B.Sc. in Computer Science and Engineering Thesis

Cloud Computing-Feasibility and Prospects for Implementation in Bangladesh Army

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December 2014

CERTIFICATION

This thesis paper titled **"Cloud Computing-Feasibility and Prospects for Implementation in Bangladesh Army"**, submitted by the group as mentioned below has been accepted as satisfactory in partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering in December 2014.

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CANDIDATES' DECLARATION

This is to certify that the work presented in this thesis paper, titled, "Cloud Computing-Feasibility and Prospects for Implementation in Bangladesh Army", is the outcome of the investigation and research carried out by the following students under the supervision of Dr. M. Kaykobad, Professor, Department of Computer Science and Engineering, Bangladesh University of Engineering and Technology.

It is also declared that neither this thesis paper nor any part thereof has been submitted anywhere else for the award of any degree, diploma or other qualifications.

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ACKNOWLEDGEMENT

We are thankful to Almighty Allah for his blessings for the successful completion of our thesis. Our heartiest gratitude, profound indebtedness and deep respect go to our supervisor, Dr. M. Kaykobad, Professor, Department of Computer Science and Engineering, Bangladesh University of Engineering and Technology, for his constant supervision, affectionate guidance and great encouragement and motivation. His keen interest on the topic and valuable advices throughout the study was of great help in completing thesis.

We are especially grateful to the Department of Computer Science and Engineering (CSE) of Military Institute of Science and Technology (MIST) for providing their all out support during the thesis work. Specially our Head of the Department Group Captain Md. Afzal Hossain, psc having immense interest on this specific subject which has been reflected in his number of seminar and journal papers regarding Cloud Computing. We are also thankful to Lieutenant Colonel Syed Muzakkir Ahmed, psc who had a long term experience of supervising and maintaining the core Army Network at Bangladesh Army Headquarters. Our heartfelt indebtedness goes to Lieutenant Colonel Mushfiqur Rahman Masum, Commandant, Army IT support organization (AITSO), Major S M Khaliluallah Russel (AITSO), Engineer Mr. Sofiul and our dearest classmate Lt Tanvir Ahamed, BN for their constant guidance through out our research tenure.

Finally, we would like to thank our families and our course mates for their appreciable assistance, patience and suggestions during the course of our thesis.

Dhaka
December 2014

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ABSTRACT

The evolution of cloud computing technology has brought a significant impact in the field of information technology (IT). Cloud computing *remotely hosting network services and data* is an emerging concept that enables the use of portable devices, increases security, and enables more effective information sharing within organizations. The view of military networks as an enterprise blurs the existing lines between cantonment and field network. Consolidation efforts are effective in permanent, cantonment networks that are connected with high-bandwidth, fiber optic cables. Furthermore, hosting mission-critical services and data in the cloud will save resources and increase cyber security in the long run. However, similar application of consolidation efforts in the temporary, tactical (field) networks presents unique challenges that will be more effectively overcome if mission oriented command systems are developed for use in both environments, issues of physical security are more fully addressed, and if the concepts of cyber are effectively incorporated in our military doctrine.

In this thesis work we mainly tried to focus on incorporating the concept of cloud computing in Bangladesh Army using its present network infrastructure and resources. We proposed a suitable option which can be easily implemented only minor modification at hardware and software level.

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LIST OF ABBREVIATIONS

IT : Information Technology
ICT : Information and Communications Technology
