian Public Sector Data centres.

Furthermore, Filani et al. (2008) proposed that to overcome the constraint of increasing cost of power and cooling in Data Centres there were three choices available which were: expand power and cooling capacity, build new Data Centres,

or employ a power management solution that maximized the usage of existing capacity.

Nair (2009) proposed the approach to fighting rapidly growing power consumption as simple: subtract machines and disks from the power equation by using storage more efficiently. He further stated that this strategy had many corollary benefits because it lowered complexity and costs. In addition, it improved network efficiency and performance through consolidation of servers and usage of higher-capacity drives. It had also improved migration of data to more efficient storage and backup. Similarly, this approach could also be useful to the Namibian Public Sector on its consolidation process.

Consoli (2011) proposed a solution of optimization through Data Centre Infrastructure Management (DCIM) tools. He said DCIM was an approach to monitoring that effectively integrates information from tools that have traditionally been “siloesd” with either IT or facilities. He further stated that while many companies had a series of disparate management solutions in place, they did not gather enough data and consolidated it into one place with a single consolidated view and translated it all into meaningful information for informed decision making. He concluded that successful optimization through DCIM yielded measurable productivity, equipment optimization and energy cost mitigation.

Dasgupta et al. (2011) proposed the use of the Emerald Workload Management tool developed at IBM, India, which focused on minimizing the overall cost of the Data Centre, while meeting the required performance guarantees. The authors further stated that the costs could include both the ownership as well as the operational costs. In addition, they reviewed on how virtualization and energy management technologies could help in consolidation and reduce the infrastructure and operating costs of a Data Centre.

Lui (2010) proposed that typically, a Data Centre is served by dedicated mechanical, electrical and fire protection infrastructure that was independent from the systems that served other portions of the building. He further stated that similar to other building types, Data Centre infrastructures were designed to meet local, state and federal building codes, as well as design standards and guidelines set forth by industry organizations. In addition, he said Data Centre design was often required to meet certain levels of redundancy, reliability, maintainability, fault tolerance, scalability and flexibility. Similarly, PSEDCC would meet the above characteristics by establishing a consortium of O/M/As devoted to maximising uptime for the consolidated Data Centre.

McNamara (2009) proposed an integrated data management approach which would simplify data management that encompasses both the management of storage devices and the data that resides on those devices. He further stated that using this approach, storage administrators would operate more efficiently and with minimal interruptions by automating routine storage management processes

and by linking those processes to specific application requirements. Similarly, PSEDCC would incorporate integrated data management approach so that IT Managers and Administrator would operate efficiently and with easy.

According to Madaffari (2013), the University of Colorado and National Center for Atmospheric Research (NCAR) needed a Data Centre to deploy the Janus supercomputer on its Boulder campus. For this project, Dell, Critical Facilities Technology and Data Centre Delivered were tapped to co-design and produce a custom-build Data Centre. The author stated that the main benefit of the co-design process was that it allowed the use of a holistic design approach that matched the facility to the system. In addition, the author said that instead of addressing each element in the facility separately and then maximizing each component based on their individual budget, all resources were pooled and the approach focused on providing the most efficient solution while staying within the total budgeted cost.

Madaffari (2013) further stated that the University facility design incorporated an IT load of just over one (1) megawatt (MW) at over 32 kilowatt (kW)/rack density for the compute cabinets. Further, the design target PUE for the facility was 1.2, and the measured PUE for the first year of operation was 1.14. Designed as a standalone structure, the Data Centre could be expanded in the future via additional Data Centre modules. In support of the above author, PSEDCC had also focused on providing the most efficient solution while staying within the limited budgeted resources. As a result, the PUE would also be significantly minimized as compared to before although there were no PUE records available.

Hirst (2013) stated that a major part of any efficient design was the Data Centre itself. Further, the author warned that reducing the heat in the Data Centre was not just about adding cooling, it needed to start with the choice of the equipment in the racks, how the environment was managed and then what cooling was appropriate. The author further stated that removing heat effectively was all about the design of the cooling systems. He mentioned the design of the Data Centre by choosing the right technology and effective use of rack equipment to monitor heat and computational fluid dynamic to predict future problems as some of the components to an effective cooling system. In support of the author, PSEDCC would not just add cooling in order to reduce heat in the Data Centre but it would also choose the best equipment in the racks and the appropriate cooling infrastructure to suit the Namibian environment.

The Cisco Unified System unites network, computational, storage access and virtualization resources in a single energy-efficient system that could help businesses reduce the cost and complexity of the IT environment while helping to extend capital assets (Network Update, 2011). Furthermore, Network Update indicated that this system uses integrated management and combines a unified fabric with an industry-standard computing platform. As a result, virtualization and the overall costs could be improved and reduced respectively. Similarly, PSEDCC had incorporated Cisco Unified System as one of its core technologies of unifying the Government network, storage, virtualization and other ICT resources.

Lui (2010) proposed the concept of an airside economizer that captures outside air with low heat content to replace internal heat gain from occupants, lighting and equipment when outdoor weather condition is favorable. He further added that traditionally conventional Data Center design utilizes chilled water or direct expansion cooled computer room air conditioning unit (ERAC) as the localized cooling device. The author said although an airside economizer was one of the cheapest Energy Conservation Measures (ECM) available and a common design practice for commercial buildings, Data Centre stakeholders had not completely embraced the concept because of the concerns of maintaining humidification, and minimizing particulate and gaseous contamination. He said there was a concern about bringing outside air into a Data Center that may make it too expensive under certain low-humidity ambient conditions.

Furthermore, he stated that bringing outside air into a Data Centre may introduce dirt, dust, airborne particulates and gaseous contamination, which put the server operation at risk and shorten the equipment's life expectancy. He therefore proposed that design engineers should pay close attention to these issues, as well as other design considerations for air side economizer. As a result, dirt, dust, airborne particulates and gaseous contamination would be minimized to a very low level of occurrences.

Energy and Power Management Magazine (2006) stated that Collective Technologies announced the successful completion of a complex Data Centre consolidation project for Columbia University. The Magazine further stated that

university was one of the first organisations to use Collective’s Data Centre Life Cycle Management Solution in its consolidation efforts. It added that prior to engaging Collective, Columbia’s Centre for Computational Biology and Bio-informics (C2B2) operated from five (5) disparate Data Centre locations in two separate buildings for its IT infrastructure. Hence, to reduce operational and maintenance costs as well as management complexity, the university decided to consolidate its IT infrastructure into a single Data Centre in a new building on the campus. Like Columbia University, the Namibia public sector should also consider its scattered facilities using Collective Data Centre Lifecycle Management Solutions.

2.5 Summary

From the literature reviewed, it was acknowledged that issues related to duplication of infrastructures and services were common in Data Centre operations all over the world. Hence, the duplication of infrastructures was not an exception for the Namibian Public Sector. As a result, Data Centers were experiencing problems related to operational cost, energy consumption, storage, floor spaces, security, cabling and scalability. However, there were many Data Centre consolidation best practices available that the Namibian Public Sector would incorporate in order to improve the design and management of its facilities. Practices such as DCIM, Emerald Workload Management tool, Integrated Data Management approach, holistic design approach, Cisco Unified System, airside economiser and Collective Data Centre Lifecycle Management Solutions were some of related work

acknowledged in this study and represented consolidation best practices applied by some international private and public organizations. As a result, these organizations had reduced their operational costs, increased collaborations and improved optimization.

3. RESEARCH METHODOLOGY

The research methodology presents a brief introduction, research design, population, sample, instruments used to collect data, procedures and data analysis tools applied in the study.

3.1 Introduction

A research method focuses on the research process and the kind of tools and procedures to be utilized in collecting data from the research participants. This section would also focus on the procedures and instruments which were used to gather relevant information from IT Managers and Data Centre support staff.

In total, seventeen (17) Data Centres in the Namibian Public Sector were selected for the study. Of the seventeen (17) facilities, fifteen (15) were randomly selected while two (2) were purposefully selected on the basis of being the strategic hubs for ICT in the Namibian Public Sector setup. The two facilities were: Office of the Prime Minister and Ministry of Information Communication Technology. In other words, the participation of these two ministries in the study was mandatory.

The study was intended to investigate the current states of various Government Data Centre infrastructures based on the design and management of ICT resources. Furthermore, the study recommended the comprehensive solution to the challenges that were negatively affecting daily operations at these facilities. Finally, the study

proposed the best practices that should be applied by the Government in order to enhance the design and management of its Data Centres’ resources.

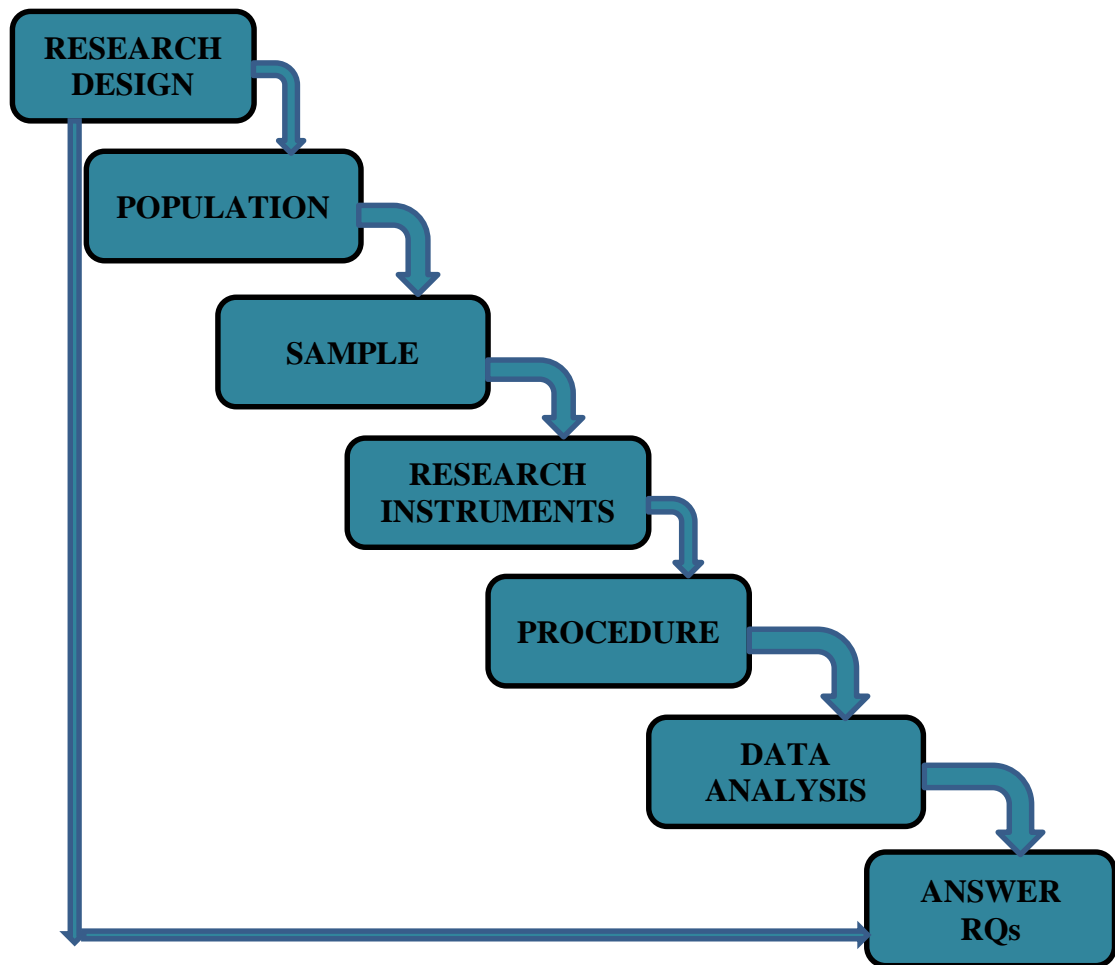


Figure 3.1: Summary of Research Methodology

Figure 3.1 shows the summary of the research methodology which was followed when conducting this research. These methodology steps includes design, population and sample selections, research instruments, procedures used, data analysis and answering of research questions.

3.2 Research design

The study used a mixed-method research design where both qualitative and quantitative methods were employed. Quantitatively, a structured questionnaire was used to explore the current state of Data Centres in the Namibian Public Sector. Furthermore, an observation checklist was employed to gather information on Data Centres. Qualitatively, an interview schedule was used to gather information on the operations, designs and management of Data Centre ICT resources in the public sector.

3.3 Population

A population is the set of all possible cases of interest. Currently, there are twenty-nine (29) main Data Centres situated at the head offices of the O/M/As in Namibia. The total number of personnel responsible with overseeing the operations of Data Centres at various IT Departments in the Namibian Public Sector was estimated to be more than one hundred. The population of this study consisted of all IT Managers and System Administrators as well as all the Data Centre sites in all the head offices of O/M/As. It was worth noting that the positions occupied by IT Managers and System Administrators played an important role in providing critical information and insight of the Data Centres, though other data could be easily obtained from all IT personnel.

3.4 Sample

A sample is a set of cases that does not include every member of the population. The sample of this study consisted of fifteen (15) (randomly selected) and two (2)

(purposely selected) Data Centres. Furthermore, the study was made up of thirty four (34) respondents in total, of which thirty (30) represented fifteen (15) randomly selected Data Centres while four (4) out of thirty four (34) were from two (2) purposely selected Data Centres. Of these respondents, seventeen (17) were IT Managers/representatives and seventeen (17) were System Administrators/IT operators who were overseeing Data Centre operations in the public sector' O/M/As. This means, the respondents' sample size was equally distributed among the two positions of IT Manager and System Administrator, one (1) from each of the O/M/As. In short, the study was made up of thirty-four (34) participants and 17 Data Centres of different O/M/As-these include randomly and purposefully selected facilities.

3.5 Research instruments

The researcher has used a structured questionnaire, semi-structured interview questions and self-observation technique as research instruments to collect data for the study. The questions that were used in the questionnaire were absolutely structured while interview items were structured in an open ended way so that respondents could respond and express their views freely and in their own words.

3.6 Pre-testing research instruments

To enhance reliability and validity of the instruments used, the questionnaire items and interview questions were pre-tested on four (4) respondents from two (2) ministries, namely: The Office of the Prime Minister (OPM) and Ministry of Fisheries and Marine

Resources (MFMR). These two ministries were selected based on two factors. The first factor was O/M/A’s close proximity with the researcher at the time of this process and the second was the availability of the respondents.

3.7 Pre-testing results

The results of the pre-test demonstrated that all the questionnaire items and interview questions were understood by the respondents. Therefore, both instruments were found to be valid and reliable for the study. Based on these results, no items in the research instruments were revised.

3.8 Procedure

After the researcher was granted permission to go ahead with the data collection process, an official letter was obtained from the supervisor of an affiliated University. The purpose of the letter was to show potential respondents the authenticity of the study being carried out. The researcher distributed questionnaires to the selected System Administrators as well as IT Managers at their workplaces for completion. Furthermore, semi-structured interviews were conducted with some of the IT Managers/representatives of the selected O/M/As Data Centres. In addition, the researcher also visited seventeen (17) selected Data Centres sites. After data collection, data validation was carried out and coded into the IBM Statistical Package for Social Sciences (SPSS) version 21 for analysis.

3.9 Data analysis

Descriptive statistics were used to analyse the participants' responses on Data Centre design and management of ICT resources. Correlations were used to explore relationships between selected variables. Fox and Bayat (2007) defined correlation as the relation between two sets of data. The two sets of variables vary together: when the values of one variable increases, then the values of the other variable also increased (a positive correlation), or when the values of the one variable increased, then the values of the other variable decreased (a negative correlation).

Correlation techniques are used to obtain numerical value for the strength of such correlations. This value is expressed statistically as a correlation coefficient. This correlation coefficient (r) can assume any value from +1 (a perfect positive correlation) to -1 (a perfect negative correlation). Furthermore the above authors stated that in most cases the values of r (irrespective of its sign) are described as follows:

1.00 A perfect correlation, 0.80 – 0.99 A high correlation, 0.60 – 0.80 A substantial correlation, 0.40 – 0.60 A reasonable (moderate) correlation, 0.20 – 0.40 A low correlation, 0.00 – 0.20 A very low correlation or no correlation at all

The findings and analysis of the data collected were presented in Chapter four while the discussion was detailed in Chapter five. Furthermore, questions asked in both the questionnaire and interviews were combined and research questions were answered in Chapters five, six and seven.

3.14 Research ethics

Respondent's right to anonymity and confidentiality during the data collection process was assured. This was assured through not revealing their names or ages. Furthermore, permission was obtained from the relevant authorities to access data centres in the O/M/As. In addition, the respondents were guaranteed of the confidentiality of their responses, as the information they shared with the researcher could not be used for any other purpose except for academic purposes.

3.15 Summary

In short, the first step was to identify research designs applied in the study. Secondly, the sample was derived from the total population. Thirdly, research instruments were administered and pre-testing was conducted. Based on the pre-testing results, the final data was collected and entered in the SPSS software for analysis and presented in bar graphs, tables and pie charts. Finally, research questions were answered based on the findings.

4. RESEARCH FINDINGS

This chapter presents the findings of the study. The data was collected through individuals using questionnaires and one-on-one interviews. In addition, the data was analysed and presented in the form of charts, pies and tables. The first sub research question of the study was also answered in this chapter.

4.1 Introduction

In this chapter the analysis of the data gathered were categorized into two parts namely: Data Centre design, and Management and operations. This implies that the questions asked in the questionnaire were categorised into those two parts and their graphs, pie chart or table was generated. Each question asked in either the questionnaire or the interview falls under one of the two categories except the two questions on position and O/M/A that were regarded as independent variables.

4.2 GRN institutions undertook the study

The institutions which participated in this study were as follows: Office of the Prime Minister (OPM), Office of the Auditor General (OAG), Ministry of Fisheries and Marine Resources (MFMR), Ministry of Education (MoE), Ministry of Environment and Tourism (MET), Ministry of Home Affairs (MHA), Ministry of Regional Local Government and Housing (MRLGH), Ministry of Agriculture Water and Forestry (MAWF), Ministry of Finance (MoF), Ministry of Justice (MoJ), Ministry of Foreign Affairs (MFA), National Planning Commission (NPC), Ministry of Labour and Social Welfare (MLSW), Ministry of Mines and Energy (MME), Anti-Corruption

Commission (ACC), Electoral Commission of Namibia (ECN) and Ministry of Information and Communication Technology (MICT).

4.3 Number of participants

The number of persons who undertook this study from various public sector institutions is presented in figure 4.1.

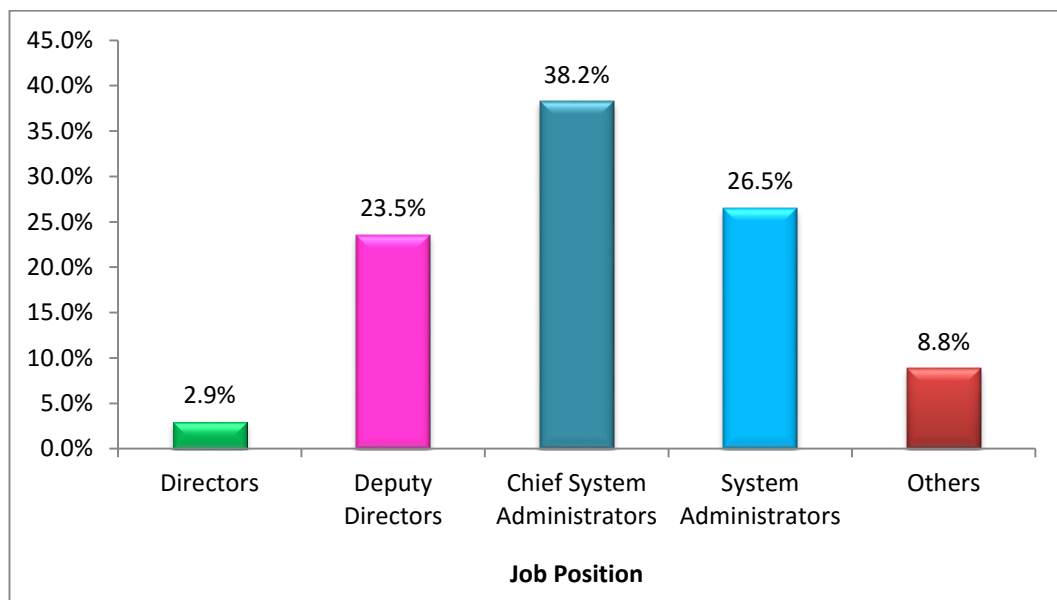


Figure 4.1: Research participants

Figure 4.1 illustrates the percentages of IT personnel by their positions who participated in this study. The figure indicated that the majority of the respondents in this study were Chief System Administrators (38.2%) followed by System Administrators and Deputy Directors who stood at 26.5% and 23.5% respectively. In addition, other IT personnel including IT support staff stood at 8.8% while the fewest participants in this research were Directors (2.9%). The positions occupied by the respondents were very important in this study because only high ranking employees

could provide critical information while other data was easily obtainable from all IT personnel. Therefore, questions which were regarded as critical were directed to the IT Managers or their representatives.

4.4 Data Centre design

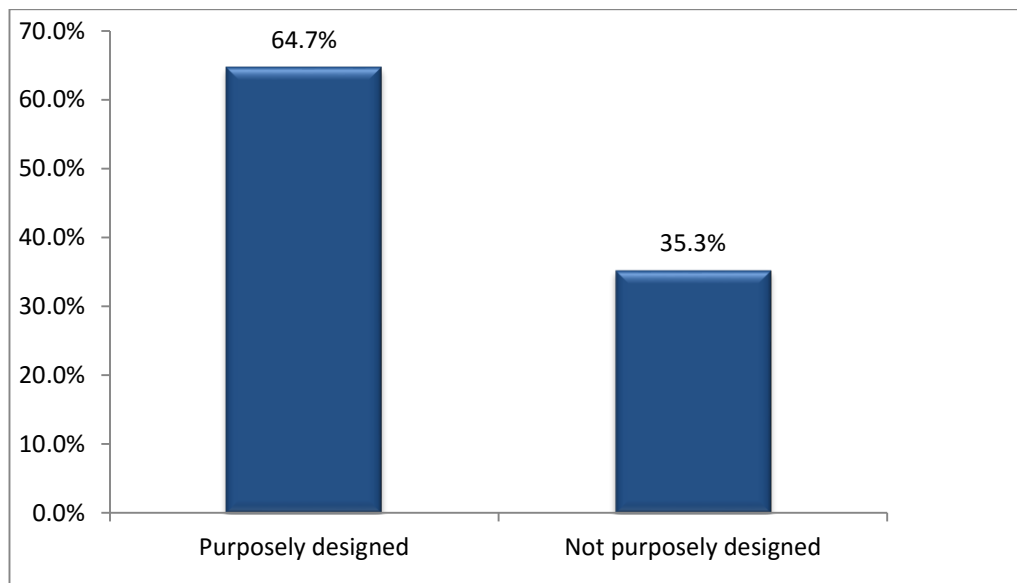


Figure 4.2: Data Centre design categories

Seventeen (17) IT Managers/representatives were asked on how they would define the design of their Data Centre infrastructures. Each Data Centre was represented by one respondent and the response rate to this question was 100%. Figure 4.2 shows that of the seventeen (17) Data Centres represented in this study, 64.7% were purposely designed while 35.3% were not purposely designed. The findings above demonstrated that there was a disparity in the way some public sector Data Centres were designed.

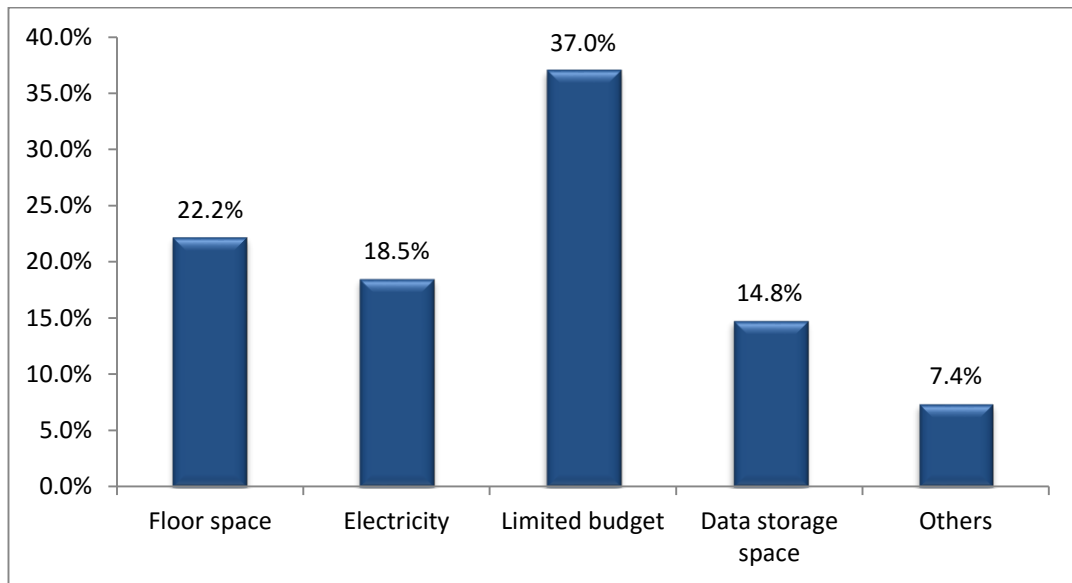


Figure 4.3: Expansion limiting factors

Figure 4.3 shows the factors which prevented the expansion of Data Centres in the Namibian Public Sector. The figure displays that the limited budget (37.0%) was the factor which mostly affecting IT Managers from adding new equipment in their Data Centres, followed by floor space (22.2%). Furthermore, electricity, data storage space, and other factors such as head-load had recorded 18.5%, 14.8% and 7.4% respectively.

Table 4.1: Public sector Data Centres physical sizes

OPM	15
OAG	15
MFMR	10
MoE	14
MET	19
MHA	7
MRLGH	16
MAWF	5
MoF	N/A
MoJ	6
MFA	5
NPC	12
MLSW	N/A
MME	7
ACC	10
ECN	N/A
MICT	20

Table 4.1 shows that the minimum size of a Data Centre infrastructure in the Namibian Public Sector was 5 m² while the maximum size was 20 m². The total size of the surveyed Data Centres stood at 131 m². Table 4.1 further shows that some O/M/As such as Ministry of Finance (MoF), Ministry of Labour and Social Welfare (MLSW) and Electoral Commission of Namibia (ECN) could not disclose sizes of their Data Centre infrastructures. Those institutions represented 18.8 % of the total sample.

4.5 Data Centre management and operations

Table 4.2: Number of physical and VM servers in the public sector

O/M/As	Physical servers	VM servers
OPM	12	20
OAG	2	4
MFMR	11	0
MoE	8	8
MET	4	6
MHA	8	0
MRLGH	31	71
MAWF	4	4
MoF	N/A	N/A
MoJ	7	0
MFA	4	10
NPC	8	16
MLSW	5	3
MME	17	10
ACC	3	6
ECN	10	43
MICT	6	0

Table 4.2 shows that there were 11 physical servers and 0 Virtual Machines (VM) hosted by the Ministry of Fisheries and Marine Resources. On the other hand, there were eighty (8) physical servers and zero (0) VM servers at the Ministry of Home Affairs (MHA). In addition, the Ministry of Justice (MoJ) and the Ministry of Information and Communication Technology (MICT) were hosting seven (7) and six (6) physical servers respectively. However; both of them had no VM servers at their Data Centres. Only the MoF failed to indicate the number of both their physical servers and VM servers. The study revealed that apart from the above institutions with no virtual machines (VMs), the rest had at least three (3) or more VMs at their facilities.

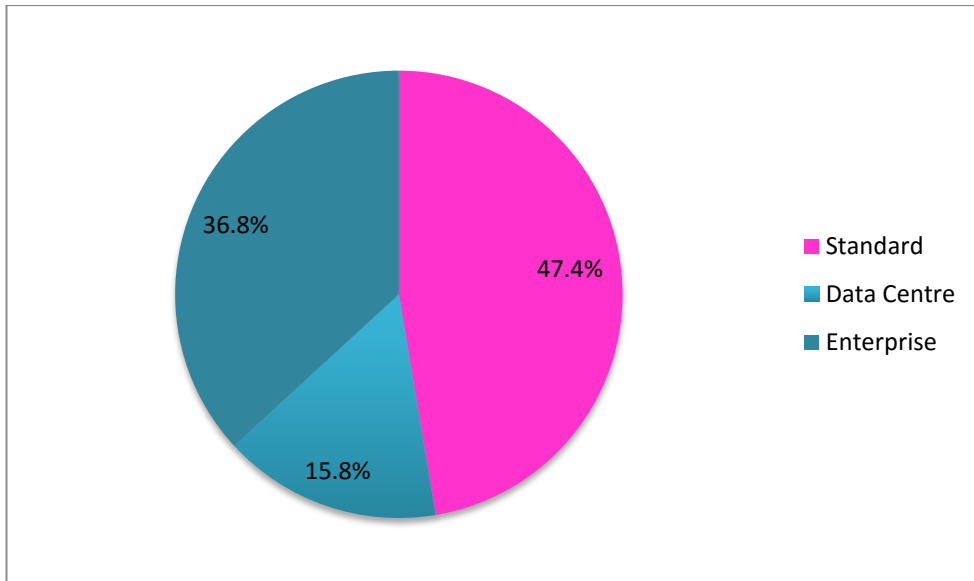


Figure 4.4: Server Editions in the public sector

Respondents were also asked the type of Windows server Editions they were running in their Data Centres. Figure 4.4 above shows that the majority (47.4%) of the servers deployed in the Namibian Public Sector were running Standard Editions while 36.8% of them were using Enterprise Edition. Data centre (15.8%) was the least used server Edition in the public sector.

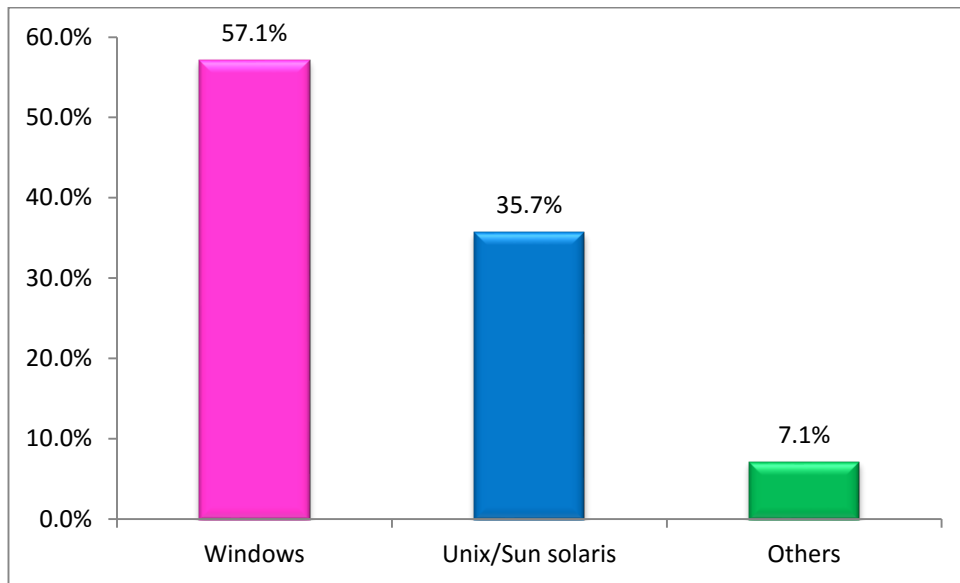


Figure 4.5: Operating Systems running in the public sector

According to results in figure 4.5 above, Windows was the most common operating system in the Namibian Public sector at 57.1% followed by Unix/Sun Solaris which stood at 35.7%. Other operating systems such Juniper and Linux were not that popular in the Namibian Public Sector therefore, they only made up 7.1 % of the entire Operating Systems inventory in the public sector.

4.5.1 Electricity usage and power saving strategies

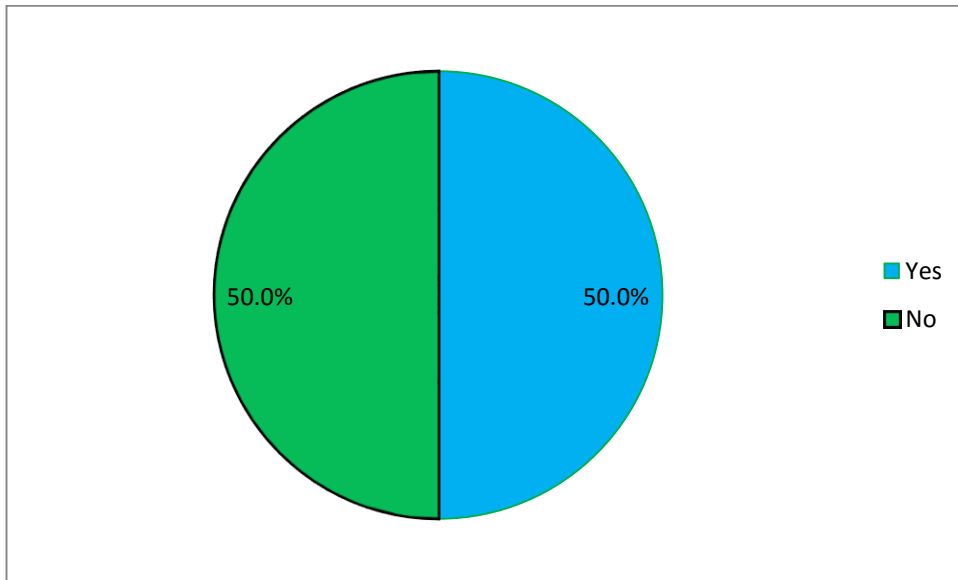


Figure 4.6: Availability of power saving strategy

On the question whether there was any power saving strategy in place at their respective Data Centres, 50% of the respondents affirmed that they did not have any strategies in place to reduce electricity consumption at their O/M/As while the other 50% declared that their infrastructures had power saving strategies deliberately employed to minimize electricity utilization as shown in figure 4.6.

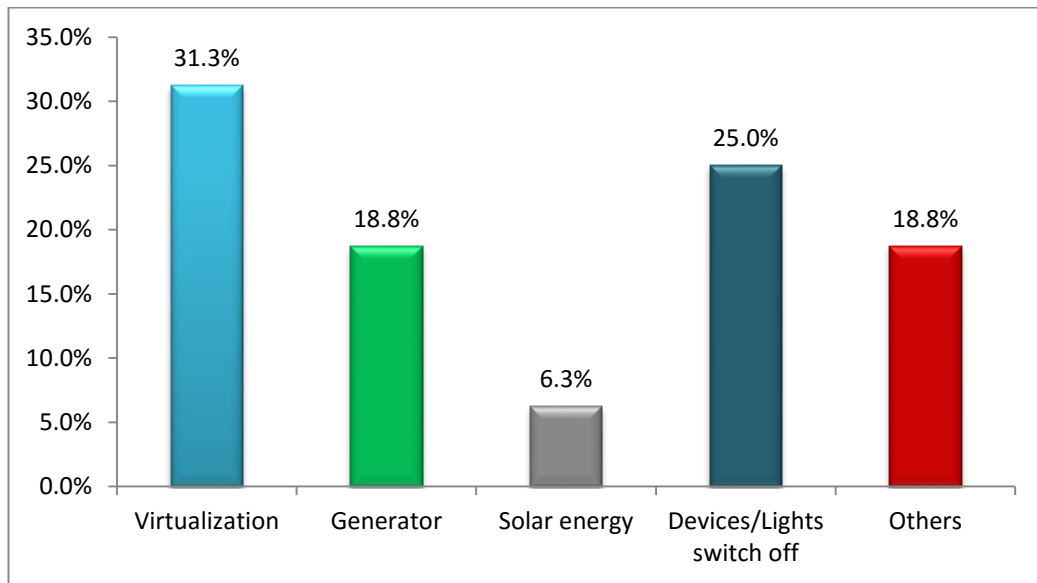


Figure 4.7: Power saving strategies put in place

Figure 4.7 above shows some of the common power saving strategies employed at various Data Centres. Virtualization (31.3%) was the most common used strategy, followed by “switching off devices/lights” (25.0%), generators (18.8%) while solar energy (6.3%) was the least used power saving strategy in the Namibian Public Sector. In addition, other power saving strategies such as automated device shutdown on idle and hibernates were not deployed by many Government institutions; however, they were standing at 18.8% when combined together.

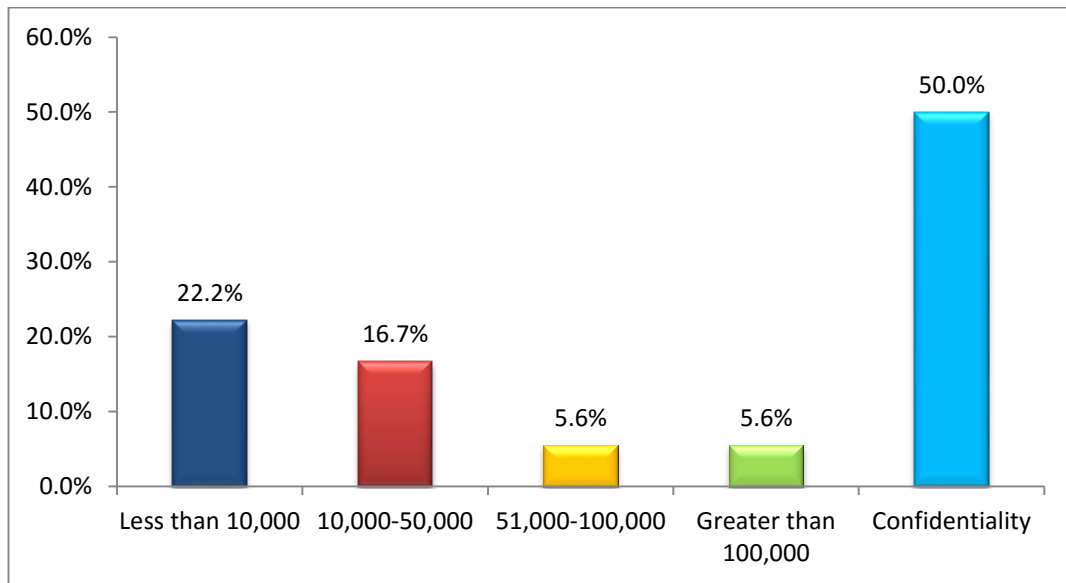


Figure 4.8: Data Centres’ monthly electricity spending

The analysis revealed that the Data Centres’ monthly electricity spending ranged between less than N\$ 10 000 and at least N\$ 1000 000. Figure 4.8 shows that 22.2% of public sector Data Centres spent (less than N\$ 10, 000) in electricity bills monthly while 16.7% spent (between N\$ 10, 000 and N\$ 50, 000) every month. The analysis also revealed that 5.6% of these Data Centres spent (between N\$ 51, 000 and N\$ 100,000) every month while another 5.6% spent at least N\$ 100, 000 monthly. On the contrary, 50.0% of the respondents could not disclose their Data Centre electricity monthly bills due to the confidentiality attached to this information.

4.5.2 IT Departments’ budget allocations

In this section, the study discussed the IT Departments annual budget allocations against the percentage budget assigned annually to Data Centres.

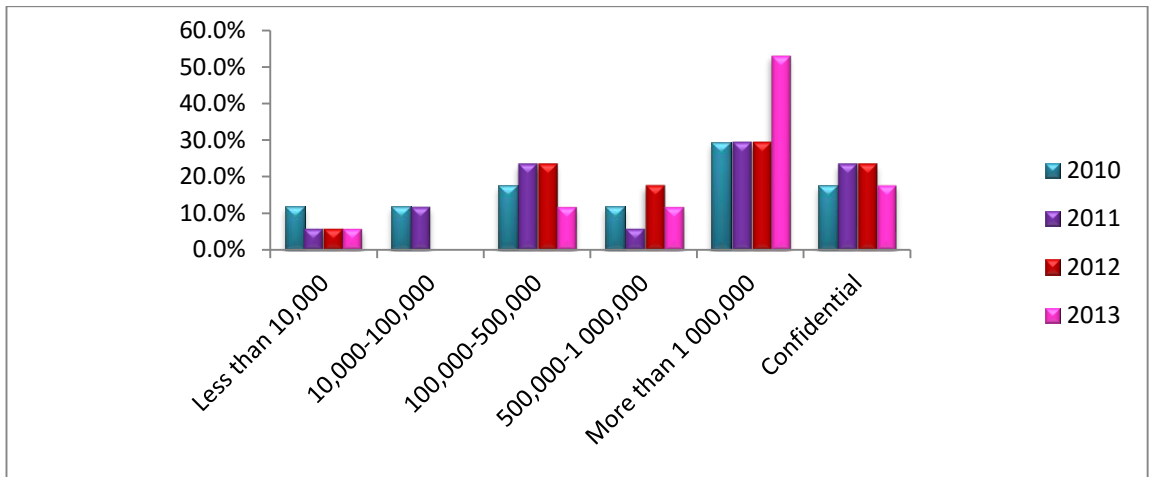


Figure 4.9: Annual budget allocations

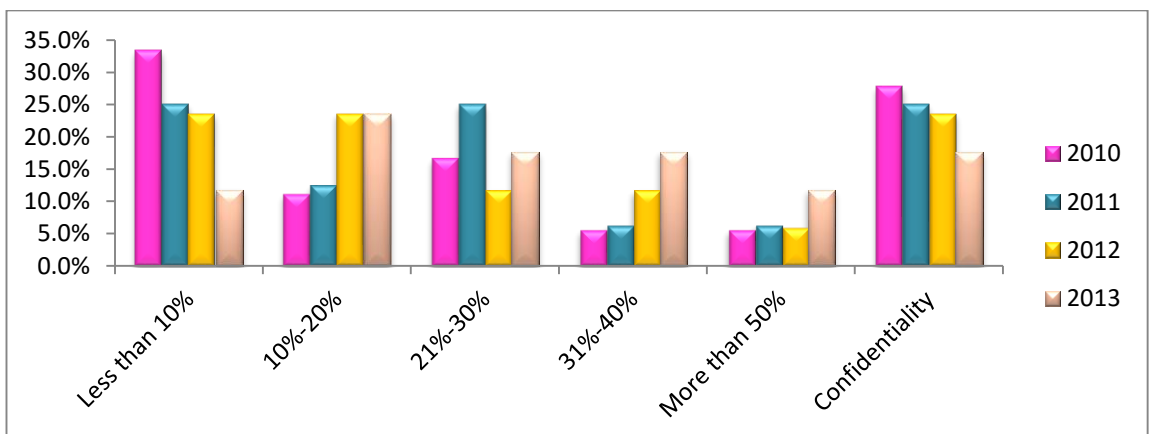


Figure 4.10: Estimated percentages distributed annually

Figures 4.9 and 4.10 above show that in the year 2010, most IT Departments (29.4%) were allocated a budget of more than one (1) million dollars (N\$ 1 000 000) each however, the majority of them (33.3%) had only assigned less than 10% of that money to their Data Centre infrastructure development.

Similarly, the majority of the IT Departments (29.4%) were allocated more than one (1) million dollars (N\$ 1 000 000) each in 2011; yet, 25% of them had allocated only less than 10% of the whole budget to their Data Centre infrastructure development.

In addition, the same number of IT Departments (29.4%) were allocated more than one million dollars (N\$ 1 000 000) each in the year 2012 however, only 5.9% of them allocated more than 50% of that money to their infrastructure development while 23.5% of them had only given less than 10 percent of the budget to IT.

Finally, in the year 2013, the majority (52.9%) IT Departments were allocated more than one (1) million dollars each but once again there were some Departments (11.8%) who had allocated less than 10% of their budget to their Data Centre infrastructure development. On the other hand, only 11.8% of these Departments had apportioned more 50% of their budget to their infrastructure development.

4.5.3 Virtualization and Private Cloud implementations

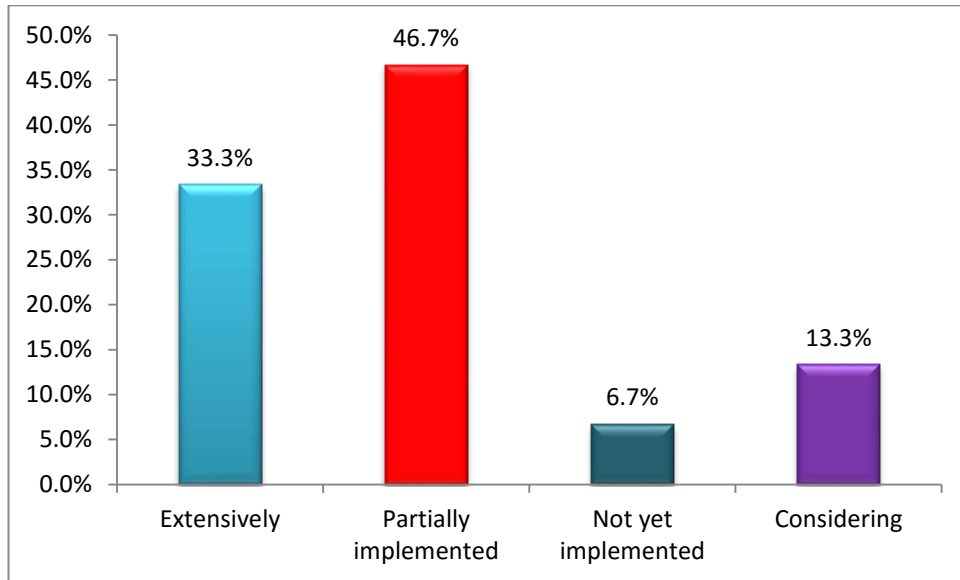


Figure 4.11: Virtualization implementation stages

Respondents were also asked to give their opinion on the extent their organisations have implemented virtualization technology. According to Figure 4.11, 33.3% respondents felt that their organizations had implemented virtualization extensively while the majority of the respondents (46.7%) proclaimed that their organizations had only partially deployed this technology. In addition, 6.7% had not yet implemented virtualization and 13.3% were considering implementing it.

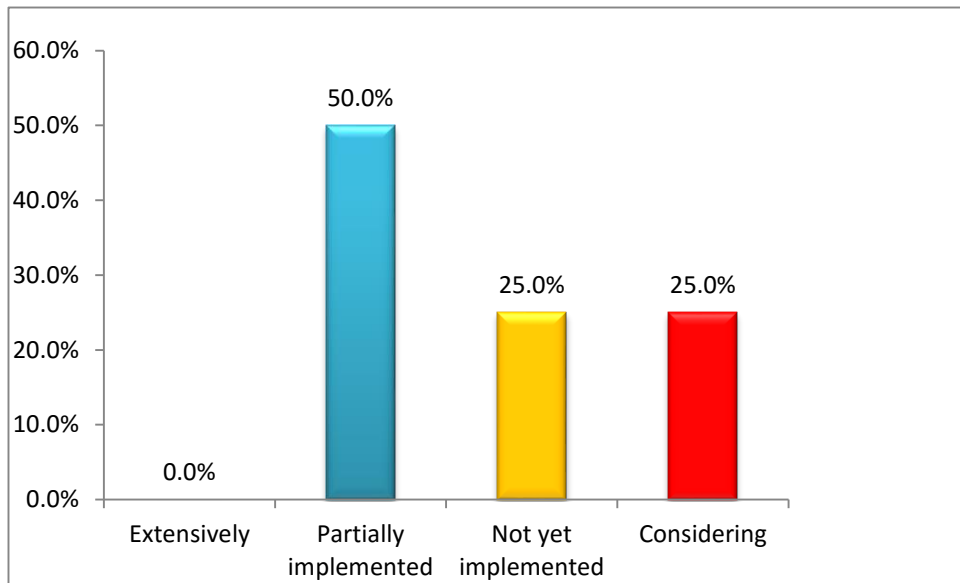


Figure 4.12: Private Cloud implementation stages

Respondents were again asked to give their views on the level they felt their O/M/A had deployed private cloud. According to Figure 4.12, no respondents felt that their organizations had implemented private cloud extensively while 50.0% respondents proclaimed that their organizations had only partially deployed this technology. In addition, those who felt that private cloud technology had not yet been implemented (25.0%) and those who were considering implementing the same technology (25.0%).

4.5.4 Western Africa Cable System deployment

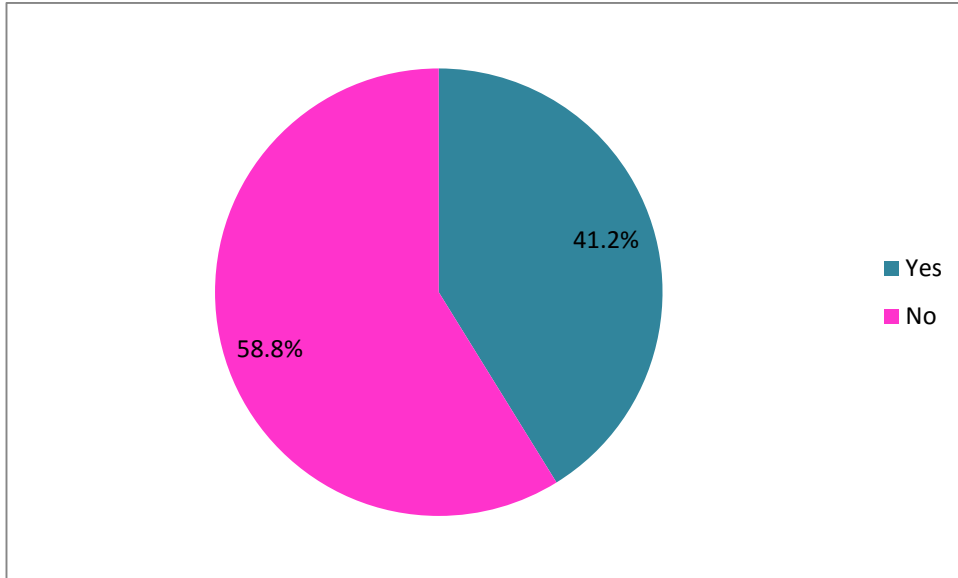


Figure 4.13: Western Africa Cable System connectivity

Of the seventeen (17) Data Centres investigated in this study, only 41.2% were connected to Western Africa Cable System (WACS), while the majority (58.8%) were not yet connected to the system. As a result, there was inconsistency in the process of WACS implementation at various Government institutions as shown in Figure 4.13.

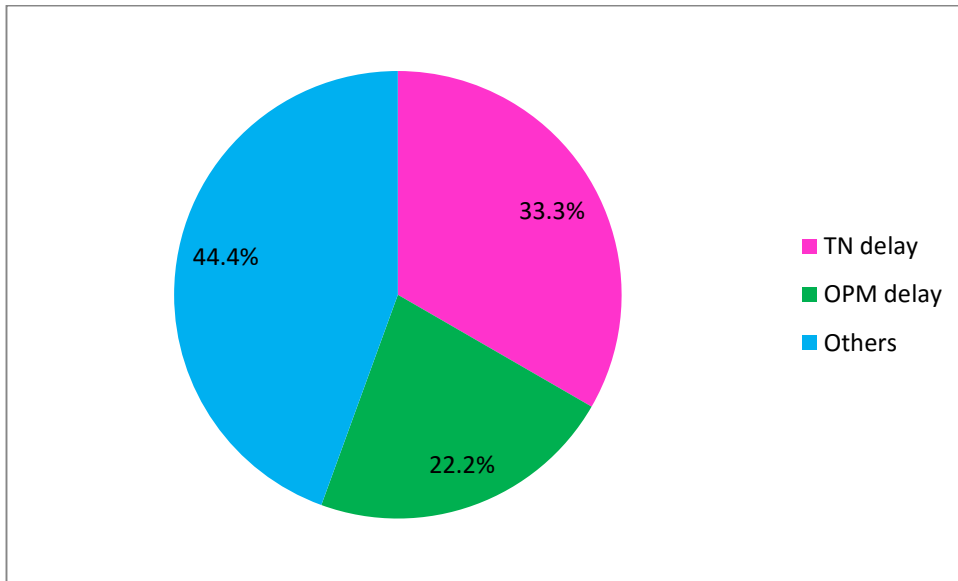


Figure 4.14: WACS connectivity delays

Figure 4.14 shows that of the 58.8% organisations which were not yet connected to WACS, 33.3% of them revealed that they had been delayed by Telecom Namibia (TN) while 22.2% indicated that the OPM was delaying their WACS implementation. The remaining percentages (44.4%) gave other reasons for example they did their operations independently and different hence they didn't need WACS.

4.5.5 Redundant Data Centre facilities

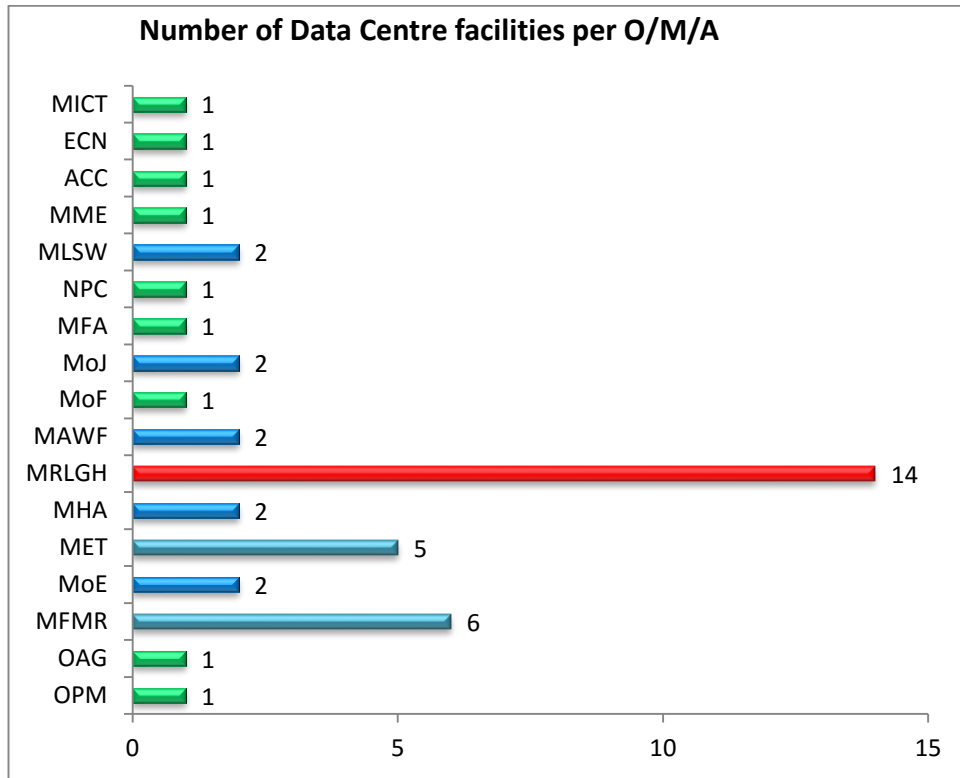


Figure 4.15: Number of Data Centre facilities per O/M/A

Figure 4.15 shows that apart from the OPM, OAG, MoF, MFA, NPC, MME, ACC, ECN and MICT which had one (1) Data Centre facility each, all other O/M/As had at least two (2) or more Data Centre infrastructures. This translates to 47.1% of Government institutions with multiple Data Centres. The analysis revealed that the Ministry of RLGH had the majority number of Data Centres with fourteen (14) facilities across the country followed by MFMR and MET with six (6) and five (5) facilities respectively. These three ministries had twenty-five (25) Data Centres among them which accounted for 64.1% of all the centres enumerated number (39) in the

study. In addition, the MLSW, MoJ, MAWF, MHA and MoE had eight (8) facilities among them, each with two Data Centres.

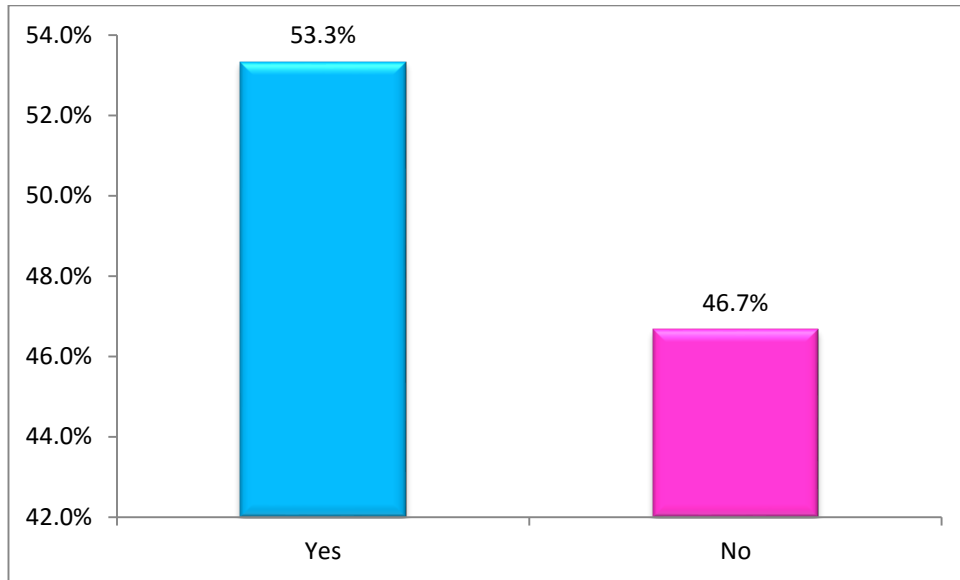


Figure 4.16: Data Centre offsite backups

According to figure 4.16 above, only 53.3% of Government Data Centres had offsite backup infrastructures in place while 46.7% of them had no offsite backup infrastructures to counter any major disaster at their OMAs.

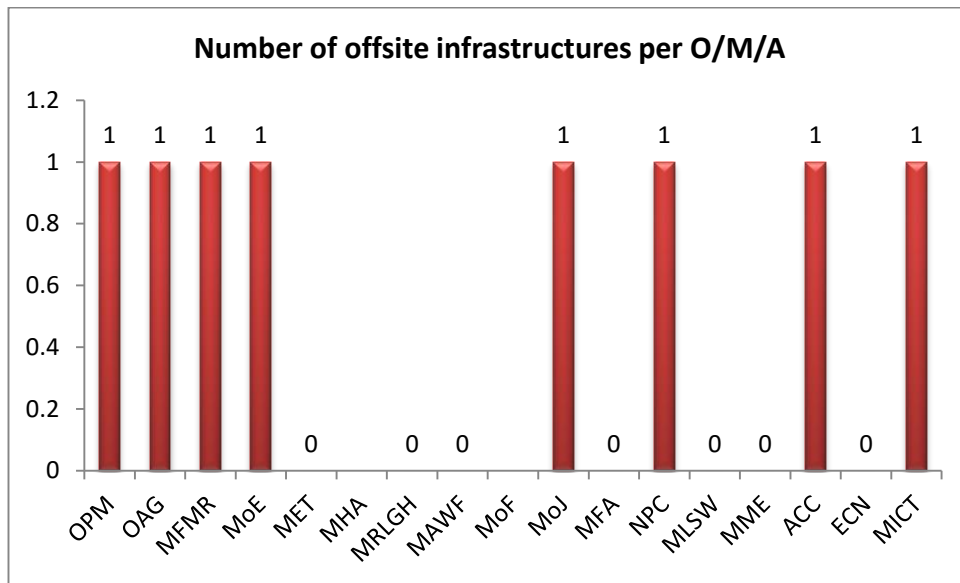


Figure 4.17: Number of offsite infrastructures per O/M/A

Figure 4.17 shows that of the seventeen Government institutions surveyed in this study, only eight (8) or 47.1% of them had offsite backup infrastructures in place. Those eight (8) institutions were the Office of the Prime Minister (OPM), Office of the Auditor General (OAG), Ministry of Fisheries and Marine Resources (MFMR), Ministry of Education (MoE), Ministry of Justice (MoJ), National Planning Commission (NPC), Anti-Corruption Commission (ACC) and Ministry Information Communication Technology (MICT). In addition, the study revealed that each of the eight (8) institutions had only one (1) offsite backup infrastructure. On the contrary, the study revealed that 52.9 % of public sector institutions had no offsite backup facilities.

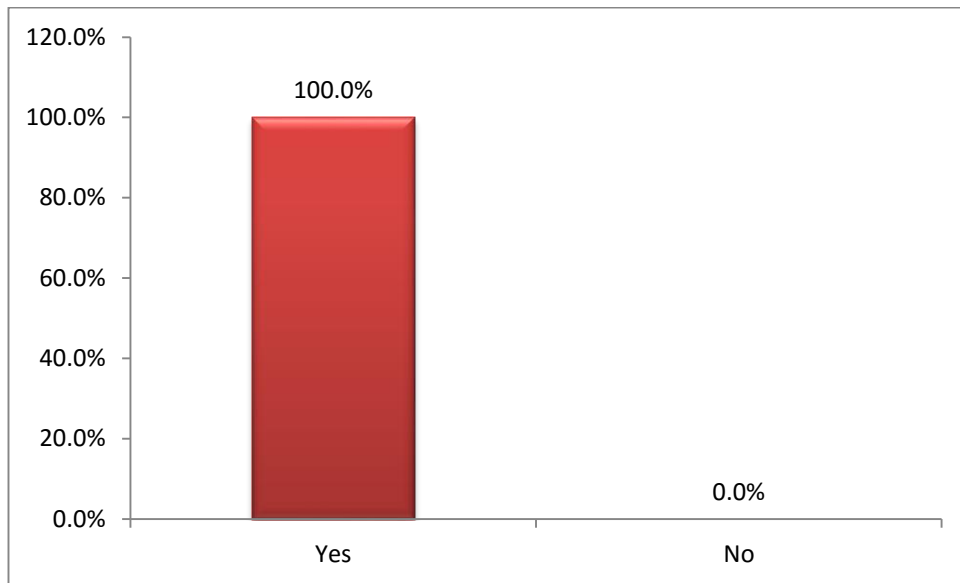


Figure 4.18: Cooling infrastructure

Figure 4.18 above shows that all Data Centres (100%) in the public sector each had a cooling infrastructure in place. It was interesting to point out that for the first time in this study, this was the only component deployed at each and every facility by all institutions.

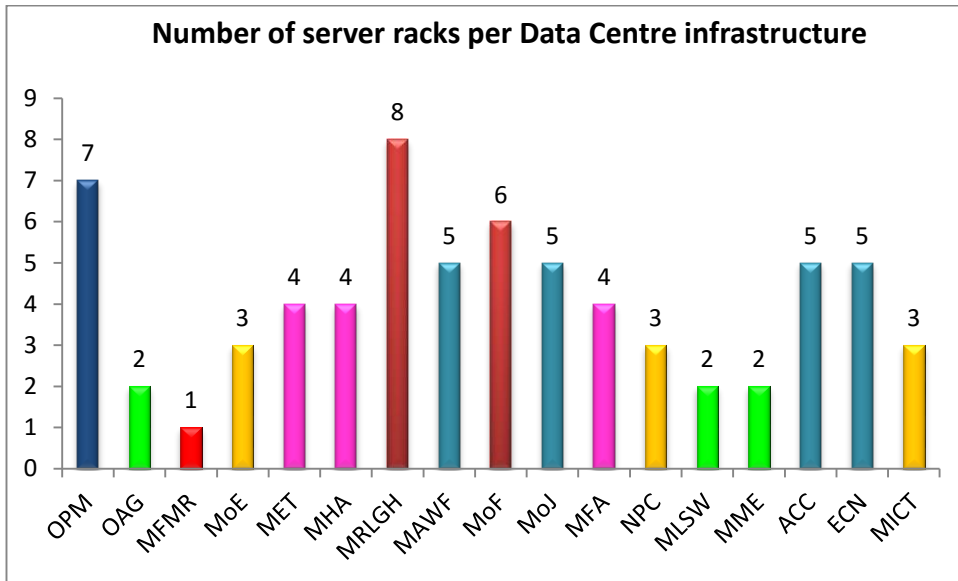


Figure 4.19: Server racks per Data Centre

Figure 4.19 showed that only the MFMR had one (1) server rack at their Data Centre. This represents only 5.8% of the Data Centres that carried out this study. On the contrary, all the OMAs shown on the figure above had at least two or more server racks which represented 94.1% of the sampled Data Centre population. The institution which had more server racks was the MRLGH with eight (8) racks, followed by OPM with seven (7) and MoF with six (6). The ACC, ECN, MoJ and MAWF had a combination of twenty (20) server racks among them, each with five (5) racks while MET, MHA and MoJ had four (4) server racks each, in total they had 12 server racks. The analysis revealed that MoE, NPC and MICT had nine (9) server racks among them, each with three server racks while OAG, MLSW and MME each had two (2) server racks.

4.6 Data Centre consolidation and its potential impacts

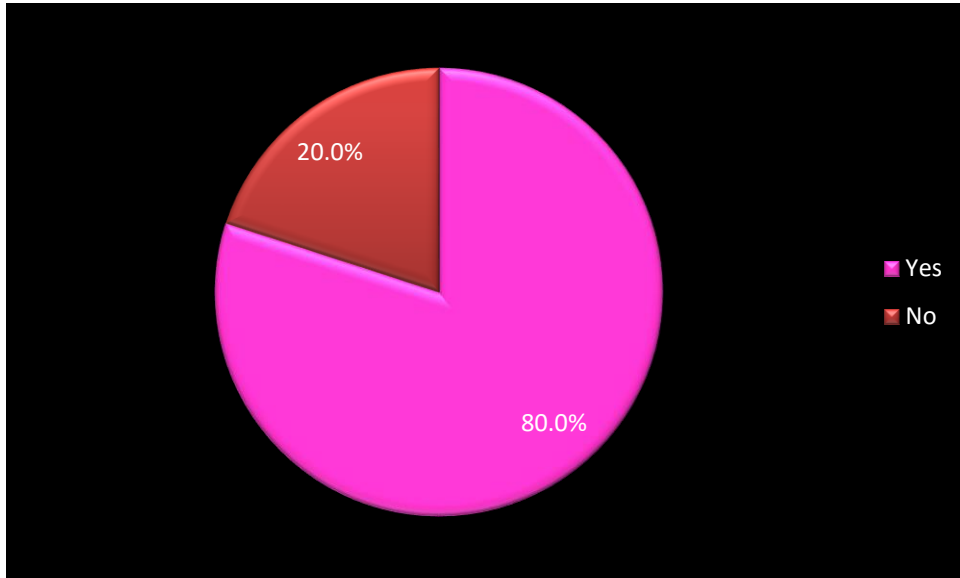


Figure 4.20: Opinions on Data Centre consolidation

To the question whether Data Centre Consolidation will transform the Namibian Public Sector for the better, 80.0% of the respondents felt positively (yes) for the technology while only 20.0% of them felt negatively (no) about it as shown in Figure 4.20.

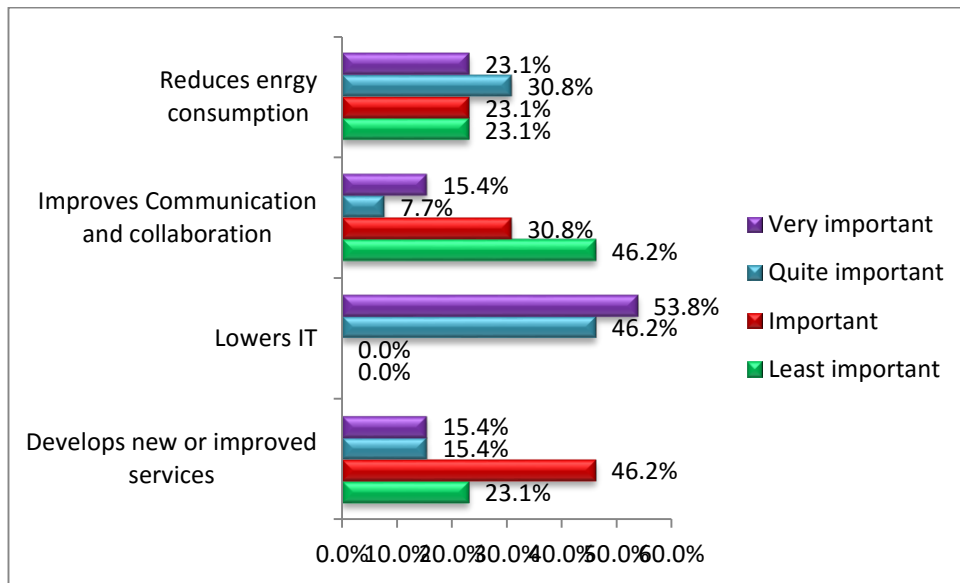


Figure 4.21: Consolidation impact evaluation

Firstly, Figure 4.21 shows that of the 80.0% respondents who answered yes to question 6 (see questionnaire Appendix), 15.0% of them felt that developing new or improved services was very important while the other 15.4% of them felt that it was quite important. Furthermore, 23.1% of the respondents felt that reducing energy consumption was important while the other 23.1% felt that it was the least important of the four (4) benefits of Data Centre Consolidation.

Secondly, Figure 4.21 shows that 15.4% of the respondents felt that improving communication and collaboration was very important while 7.7% of them felt that it was quite important. Furthermore, 30.8% of the respondents felt that improving communication and collaboration was important while the other 46.2% of them felt that it was the least important of the four (4) benefits of Data Centre Consolidation.

Thirdly, Figure 4.21 shows that 53.8% of the respondents felt that reducing IT costs was very important while 46.2% of them felt that it was quite important. On the contrary, none of the respondents (0.0%) felt that reducing IT cost was important or that it was the least important.

Finally, Figure 4.21 shows that 15.4% of the respondents felt that developing new or improved services was very important while the other 15.4 % of them felt that it was quite important. Furthermore, 46.2% of the respondents felt that the above benefit was important while 23.1% of them felt that it was the least important of the four (4) benefits of Data Centre Consolidation.

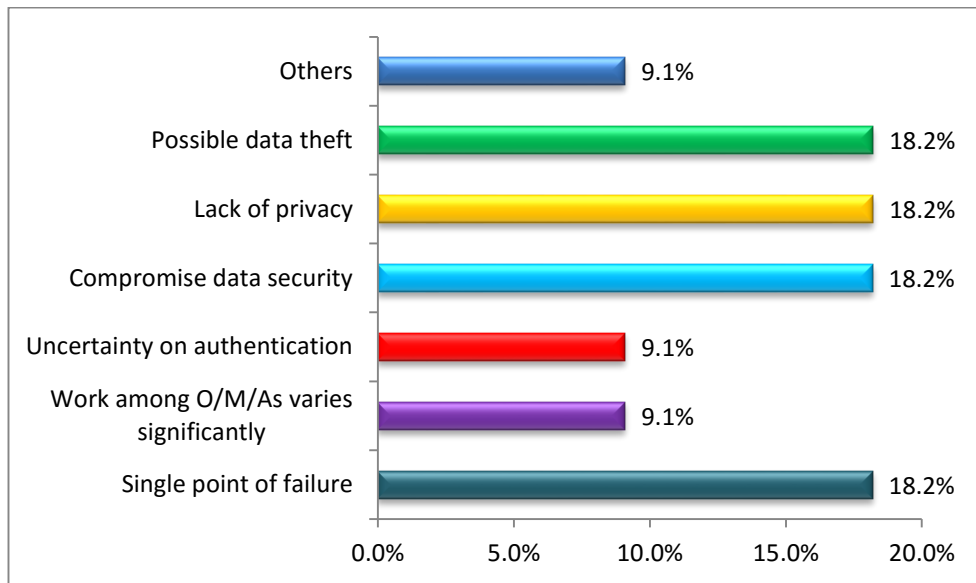


Figure 4.22: Consolidation fear among employees

Figure 4.22 above shows that of the 20.0% who were not supporting Data centre Consolidation, 18.2% of them felt that it could lead to single point of failure while 9.1% of them felt that work among government institutions varies significantly. In addition, 9.1 % of them were uncertain on authentication while 18.2% felt that Data Centre Consolidation could compromise data security. The lack of privacy and possible data theft were feared by 18.2% each while other elements such as difficulty in administration were feared by 9.1% of the respondents.

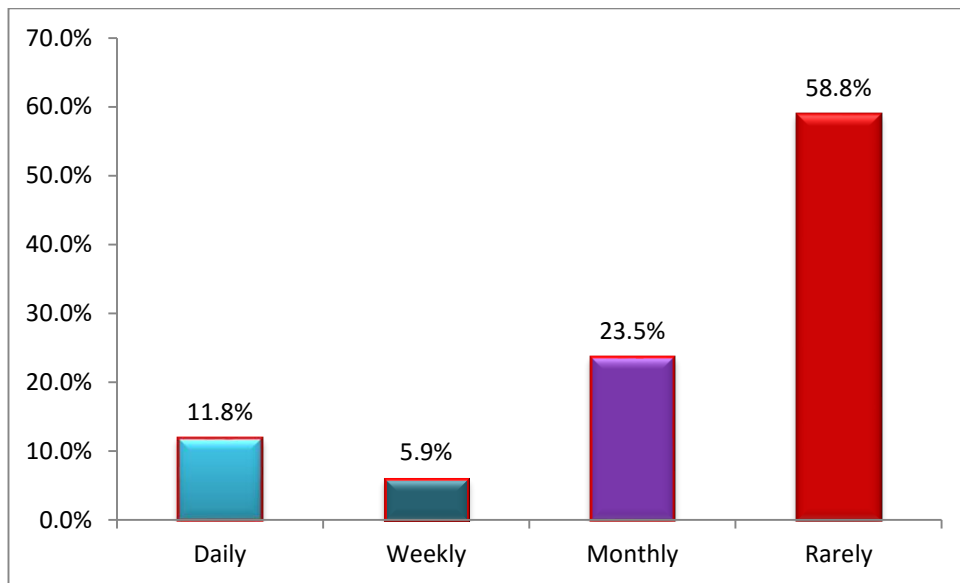


Figure 4.23: Internet and email services down time

Figure 4.23 shows that 11.8% of the OMAs were experiencing Internet and email services downtime on a daily basis while 5.9% of them were experiencing it on a weekly basis. Furthermore, 23.5% of these government institutions were experiencing Internet and email services downtime on a monthly basis. On the other hand, 58.8% of them were rarely experiencing downtime.

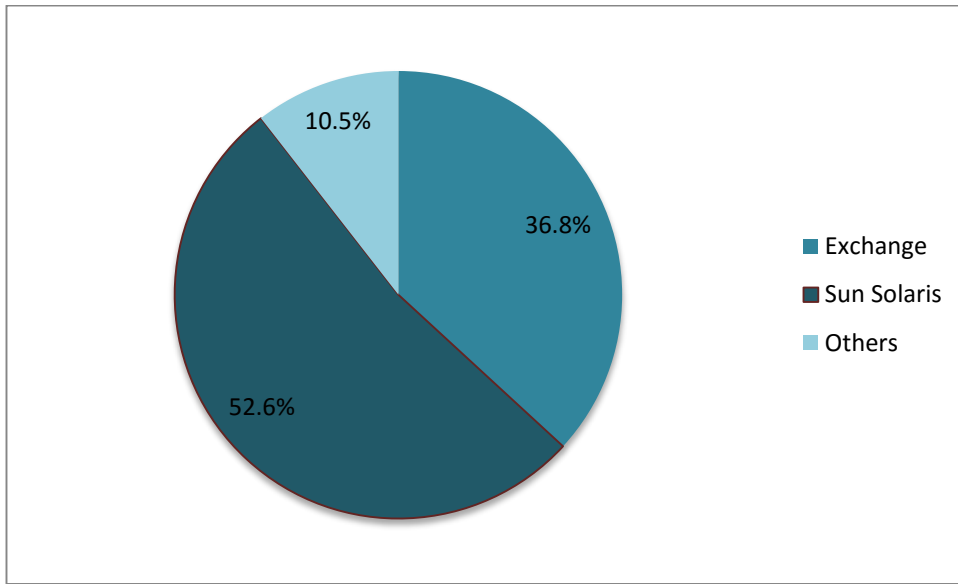


Figure 4.24: Email platforms

Figure 4.24 shows that 36.8% public sector institutions were using Exchange platform for running their email services while the majority of them were using Sun Solaris platform. In addition, other platforms such as Linux were uncommon in the Namibian Public Sector and only used by 10.5% of the institutions.

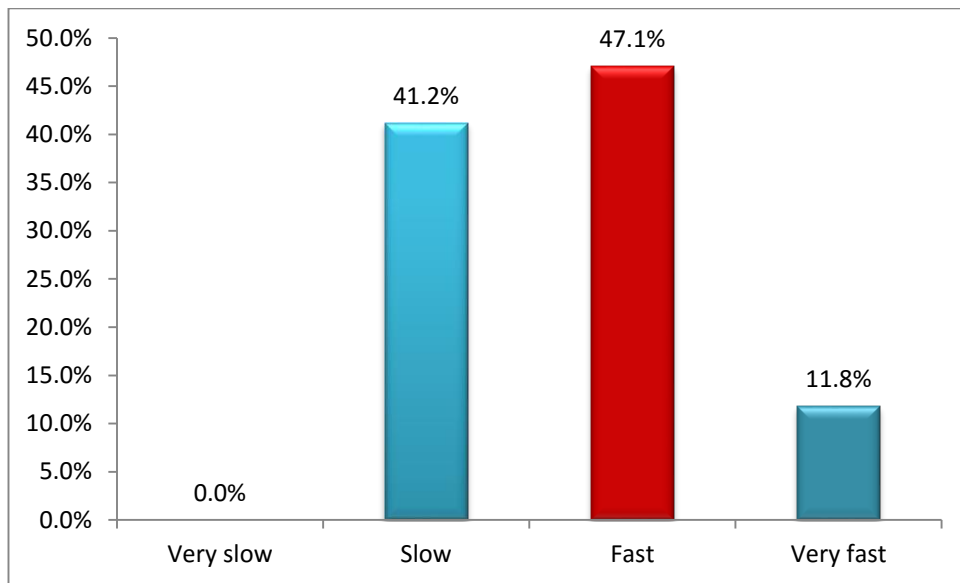


Figure 4.25: Internet services speed

Figure 4.25 shows that about 41.2% respondents indicated that their Internet services were slow while the majority (47.1%) affirmed that theirs were fast. In addition, only 11.8% respondents felt that their Internet services were very fast. On the other hand, there was no any respondent (0.0%) who felt that their Internet services were very slow.

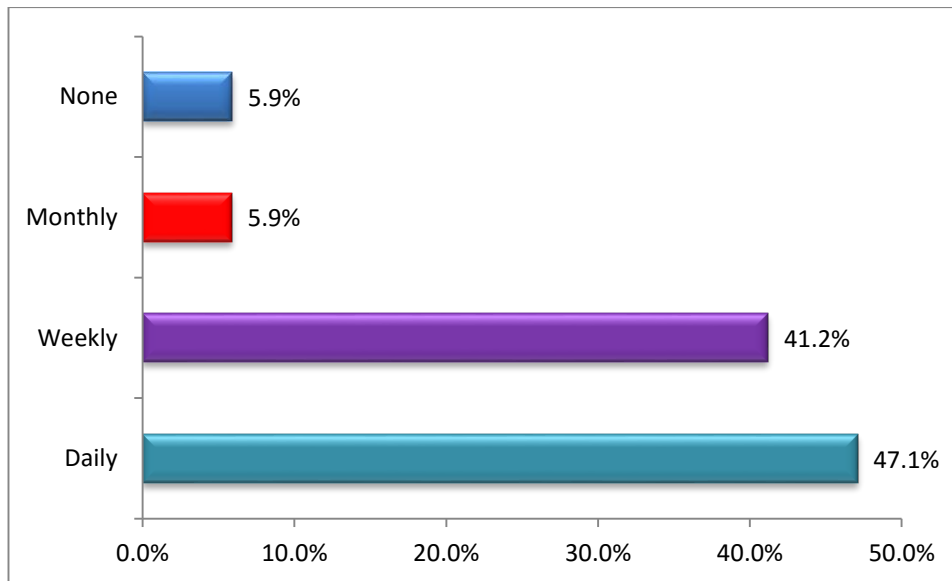


Figure 4.26: Data backups

Figure 4.26 shows that 47.1% public sector institutions were executing their data backups on a daily basis while 41.2% of them were doing it on a weekly basis. In addition, only 5.9% institutions were performing their backups monthly. On the contrary, 5.9 % were not performing data backups at all.

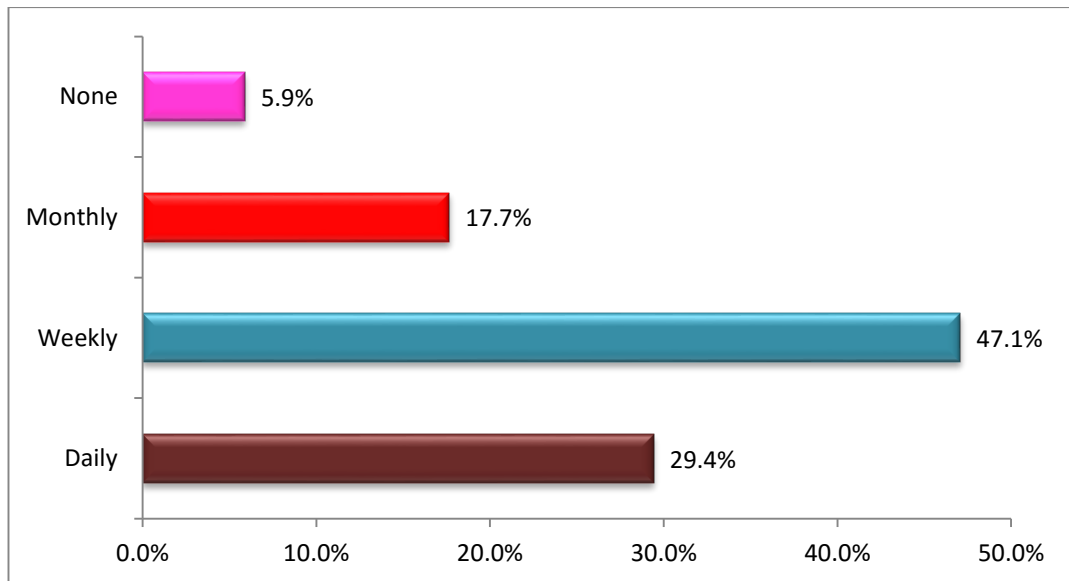


Figure 4.27: Application updates

To the question of “To what extent does your organization carry out its application updates?” 29.4% indicated that the OMAs perform this task daily while the majority (47.1%) do it weekly. Furthermore, 17.7% of the government institutions were performing their updates monthly. On the other hand, 5.9 % institutions were not carrying out updates at all as shown in Figure 4.27

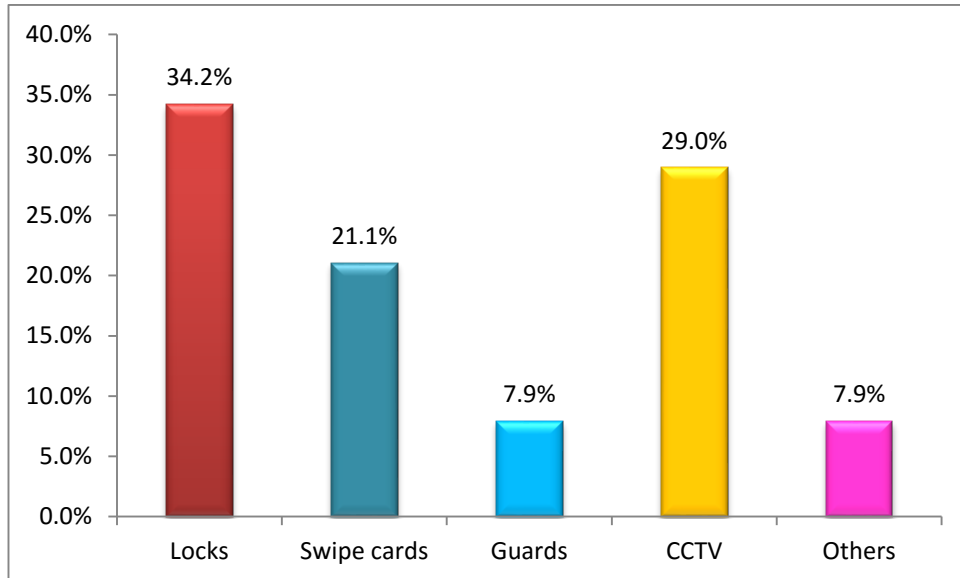


Figure 4.28: Data Centre physical access control

Figure 4.28 shows that about 34.2% Government institutions had locks at their Data Centres while 21.1% had swipe cards to monitor access control. In addition, 7.9% of them had guards to protect their Data Centres while 29.0% had CCTV installed at their facilities to monitor physical threats. Meanwhile, other security measures such as biometric identifications were only deployed by 7.9% O/M/As across the public service.

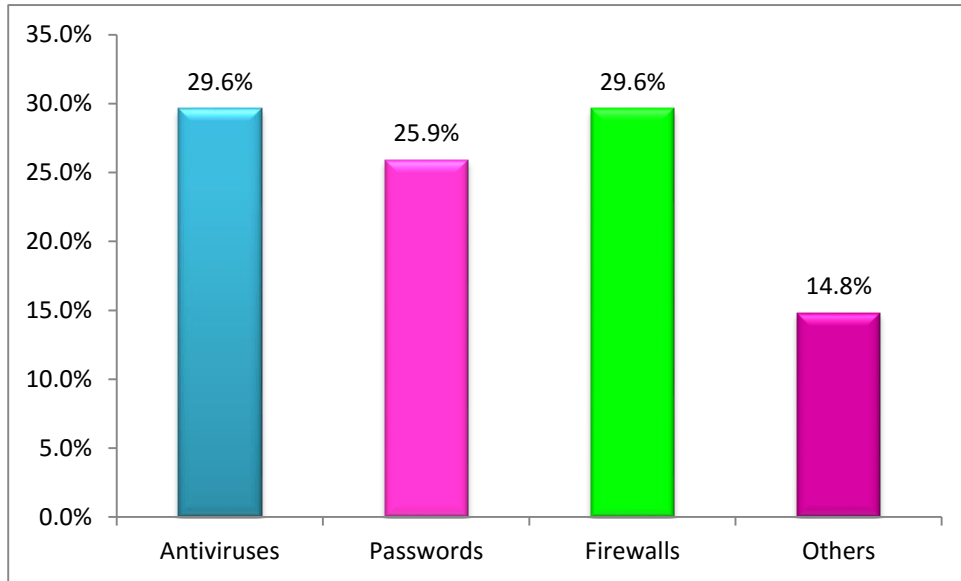


Figure 4.29: Technical measures in place

Figure 4.29 illustrates that 29.6% of GRN institutions were using antivirus software to prevent network security threats at their Data Centres while 25.9% were using passwords as access control for the computers. In addition, 29.6% were using firewalls while 14.8% have configured proxy servers between their client and server computers to prevent security threats.

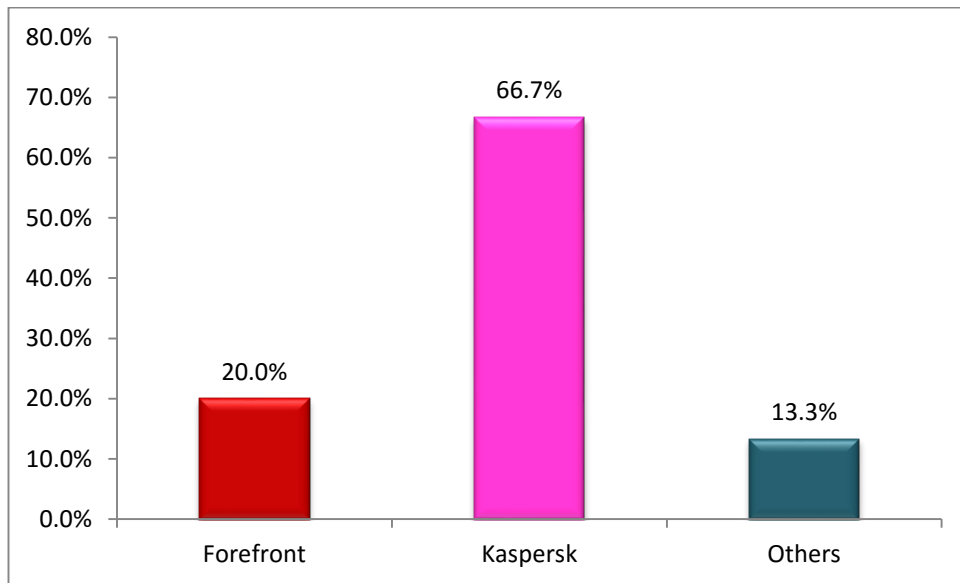


Figure 4.30: Antiviruses software

Figure 4.30 shows that of all the public sector O/M/As, who used different antivirus software to counter network and external threats, the majority (66.7%), indicated that they were using Kaspersky while 20.0% were using Forefront antivirus. The remaining 13.3% were using other antiviruses such as Norton, and AVG.

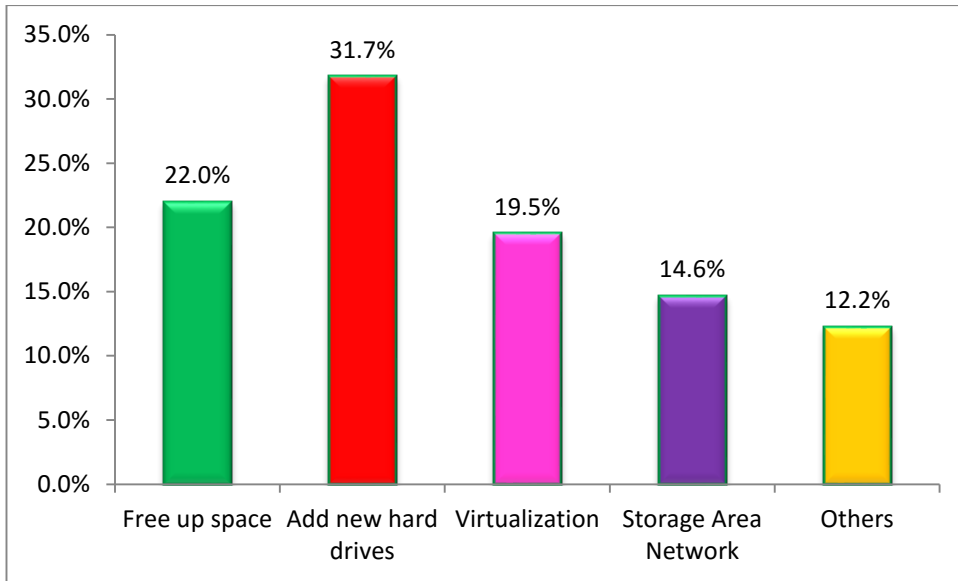


Figure 4.31: Storage capacity control

Figure 4.31 shows that 22.0% Government institutions were managing their storage capacity by freeing up space on their hard drives, 31.7% which is the majority were adding new hard drives to manage the storage capacity, 19.5% were using virtualization, 14.6% were using Storage Area Network while 12.2% were using other methods such as NAS and big data.

4.7 Interviews Results

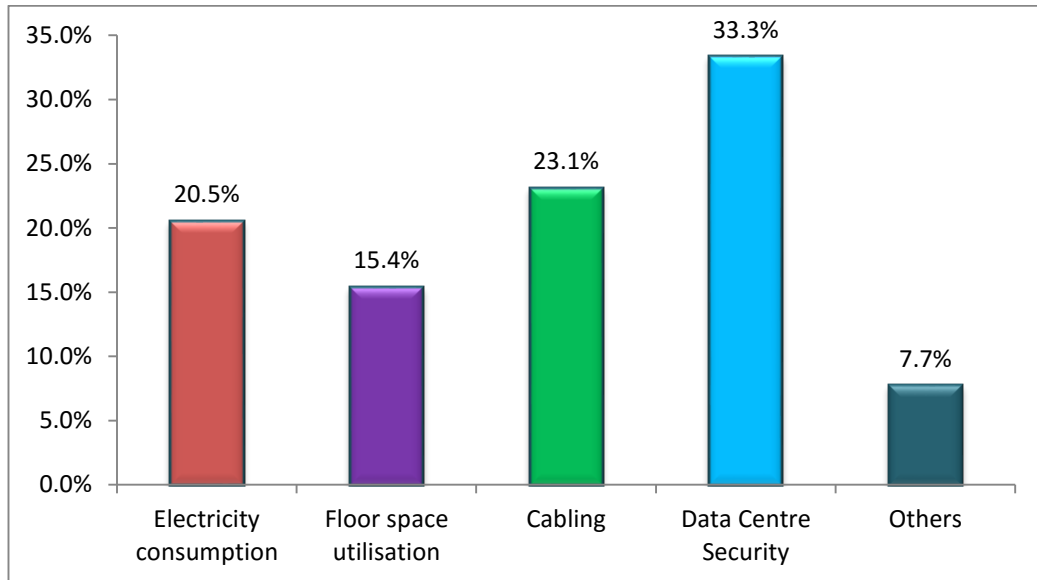


Figure 4.32: Perceptions on Data Centre designs

IT managers were also asked to express their opinions on which elements they felt mostly affected by the poor design of Data Centre infrastructures. Figure 4.32 shows that of all the participants who answered this question, the majority (33.3%) felt that Data Centre Security was mostly affected by the poor design of Data Centre infrastructures, followed by Cabling (23.1%) and electricity (20.5%). Furthermore, floor space utilization and other elements including administration stood at 15.4% and 7.7% respectively.

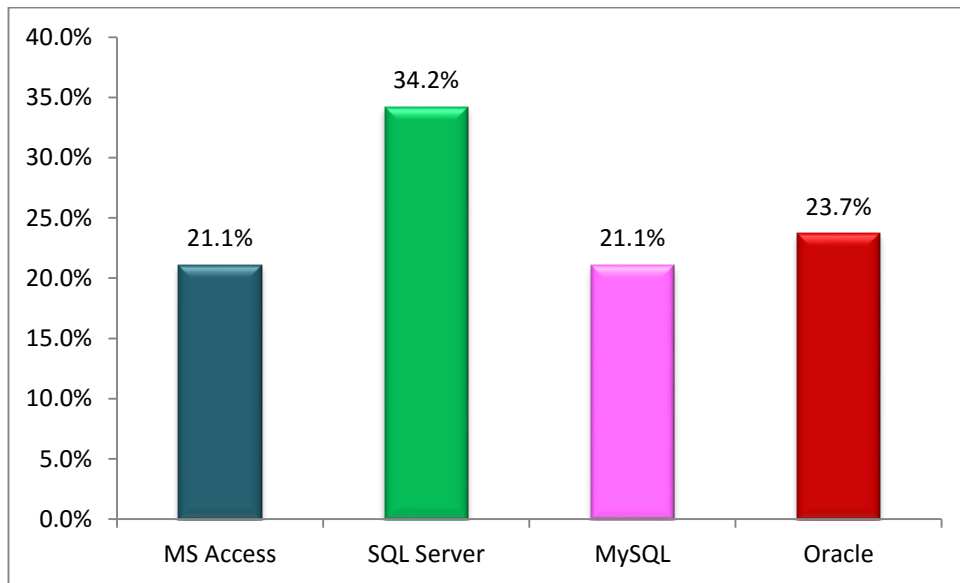


Figure 4.33: DBMS in the public sector

Figure 4.33 shows that there were four common Database Management Systems (DBMS) which were used in the development and support of public sector Information Systems (ISs) in Namibia which were Microsoft Access which was used by (21.6%) of the institutions, SQL Server (35.1%), MySQL (21.6%) and Oracle (21.6%). This meant the majority of institutions in the Namibian Public Sector supported and developed their ISs using SQL server while MS Access, MySQL and Oracle were also common among the O/M/As though not as common or used as SQL Server.

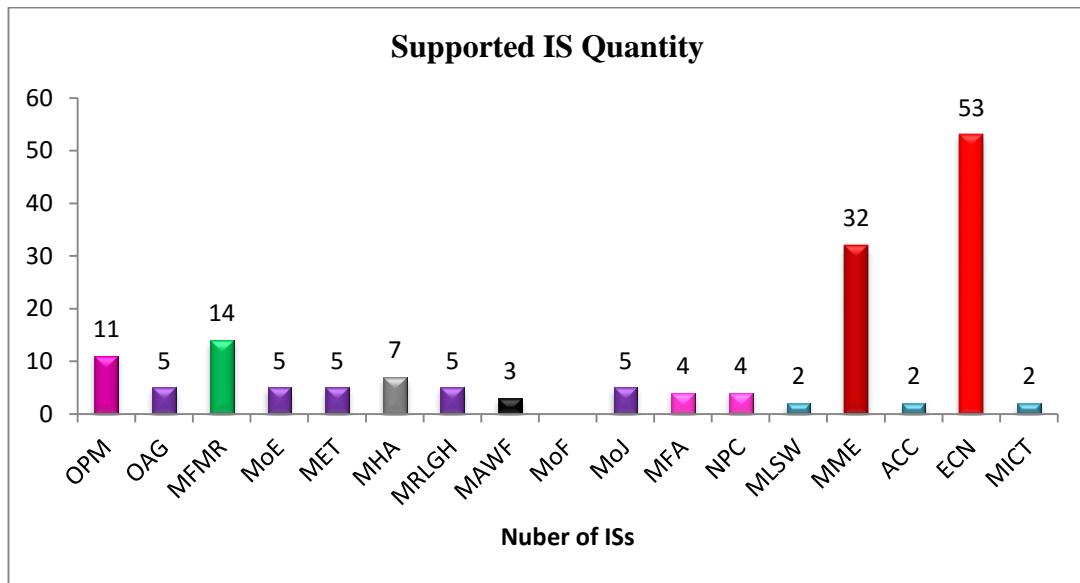


Figure 4.34: Number of Information Systems per O/M/A

Figure 4.34 shows that the OPM has eleven (11) Information Systems which they hosted and supported. In addition, the analysis revealed that the OAG has five (5) Information Systems, MFMR (14), MoE (5), MET (5), MHA (7), MRLGH (5), MAWF (3), MoJ (5), MFA (4), NPC (4), MLSW (2), MME (32), ACC (2), ECN (53) and MICT (2).

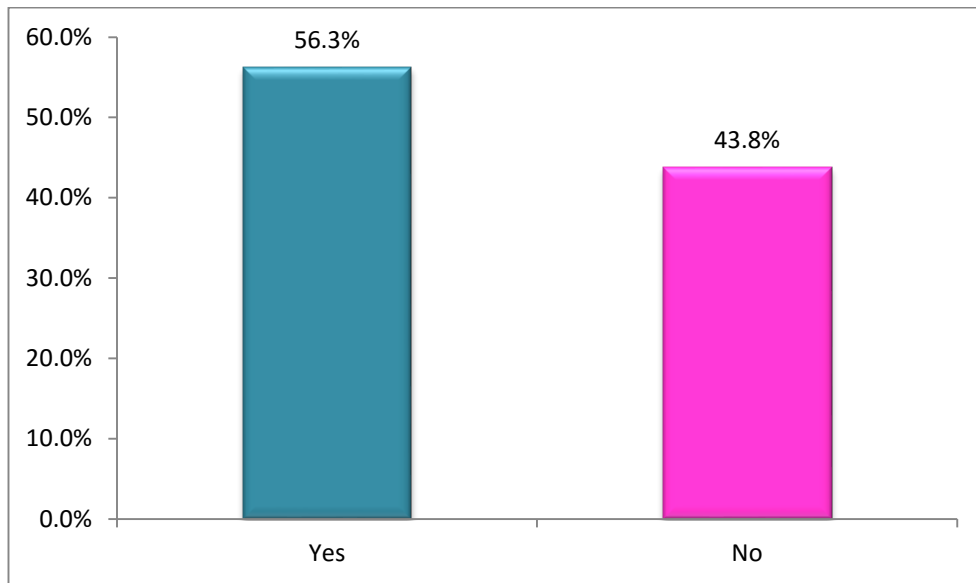


Figure 4.35: IT Managers perspective on ISs integration

According to Figure 4.35 above, 56.3% of IT Managers expressed that there were isolated Information Systems (ISs) being hosted at their Data Centres. These systems needed to be integrated in order to get rid of redundancy. However, 43.8% of the Managers indicated that there was no need to integrate any of the stand-alone systems at their institutions.

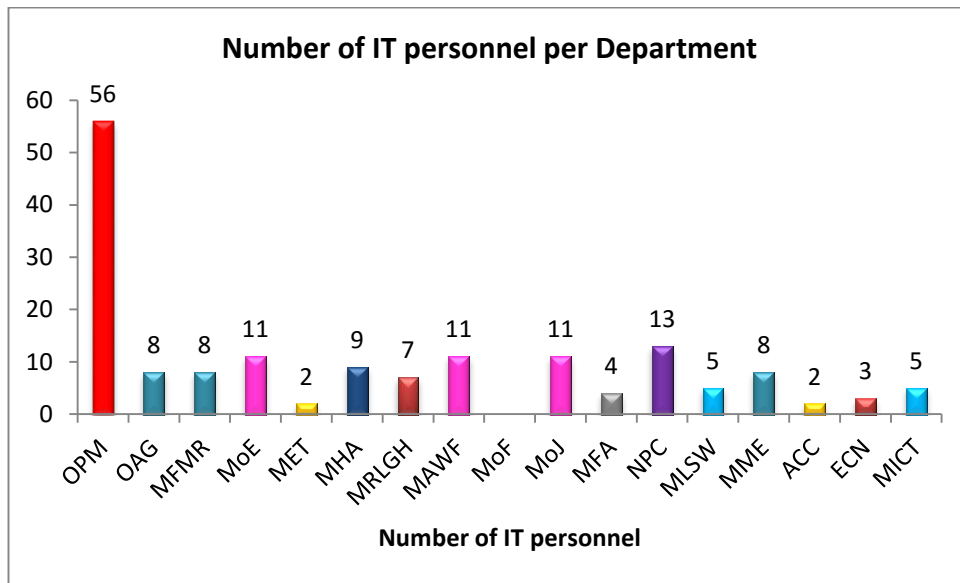


Figure 4.36: Number of IT employees in each O/M/A

Figure 4.36 shows the number of IT employees which were working at each O/M/A in the Namibian Public sector. The study found that the OPM had the biggest number of IT personnel at its Department with 56 employees while the MET and ACC were the organizations with the fewest employees at their IT Departments with two (2) employees each. Furthermore, OAG, MFMR and MME had eight (8) IT employees each while MoE, MAWF and MoJ had eleven IT staff each. In addition, MHA had nine (9), MRLGH had seven (7), MFA (4), NPC (13) while MICT and MLSW had 5 personnel each. The ECN was the second last with few IT personnel (3).

5. DISCUSSION AND DATA ANALYSIS

This chapter discusses the findings of the study. It also interprets some of the results and relationships found during Data Analysis. Sub-research question one was also answered in this section.

5.1 Current states of Data Centre infrastructures in the Namibian Public Sector

Based on the study findings, the discussion was outlined as follows.

5.1.1 Data Centre design

The study found that there was a reasonably high number of Data Centers that were not purposely designed (35.3%) in the Namibian Public Sector (see Figure 4.2). From the findings, it was observed that there was no consistence in the way Data Centres were being designed. The findings in figure 4.2 were justifying the remarks made in the Namibian Strategic Action Plan Report (2012) that poor Data Centre infrastructure design was one of the biggest challenges faced by the public sector. As a result, not purposely designed facilities in the Namibian Public Sector had been exposed to security threats, cabling difficulties and significant increases on electricity consumption (see Figure 4.32). Furthermore, due to the increase on hardware assets in Data Centres, floor space has rapidly diminished at some facilities. Based on the above, Data Centres were left in a situation where they could not scale up their facilities to accommodate additional ICT resources.

5.1.2 Operating systems

The study indicated that Windows (57.1%) was the common operating system used in the Namibian Public Sector, followed by UNIX (35.7%). As a result, almost every institution in the public sector has multiple servers running Windows or Unix Operating Systems. Furthermore, other operating systems were less common in the public sector and accounted for 7.1% only (see Figure 4.5). These other operating systems include Junos which was still new, not only in Namibia, but also all over the world. Therefore, Government institutions were still training their IT employees on how to effectively use, implement and manage Juniper before considering deploying it. Although few institutions had deployed this operating system at their Data Centres, more research and training were still required in order to identify the possible strengths and weaknesses of this new operating system. Respondents were also asked to specify the type of Windows server Editions they were running in their Data Centres. The results revealed that the majority (47.4%) of Data Centres were running Standard Editions, Enterprise Editions (36.8%) while Data Centre Editions was deployed by 15.8% only (see Figure 4.4). Based on the above information, it shows that there were various Windows Editions running in the Namibian Public Sector.

5.1.3 Number of Data Centres

The study has also discovered that some O/M/As (47.1%) had more than one Data Centre infrastructures while one facility would have been enough for them. This meant that only 52.9% were having one Data Centre facility at their institution. The study further disclosed that of the 47.1% with multiple facilities, MRLGH was the leading

institution with four teen (14) Data Centers across the country followed by the MFMR and MET with six (6) and five (5) centers respectively. In addition, the study divulged that 29.4% of the public sector institutions had ten (10) Data Centers among them, each with two (2) facilities. These are: MLSW, MoJ, MAWF, MHA and MoE (see Figure 4.15). The duplication of Data Centers in the Namibian Public Sector has led to complexity and high operational costs. These findings justify remarks made by Computer Economics Report (2007) that many organizations had multiple Data Centers, even though a smaller number of facilities would be sufficient.

5.1.4 Limited budgets

IT organizations were spending a rising percentage of their IT budgets on operating systems, utilities, and Data Centre management applications each year (Computer Economics, 2010). However, this study revealed that some Managers in the public sector were experiencing difficulties on their IT spending hence, unable to scale up their Data Centre facilities. These difficulties were mostly attributed to limited budgets (37.0%) as shown in Figure 4.3. These findings were justified by the results shown in Figures 4.9 and 4.10 which showed that some IT Departments were allocated less budgets and as a result, they were left with little or no money that they would allocate to their Data Centre development activities. Although some IT Departments were allocated millions of dollars, the amount they allocated towards their Data Centre development activities were far too less and hardly make any positive impact. These little allocations to IT Departments came as a result of some decision makers' inability to recognise ICT infrastructure as a backbone for delivering Government services and

to exchange information communication transactions between Government and Businesses, Government and Government institutions and between Government and Citizens. In short, the study established that there was a disparity in terms of budget allocation in with respect to the Data Centre infrastructure development. For example, some offices/ministries and agencies were receiving huge amount of money however, they did not prioritize infrastructure development therefore they ended up giving little amount of money in this crucial area.

5.1.5 Floor space management

The study further revealed that floor space (22.2%) was another limiting factor preventing some IT Managers to expand or add new equipment to their Data Centres (see Figure 4.3). These findings were supported by the results in Table 4.1 some of which were showing that the physical sizes of O/M/As facilities were too small compared to the number of physical servers they were hosting. For example, the average physical size of a public sector Data Centre facility was estimated to be 9.5 square metres while the average number of physical servers hosted at each centre was 8.2 servers/facilities. Based on the above results, it showed that there was a shortage of floor space at some facilities in the Namibian Public Sector considering that Data Centres did not only host servers but they also house other devices such as routers, switches, monitors and racks.

5.1.6 Electricity consumption

The study further revealed that electricity (18.5%) was the third highest limiting factor (see Figure 4.3) which depleting much of their budgets. The finding in Figure 4.3 was strongly supported by some revelations in Figure 4.8 which showed that about 27.9 % of public sector Data Centres spent between 10 000 and more than 100 000 thousand Namibian dollars per month on electricity. It was important to know that this monthly spending might be slightly higher than the amounts given in the study. This was partly because these figures were based on estimations and some respondents (50.0%) were not even willing to disclose their Data Centres’ electricity monthly bills. On the other hand, some IT Managers could not divulge their monthly electricity bills because there were no clear mechanisms put in place to measure monthly electricity utilization in Data Centres. As a result, IT Departments or O/M/As often pay electricity bills without knowing the number of power units their Data Centres had consumed.

5.1.7 Data Centre storage management

Figure 4.3 showed that data storage space was also one of the limiting factors preventing IT Managers from handling massive amount of data that were ever increasing. These findings were supported by results in Figure 4.31 whereby 31.7% respondents revealed that their common storage mechanism was by adding new hard drives while 22.0% of them showed that they free up space on their hard drives to manage their storage spaces. This showed that most Data Centres were experiencing difficulties in keeping up with massive and critical data that needed to be stored and backed up every day. However, this finding contradicts Nacke’s (2012) statement that

most public sector Data Centres collect, store and manipulate data. Therefore, these critical facilities were designed to be flexible so they could grow based on capacity and availability needs, customer demands and Return on Investment (ROI). There was no flexibility when it came to data storage mechanisms in the Namibian Public Sector.

5.1.8 Email services provisioning

The study revealed that some ministries were using different email platforms for example some were using Microsoft Exchange while some were using Sun Solaris (see Figure 4.24). As a result, some users could access their inboxes anytime, from anywhere and with any relevant communication device while some could only read their emails when sitting at their workplaces using a device connected to their domain. Therefore, there was a need to consolidate the existing email platforms into one reliable platform which is flexible and universal. The universal platform would standardize and improve the provisioning of email services across the public sector.

5.1.9 Information access and provisioning

Through observation and thorough investigation, the study discovered that some Information Systems such as e-Service webpage could only be accessed internally. As a result, employees were deprived to view essential information on time, everywhere and with any communication device at their disposal. Therefore, there was a need to diversify these Information Systems so that they could be universally accessible.

5.2 Correlations of variables

In this section the researcher looked at the correlations of some important variables as shown below:

The formula of calculating the correlation between variables is also shown below:

$$r = \frac{\text{Cov}(x,y)}{S_x S_y}$$

, r=Correlations between variables, Cov (x,y)=Covariance of x and y

and $S_x S_y$ = Product of Standard deviation of x and y.

Table 5.1: Correlations between the number of physical and VM servers

		Number of Physical Server(s)	Number of VM Server(s)
Number of Physical server(s)	Pearson Correlation	1	.791**
	Sig. (2-tailed)		.000
	N	16	16
Number of VM Server(s)	Pearson Correlation	.791**	1
	Sig. (2-tailed)	.000	
	N	16	16

** . Correlation is significant at the 0.01 level (2-tailed).

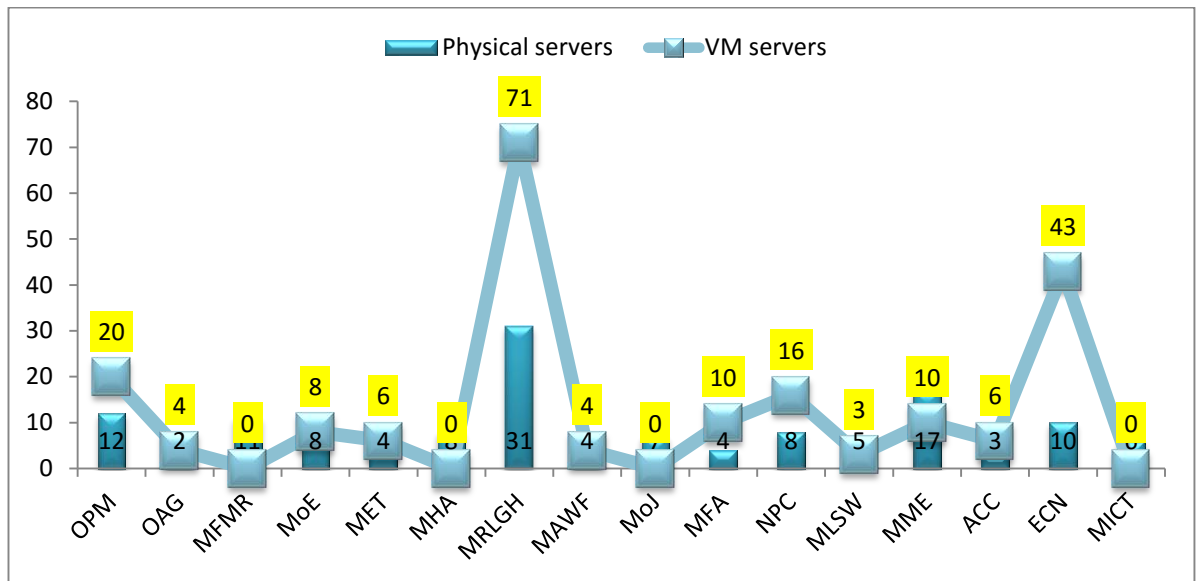


Figure 5.1: Physical versus VM servers

Table 5.1 above showed that there was a positive correlation between the numbers of VM and physical servers in the public sector Data Centres. Since the Correlation was 0.791, this correlation was considered to be strong. The above information illustrated that if the number of physical servers were increasing, the number of VM servers were also increasing. Based on the above results, it showed that the Namibian Public Sector was not applying server management best practices. Hence, there was a need to change the current pattern of server management in public Data Centres through consolidation. The current server management pattern was shown in figure 5.1.

Table 5.2: Correlations between the number of ISs and IT employees

	Number of Information System(s)	Number of IT personnel
Number of Information System(s)	Pearson Correlation	.826**
	Sig. (2-tailed)	.003
	N	10
Number of IT personnel	Pearson Correlation	.826**
	Sig. (2-tailed)	.003
	N	16

** . Correlation is significant at the 0.01 level (2-tailed).

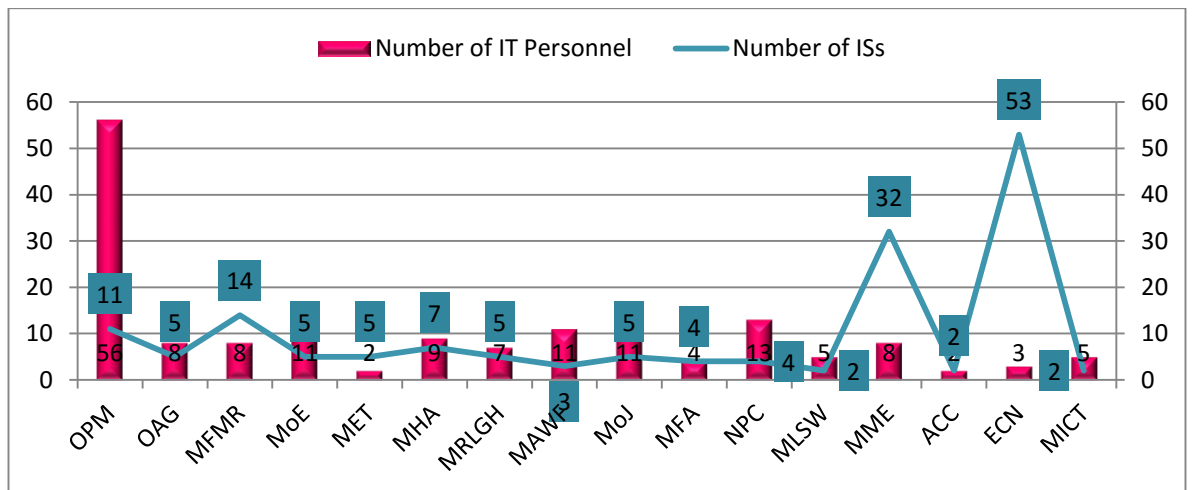


Figure 5.2: Number of ISs versus IT personnel

Table 5.2 above showed that there was a positive correlation between the numbers of IS and IT personnel in the public sector. Since the Correlation was 0.826, this correlation was considered to be strong. The above information illustrated that if the

number of ISs were increasing, the number of IT personnel were also required to increase. The pattern of the above information was illustrated in Figure 5.2.

Table 5.3: Correlations between the number of physical and Data Centre sizes

		Number of Physical Server(s)	Data Centre physical size
Number of physical server(s)	Pearson Correlation	1	0.073
	Sig. (2-tailed)		0.804
	N	16	14
Data Centre physical size	Pearson Correlation	0.073	1
	Sig. (2-tailed)	0.804	
	N	14	14

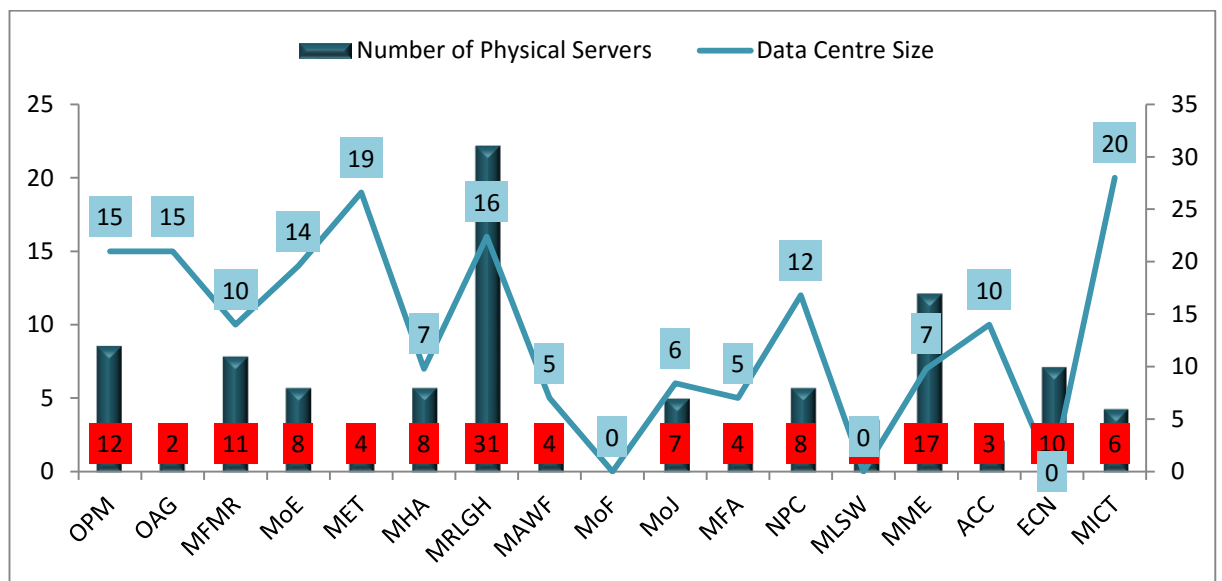


Figure 5.3: Government Data Centre infrastructures space utilization

Table 5.3 above showed that there was a positive correlation between the numbers of VM and physical servers in the public sector Data Centres. However, since the Correlation was 0.073, this correlation was considered to be very weak. In addition,

from Figure 5.3, it was clear that some of the physical sizes of Government Data Centres were too big compared to the number of physical servers they were hosting while some were too small. This meant some Data Centre sizes were conversely proportional to the number of hosted physical servers.

In addition, other interesting situation (see Figure 5.4) established by the study was the number of server racks against the number of physical servers in some Government Data Centres. For example, the Ministry of Agriculture Water and Forestry had only four (4) servers against five (5) server racks in its Data Centre. The study also revealed that the Anti-Corruption Commission had three (3) physical servers against five (5) racks. The above information showed that there was no efficient allocation of resources because it was an inappropriate practice to have more racks than physical servers.

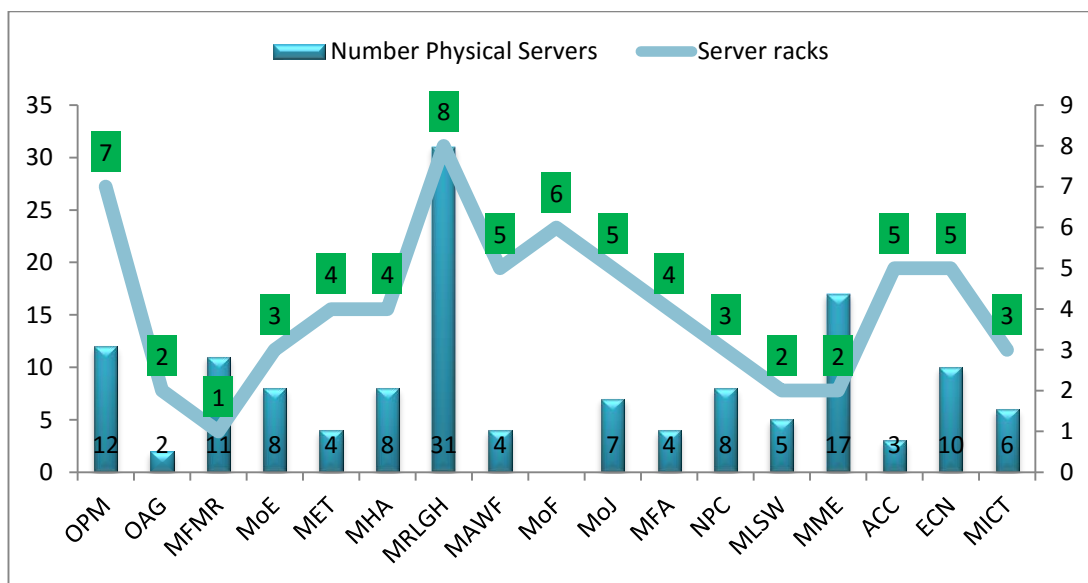


Figure 5.4: The number of physical servers against server racks at each organization

Another interesting finding on this study was the number of institutions with power saving strategies put in place. It was established that only 50% of them had power saving strategies, while the other 50% had no power saving strategy put in place to minimize the consumption of electricity. Furthermore, it was interesting to note that the 50% institutions had different power saving strategies put in place. This meant that there was no standard power saving strategy for the whole public sector therefore there were various strategies put in place such as virtualization (31.3%), generator (18.8%), solar energy (6.3%), lights switch off (25.0%) plus other strategies (18.8%) see Figure 4.7. From the observation, it was clear that some of these power saving strategies were sufficient while some were not sufficient enough to make a positive impact on the utilization of electricity.

In addition, the researcher observed that some respondents indicated that they had power saving strategies at their Data Centres. On the contrary, when they were asked to describe the strategies they had in place, they indicated that UPS is one of their power saving strategies. However, it was noted that UPS was not a power saving strategy but it was rather a power backup in case the power was off temporally. Moreover, the study revealed that almost all sampled Data Centres (100%) had installed UPS. However, the study could not disclose the type of UPS these facilities were using. Through observation, the study established that Data Centres were using different models of UPS and this had created further disparity in public sector operations.

The study has also revealed some interesting findings with regard to the speed of the Internet services at various Government institutions. There was no standard Internet speed in the public sector because institutions had an Internet speed varying from slow to very fast (see Figure 4.25). However, what was more surprising was the number of institutions (41.2%) with slow Internet speed (see figure 4.25). This results showed that the bandwidth at various institutions was too small and had caused the Internet to be slow altogether or at various peak times of a day. The slow internet services were experienced as a result of the slow implementation of WACS at various O/M/As (see Figure 4.13). The figure illustrated that most public sector Data Centres (58.8%) were not yet connected to WACS data line.

In addition, the researcher observed that the process of connecting O/M/As to the WACS was very slow partly because some Government institutions did not follow the right procedures of receiving Internet services through OPM. Furthermore, some O/M/As had their own Internet Service Providers (ISPs) and to implement WACS they had to spend a little bit more money from their own budget allocations which at times was limited. Some of the common obstacles specified by the respondents regarding the rollout of WACS were Telecom Namibia (TN) and OPM inability to speed up the implementation process.

The researcher further discovered that although some respondents indicated to have partially implemented private cloud technology at their Data Centres (see Figure 4.12); in fact none of the Government institutions had officially deployed this technology as yet. On the other hand, there was less understanding on what private cloud was and

how it worked. As a result, there were mixed opinions on the implementation of private cloud technology.

5.3 Security mechanisms

Figure 4.28 showed that the majority (34.2%) of Government institutions use locks at their Data Centres while 21.1% used swipe cards to monitor access control. In addition, 7.9% of them had guards to protect their Data Centres while 29.0% had CCTV installed at their facilities to monitor access movements. Other measures such as biometric fingers were only deployed by 7.9% facilities. Moreover, the study illustrated that 29.6% of the institutions which participated in this study were using antiviruses to monitor and secure their Data Centre ICT resources while 25.9% had enforced passwords usage as their technical measures at their organisations (see Figure 4.29). Of the 25.9% using antiviruses, the majority (66.7%), indicated that they were using Kaspersky while 20.0% were using Forefront antivirus. The remaining 13.3% were using other antiviruses (see Figure 4.30). Based on the above findings, the study established that there was no standardized public sector security measures employed to protect and monitor Data Centre facilities. As a result, O/M/As were deploying their own independent security mechanisms which they felt could secure their environments properly. Some of these security mechanisms were deployed without conducting proper consultations or research. As a result, some of these security mechanisms had left public sector facilities and their resources vulnerable to security threats.

5.4 Discussion of key points

The study found that there was a reasonable number of Data Centers that were not purposely designed (35.3%). Furthermore, Data Centre security (33.3%), cabling (23.1%) and electricity utilization (25.5%) were the top three elements chosen by the participants to be likely affected by the poor design of Data Centre infrastructures.

In addition, limited budget and floor space were identified as the top two (2) limiting factors which prevent various Government institutions to expand their Data Centers. Moreover, there was a huge inequality in the physical sizes of various Government Data Centers. For example some facilities were too big while others were too small.

Standard and Enterprise Editions were the two (2) common server Editions in the public sector while Windows and UNIX were the two common operating systems. The study revealed that the number of Government institutions without power saving strategies stood at 50% while virtualization and “switch-off lights” were the two common techniques employed among the institutions (50%) with power saving strategies in place.

About 50% of the respondents indicated that their monthly electricity consumption figures were confidential, hence, could not be revealed to the researcher. On the other hand, 22.2% of them revealed that they only spent less than N\$10 000 monthly on power consumption. It was fascinating to note that the figure they gave was based on estimations; hence the researcher believes that the cost for power consumption was likely to be higher than indicated in this study.

The percentages spent on Data Centre infrastructure developments at each O/M/As were relatively lower compared to the budget allocated to their respective IT Departments. Virtualization was a common practice in the public sector however, there was still more work to be done because most organizations (33.3%) had implemented it partially and 13.3% were still considering the option of implementing it.

The other technology that required serious consideration was cloud computing, which like virtualization had not been fully implemented yet by the majority of Government institutions.

The study established that most institutions were yet to be connected to the WACS which was aimed at expanding the Government bandwidth and to eventually speed up the Internet. As a result, there was an unbalanced provisioning of Internet services at various O/M/As.

The study has also revealed that some ministries had more than one Data Centre infrastructure while one facility would have been enough for them. The research found that some ministries did not have backup facilities as measures in case of massive data loss caused either by natural or human disasters. Furthermore, it was discovered that some Data Centers had more server racks than the physical servers hosted at their facilities.

Most Government employees were positive on the possible implementation of Data Centre Consolidation. In addition, they felt that it would make significant contribution

on cost cuts, energy consumption, communication and collaboration as well as on-service delivery. On the other hand, the minority who indicated fear on Consolidation stated that single points of failure, theft and privacy were their concerns.

There was also a serious concern on some of the ministries who had been experiencing Internet and email downtime on daily and weekly basis. Based on the above analysis, it was clear that there was disproportion in terms of Internet and email services provisioning in the Namibian Public Sector. As a result, public institutions were experiencing dilemmas such as lack of availability for critical services at different periods of time.

The study established that there was no standardized email platform across the public sector. There was also no conformity in data backups and application updates. Therefore, some O/M/As had been performing their updates and backups daily while others did it on a weekly, monthly or not at all. The study revealed that there was multiple Database Management Systems in the Namibian Public Sector.

The study had also established that there was no consistency in the deployment of anti-virus at various O/M/As. For example, some ministries had Kaspersky as their anti-virus software while some had Microsoft Forefront.

Physical and technical securities were not at the same standard across the public sector. There were also multiple Information Systems in various Government ministries, some of which needed to be integrated.

The other outcome of this study was how various ministries control their storage capacity in their Data Centers. The study showed that the majority of Government institutions had been adding new hard drives to expand their storage capacity while some of them were using techniques such as “free-up space”, virtualization, and Storage Area Network.

The researcher has also observed that if Namibia sets out to start the process of Data Centre consolidation, it should be done in phases and the estimated period to consolidate the whole ICT inventory is three years. This period would allow the consolidation team to completely bring this process to its logical conclusion without any hiccups. Furthermore, it is very important not to disrupt the business continuity during the consolidation process. Therefore it was imperative to keep the current Data Centres operating fully as normal until the consolidation process is developed, tested and implemented. As a result, disruptions during and after implementation would be prevented. The other alternative technique was for the consolidation team to apply hot backup while migrating to the new environment.

5.5 Summary

In short, it was concluded that there was no consistence in the way Data Centres were designed and the way ICT infrastructure resources were managed. As a result, restructuring through consolidation was required if the design and management of resources were to be improved.

6. PROPOSED PSEDCC ARCHTECTURE FOR NAMIBIA

The aim of this chapter was to present the proposed architecture that could be adopted in the implementation of Public Sector Data Centre Consolidation in Namibia. Each component of the architecture was explained in full detail. Furthermore, sub-research question two was addressed here.

6.1 Introduction

The solution to improve Data Centre design was to simply introduce Public Sector Data Centre Consolidation (PSEDCC). The architecture would merge all Government Data Centre infrastructure into two centres of which one is a Disaster Recovery hot site. A “proactive” hot site allows you to keep servers and a live backup site up and running in the event of a disaster. Basically, you replicate your production environment in the data centre. This allows for an immediate cutover in case of disaster at your primary site. It is very important to have a hot site for mission critical sites such as PSEDCC infrastructure.

The architecture in Figure 6.1 illustrated the proposed unified Data Centre architectural design for Namibia known as PSEDCC. In addition, the unified Data Centre site was supported by the backup Disaster Recovery (DR) site which was a replication of the DC site.

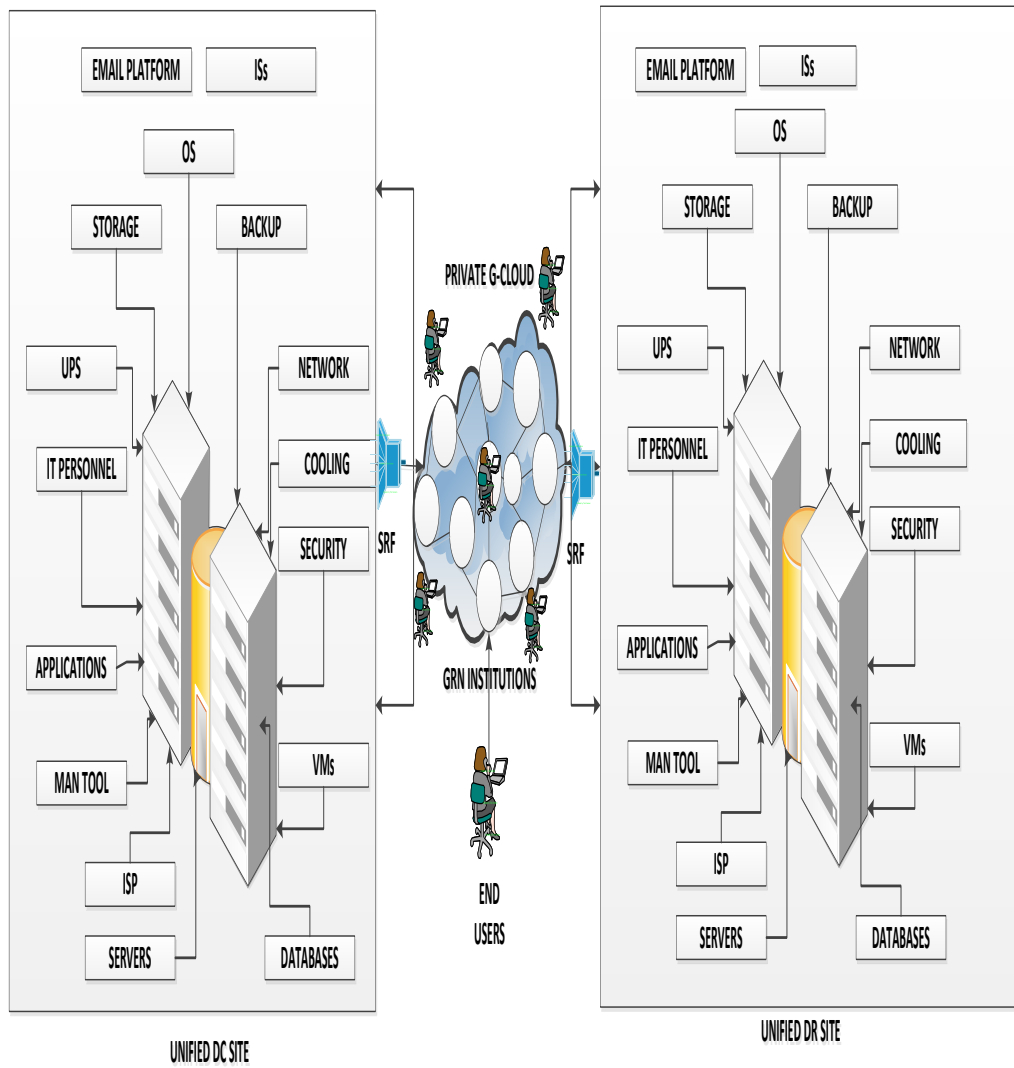


Figure 6.1: Proposed PSEDCC Architecture

6.2 Architectural components

Below is the detailed list of PSEDCC architecture components:

6.2.1 GRN Institutions

The GRN institutions component on Figure 6.1 represented a sample of all the public sector Offices, Ministries and Agencies that were connected and receiving services from the unified Data Centre infrastructure. In this architecture all ministries were connected together and were sharing one Data Centre as opposed to the traditional setup whereby each O/M/A had its own Data Centre facility operating independently.

6.2.2 Unified DC site

The unified DC component represented a unified public sector Data Centre infrastructure. In that architecture, all O/M/As Data Centres were consolidated into a single facility (see Figure 6.1). Furthermore, all O/M/As were sharing services and some important applications such as email services, servers and so on. In other words, the main function of this component was to provide Internet and email services to various public sector institutions through cloud services request. In addition, PSEDCC would combine twenty nine (29) Government Data Centres into a single facility. However, it was interesting to note that this was not just a physical relocation of computer hardware and support personnel but it was a more aggressive effort whereby other consolidation mechanisms were also deployed.

6.2.3 Unified DR site

The unified DR site component represented a Disaster Recovery site of the unified public sector Data Centre. The DR site was a replication of the main Data Centre. It worked exactly like the main Data Centre infrastructure. It also provided similar services to that of the main centre. However, it could only take over in times of disasters. For example, when the main site was experiencing downtime or some maintenance works were taking place there. This implies that DR site would enhance services availability at all times.

6.2.4 Service Request Filter (SRF)

Service Request Filter (SRF) component was responsible to filter the services requested by each end user at the various Government institutions. Furthermore, SRF identified the source of the user request and directs it to the right destination in the DC or DR sites. In addition, SRF directed the requested response of service to the rightful user (requestor). In other words, SRF operates like a relay between the source and the destination. It delivered the request to the destination and it also delivered the response back to the source.

6.2.5 Internet Service Provider (ISP)

ISP component represented a unified Internet Service Provider that provides Internet services to the Data Centre site and ultimately to all O/M/As. In addition, both the Data

Centre and its backup site were connected to the ISP. This strategy was employed to prevent an entire possible blackout of Internet services in the Namibian Public Sector. This meant, if the main Data Centre was down, the backup site would have taken over immediately. The backup site was a replication of the main Data Centre infrastructure both in design and functionality.

6.2.6 IT Personnel

The IT Personnel component represented IT Managers, Administrators and IT support staff who oversee the day-to-day operations of any O/M/A facility. In this architecture, most IT employees were working under one Data Centre roof. This implies that all the current staff would be retained and consolidated in one roof with however, the IT staff structure should remain intact until such a time when the need for change arise. In addition, few IT staff have to remain at the O/M/As to address minor issues which may arise on a daily basis.

6.2.7 Servers

According to this study the average number of physical servers in the Namibian public sector was 8.23 servers per Data Centre. It showed that there were many physical servers in the public sector which contributed greatly to the complex administration of resources, lack of space and high electricity bills. Therefore, PSEDCC would not only moved these servers to a single location but it would also have consolidated their workloads through the use of virtualization. In addition, PSEDCC would reduce the number of physical servers from 8.23 servers per ministry to at most two servers per

ministry. It was interesting to note that this represented 72.2% less the number of physical servers’ henceforth simple administration, proper management of space and significant cut on electricity bills.

6.2.8 Applications

According to the Computer Economics Report (2014), applications running in multiple Data Centres maybe consolidated into a smaller number of applications in the consolidated Data Centre. Similarly, PSEDCC would integrate HCMS, IFMS and other interrelated applications in the Namibian Public Sector. Applications which were running in the previously multiple O/M/As Data Centres had been consolidated into the smaller number of applications.

6.2.9 Databases

Previously, multiple databases were maintained as a result of multiple Data Centres at various institutions. As shown in Figure 4.33, there were many Database Management Systems instances at various ministries. Therefore, the implementation of PSEDCC resulted in the reduction of DBMS instances in the Consolidated Data Centre from four (4) to two (2) instances namely, Oracle and SQL Server. This represented a 50% decrease on the number of DBMS instances found in the Namibian public sector. In addition, Oracle and SQL Server would be the standardised database instances for all Information Systems within the PSEDCC infrastructure model. By consolidating database instances, it would cut licensing costs and it would also simplify database

administration. Furthermore, it may improve data quality by eliminating the need of multiple database duplications.

6.2.10 Storage

The study revealed that there was no uniform storage technique in the Namibian public sector. As a result, each ministry was practicing or employing its own storage methods. To counter the over utilization of storage spaces and to cut the cost of buying multiple storage devices, Big Data elastic storage technology would be deployed in the PSECC architecture. The elastic storage would be a universal storage technique for the Consolidated Data Centre.

6.2.11 Networks

Collapsing a number of O/M/As' Data Centres into a single facility would reduce the number of network devices such as switches, hubs, routers and network points. Furthermore, the number of data lines would be reduced too. At the moment, each ministry has multiple Network lines from its Data Centre directed either to the Office of the Prime Minister or to their respective Internet Service Providers. PSEDCC would only have few data lines in a mesh form whereby each ministry was connected to one another and then to the Consolidated Data Centre.

6.2.12 Operating Systems (OS)

It was fascinating to note that in the PSEDCC architecture, the number of operating systems would be minimized from multiple versions as shown in figure 4.5 to at least

two (2) versions namely Windows and UNIX Operating Systems. According to the Computer Economics Report (2014), the effectiveness of Data Centre Consolidation as cost-reduction strategy based on the powerful economies of scale that large Data Centres enjoyed. To substantiate the above claim, the report stated that regardless of operating system, large Data Centres spent less on a per-server basis than smaller Data Centres.

6.2.13 Security

Lim (2009) emphasised that IT consolidation and virtualization project that did not directly address security issues could result in weaker and less efficient Data Centre protection. Therefore, he felt that centralised management of Data Centre security had several benefits beyond greater efficiency and scalability. He further stated that it gave visibility into, and control over, security polices and their enforcement across the enterprise. He added that this could greatly improve the reliability and consistency of policy enforcement at remote sites, and it could also help security planners ensure that business continuity and disaster recovery capabilities were in place for essential IT services and data, regardless of their location.

In line with Lim (2009) idea, centralised security was an integral part of the PSEDCC architecture. Here, security of all consolidated data centres had been standardised and managed from the main facility. Internal security was very important in this architecture whereby a strong firewall was built to counter any external network threats. Anything suspicious of being a security threat would not be allowed to access

the entire Government network. Meaning, PSEDCC would consolidate security in the public sector. As a result, both physical and technical securities would be consolidated and standardized. For example, in the PSEDCC architecture the Data Centre would deliberately deploy Forefront antivirus software supported by any other five antiviruses to counter internal and external technical threats. On the other hand, biometric technology, CCTV, guards and locks would be the measures for access control management and monitoring.

6.2.14 Uninterrupted Power Supply (UPS)

In the PSEDCC architecture, UPS would be standardized into a single model. The Namibian Public Sector should use redundant Uninterrupted Power Supply (UPS) modules for power availability and scalability. According to Shetler (2008) using redundant UPS modules helped to ensure that one can achieve appropriate levels of availability. He further said, depending on the configuration type, redundancy may also have enabled scalability.

6.2.15 Management tools

According to Buildings (2013) to reach the next level of Data Centre management, one needed a unified approach. Buildings further stated that integration through DCIM of the core infrastructure brought more capacity. Therefore, MAN tool component in Figure 6.1 showed an integrated management tool that monitored, measured, and managed Data Centre performance, utilization, and energy consumption.

6.2.16 Private G-Cloud

Private G-Cloud component in Figure 6.1 was responsible for providing all hosted services on a private Government network. In addition, end users at GRN institutions could access all their Internet services and emails through private cloud.

6.2.17 End users

These were non-technical users of the Data Centre. They accessed Data Centre services remotely by using their laptops, desktop computers, mobile phones. However, to access these services the users should have accessed rights. This implies that their personal details must be populated in the Active Directory.

6.2.18 Email platform

The e-mail platform component represented a consolidated Exchange mail platform whereby Government employees' could access their emails anywhere, anytime and with any relevant telecommunication device.

6.3 Summary

Adopting the above architecture could help the Namibian Public Sector conduct its core businesses efficiently and with little interruptions. In addition, data within this architecture was highly protected through encryption. Furthermore, the architectural design discussed above improved Data Centre performance and significantly reduced IT costs.

7. RECOMMENDATIONS AND CONCLUSION

This Chapter provided recommendations depending on the findings of the study. Furthermore, sub research question three was answered in this chapter. Future research needs were also suggested here. The section concluded with the conclusion of the study.

7.1 Recommendations

In view of the findings done in the study, the following recommendations were made, directed at the Namibian Government IT Managers and other relevant stakeholders who are running and managing Data Center infrastructures and their resources. These recommendations included best practices that should be followed when incorporating Data Centre consolidation in the public sector. These were:

- For the Namibian Public Sector to fight rapidly growing power consumption, it should reduce the number of public sector Data Centres to at least two of which one is a DR site.
- IT Managers/Administrators should define objectives and metrics for the consolidation success.
- Before deciding on what to consolidate, IT Managers should involve Human Resources (HR) staff for advice. Furthermore, detailed and coordinated planning should be conducted with key functional participants.

- Common and less risky services should be the first targets to be consolidated. Furthermore, IT Managers should determine service levels and measure before move.
- IT staff should reuse equipment where possible when implementing the Data Centre consolidation.
- The Government should work with IT vendors on equipment contracts and use consolidation to modernize Data Centre.
- IT Managers should choose the right technology and effective methods to monitor Data Centre temperature.
- The Government should adopt DCIM tool to optimize the public sector Data Centre operations.
- When rolling out consolidation, avoid over-sizing and enhance scalability
- Enhance operational efficiency by adopting effective Data Centre management.
- The Namibian Public Sector through PSEDCC should introduce the metric below to calculate the Data Centre efficiency.

$$PUE = \frac{\text{Total Facility Power}}{\text{IT Equipment Power}}$$

- Downtime prevents Government institutions from achieving their set objectives. In addition, this study revealed that there was a lack of consistency when it came to Internet and email services downtime at various O/M/As. As a result, PSEDCC should be accompanied by VMware v Centre Site Recovery Manager which automates disaster recovery and improves business continuity. Furthermore, to minimize downtime and increase availability the entire Government network should be a mesh designed topology.

- Incorporate Cisco Network Unified System within the PSEDCC architecture to unify Government networks.
- Deploy Airside Economizer to prevent heat in the Data Centre
- Data Centre security should be consolidated from being made up of different components to being standardized across the public sector.
- Data Centre infrastructure should be custom-built to suit the Namibian Government settings. Furthermore, it should meet prescribed standards and guidelines set forth by international industry organizations such as a certain level of raised floor, cabling, electrical, fire protection infrastructure and security.
- The Namibian Public Sector should diversify the accessibility of all ISs so that authorized individuals would be able to access them anytime and from anywhere. In addition, similar ISs should be integrated and shared by all ministries rather than being dedicated to an individual institution only.
- Virtualization and Private Cloud technologies should be fully deployed to reduce the number of physical servers and privatize the Government Network respectively.
- The number of server racks should be reduced from hundreds to at least one rack per ministry but should be located in one Data Centre.
- The number of email platforms should be integrated into one Exchange platform across the public sector. Furthermore, the unified platform should be accessible anywhere, anytime and with any relevant communication device.
- The Consolidated Data Centre should deploy solar as its source of energy to cut the power cost.

- Use Direct Current (DC) power distribution as an alternative to solar energy for efficiency.
- Anti-viruses software should also be consolidated. The preferred antivirus software in this architecture is Forefront incorporated with at least five (5) other antiviruses' software.
- To ensure appropriate levels of availability and scalability in the Data Centre, operators should use redundant Uninterrupted Power Supply (UPS) modules.
- Countless copies of data files consume vast amounts of storage. As a result IT Managers should use deduplication technology which helps to dramatically reduce the amount of disk storage needed to retain and protect Government data.
- IT Managers should establish a baseline of 80% that indicates the excellent status of the Data Center. This implies that anything below that baseline should be regarded unhealthy and addressed as soon as possible.
- Server consolidation project should consider management software such as BMC Software Inc.,' Patrol, which provides enterprise resource allocation and performance assessment capabilities.
- The IT Managers/Administrators should minimize the use of primary storage by migrating data to more efficient secondary storage where appropriate. Furthermore, they should increase storage utilization by using thin provisioning-a technique that lets storage administrators to quickly and dramatically resize flexible volumes, eliminating the need for over allocation.
- The consolidated infrastructure should be protected with VMware v Shield which provides a comprehensive framework for securing virtual Data Centers and cloud environments at all levels.

- Data Centre should have dedicated mechanical, electrical and fire protection infrastructure that is independent from the systems that serve other portions of the building.
- The number of Data Centre staff should be reduced and integrated in order to effectively implement PSEDCC. Furthermore, less experienced IT administrators should be deployed at O/M/As to help end users experiencing technical problems there while more experienced IT staff should be based at the main Data Centre infrastructure.
- To avoid pitfalls emanating from inconsistency decisions, the Namibian Public Sector through PSEDCC should introduce a collective decision making body comprised of all IT Managers in the public sector. This body should review and decide on new service provisioning techniques.
- To fully realize the consolidation and management benefits of networked storage, Data Centres should deploy a solution with a single set of management tools that meets both the SAN and NAS requirements inherent in most Data Centres. Moreover, a unified pool of storage would have higher storage utilization, a single data recovery solution, a single data management model, and greater leverage of IT staff and skills.
- A unified platform for securing stored data across the enterprise, with support for NAS, DAS and SAN environments, should be the optimal solution for Data Centres to protect data assets.
- Data Centres should use pre-terminated cables in order to meet Government’s needs and help cut costs, without sacrificing quality.

- Avoid build-in application directories and turn to single sign-on or directory synchronization tools to make application consolidation easier without disrupting existing user names or passwords.

7.2 Answering research questions

The main research question was addressed through answering the three sub-research questions. Firstly, the researcher outlined the current states of Data Centres in the Namibian Public Sector (see Chapter 5). Secondly, he proposed the architecture that should improve the current Data Centre infrastructure design (see Chapter 6). Finally, the best consolidation practices that would enhance the design and management of ICT resource in Namibia was discussed (see Chapter 7). As a result of this approach, the researcher answered the main research question of the study without tackling it directly. The problem statement was addressed based on answering the three questions.

7.3 Direction of Future Research

Security is one of the dynamics in the management of Data Centres and will always be a major concern in any organization especially the public sector. Based on that, one does not need to comfortably sit down and wait without paying more attention on how public sector Data Centres should be secured over time. Therefore, immediate and future researches should concentrate on frequent reviewing and improving of Data Centre infrastructures security. Furthermore, other researchers are encouraged to explore and discover new consolidation best practices that would further improve the design and management of ICT infrastructure resources.

7.4 Conclusion

Firstly, the study investigated the current state of Data Centre infrastructures in the Namibian Public Sector. This study revealed that most Data Centres were poorly designed and this had led to the inefficient management of ICT resources. For instance, some O/M/As operated more than one Data Centre. In addition, the study discovered that there was a gap when it came to the provisioning of services in Government Data Centres. For example, some O/M/As had more servers while the physical size of their Data Centres was way too small. Secondly, the study further established that most institutions were not applying best practices at their Data Centres. As a result, this has led to high operational costs, under-utilization of some resources, poor security measures, disrupting availability of services, unnecessary over-staffing, unbalanced services and the overall lack of coherence for the provisioning of IT services. Finally, the study has revealed that Data Centre Consolidation was very important and was found to be the reliable solution to the current challenges faced by the public sector. The general perception of most respondents in this study was that Data Centre Consolidation would transform the Namibian Public Sector for the better.

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APPENDIX A- RESEARCH QUESTIONNAIRE



QUESTIONNAIRE

Public Sector Data Centre Consolidation (PSEDCC): Enhancing the Management of Government ICT Infrastructure Resources in Namibia

The purpose of this questionnaire is to help collect data of the study. Please complete either section that applies to you.

All your responses will be treated with **CONFIDENTIALITY** and **ANONIMITY** and only be used for educational purposes.

Section A: IT Managers/Senior IT Support Staff

Please **Put** a cross (X) in the appropriate boxes and **write** in the spaces provided.

1. Ministry/Office/Agency.....
2. Position: Director Deputy Director
Others (specify)
3. How would you define the design of your Data Centre infrastructure?
Purposefully designed Not-purposefully designed
4. What are the limiting factors preventing you from adding new equipment in your Data Centre? (you can select more than one item)
Floor space Electricity Limited budget Data Storage space
Others (specify)
5. How big is the physical size of your main Data Centre? m²
6. Enter the total number of physical servers and VM servers residing in your Data Centre:
Physical Servers VM servers
7. How many servers are running the following Windows server Editions?
Standard Data Centre Enterprise

8. Which of the following Operating Systems are you currently running in your Data Centre? (you can select more than one item)

Windows Unix/Sun Solaris

Others (specify):

.....

9. Do you have any power saving strategy in place at your O/M/A Data Centre (s)?

Yes No

10. On average, how many units of power does your Data Centre consume every month? Kw

11. If **Yes**, which power saving strategy is in place at your O/M/A? (you can select more than one item)

UPS Virtualization Generator Solar energy

Others (specify):

.....

12. Approximately how much money does your O/M/A spend every month on electricity usage in your Data Centre?

Less than N\$ 10, 000 N\$10, 000- N\$ 50,000
N\$ 51,000-N\$ 100,000 More than N\$ 100,000

13. How much money was allocated to your Department/Division for the past 4 years?

	2010	2011	2012	2013
Less than 10,000	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10,000-100,000	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
100,000-500,000	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
500,000- 1000,000	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Greater than 1000,000	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

14. What percentages (%) of the allocated money went to your Data Centre infrastructure development in each of the past 4 years?

	2010	2011	2012	2013
Less than 10%	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10%-20%	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
21%-30%	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
31%-40%	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
41%-50%	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
More than 50%	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

15. To what extent has your organisation implemented Virtualization?
Extensively Partially implemented Not yet implemented
Considering

16. To what level have your organisation implemented Private Cloud?
Fully implemented Partial implemented Not yet implemented
Considering

17. Is your O/M/A connected to Western Africa Cable System (WACS)?
Yes No

18. If **No**, what is the main delay in connecting to WACS?

.....
.....
.....

B: Systems Administrators/ IT Support staff

1. Ministry/Office/Agency.....

2. Position: System Administrator Senior Chief

3. How many Data Centres does your O/M/A/ have across the country?

4. How many off site Backup(s) infrastructure for your Data Centre?

5. Does your Data Centre have a cooling infrastructure in place?
Yes No
6. If **No**, how do you control the temperature level in your Data Centre?
.....
.....
7. How many server racks are in your Data Centre?
8. Do you think Data Centre Consolidation will transform the Namibian Public Sector for the better?
Yes No If **Yes**, go to 9 and If **No**, go to 10
9. Evaluate the positive impact of Data Centre Consolidation in the Public Sector (Number these items in order of importance i.e. 1,2, 3, 4) with 1 being the most important and 4 the least important.
- | | |
|--|--------------------------|
| Data Centre Consolidation lowers IT cost..... | <input type="checkbox"/> |
| Developing new or improved services..... | <input type="checkbox"/> |
| Improving communication and collaboration in the public sector.... | <input type="checkbox"/> |
| Reducing energy consumption in the public sector..... | <input type="checkbox"/> |
10. What is your opinion on the impact of Data Centre Consolidation in the Public Sector?
.....
.....
11. How often do you experience Internet and email services downtime at your Office/Ministry/Agency?
Daily Weekly Monthly Rarely
12. What type of platform is running your email services?
Exchange Sun Solaris
Others (Specify)
13. How fast is your Internet service?
Very Fast Fast Slow Very slow
14. How often does your organisation carry out Data Back-ups?
Daily Weekly Monthly Rarely
15. To what extent does your organisation carry out its Application updates?
Daily Weekly Monthly Rarely
16. Which preventive physical measures have you put in place for maintaining access control of your Data Centre? (you can select more than one item)
Locks Swipe cards Guards CCTV
Others (specify):

17. Select the type of technical measures that are in place for monitoring security of your Data Centre? (you can select more than one item)

Antiviruses Passwords Firewalls

Other (specify):

18. Which of the following antivirus software installed at your Data Centre for security purposes?

Forefront Kaspersky

Other (specify).....

19. How do you manage data storage capacity/volume in your Data Centre? (you can select more than one item)

Free up Space Add new hard drives Virtualization

Storage Area Network

Other (specify).....

Thank you very much for your time in completing this questionnaire!

APPENDIX B- INTERVIEW ITEMS



Interview Questions

Public Sector Data Centre Consolidation (PSEDCC): Enhancing the Design and Management of Government ICT Infrastructure Resources in Namibia

The purpose of this interview is to help collect data of the study. All your responses will be treated with **CONFIDENTIALITY** and **ANONIMITY** and only be used for educational purposes.

IT Managers/ IT Support Staff

Please **Put** a cross (X) in the appropriate boxes and **write** in the spaces provided.

19. Ministry/Office/Agency.....

20. Position: Director Deputy Director
others (specify)

21. Which of the following Database Management Systems have been used in the development and support of your Information Systems? (you can select more than one item)
MS Access SQL server MySQL Oracle

22. How many Information Systems are hosted and supported by your O/M/A?

23. List all the Information System(s) which are currently hosted and supported by your O/M/A? i.e. HCMS, IFMS
.....

24. Is there some Information Systems hosted and supported by your O/M/A which you think need to be integrated with similar systems in the public sector?
Yes No

25. If **yes**, how many Information System (s) that you think need to be integrated?

26. How many IT personnel employed at your Department?

Thank you!!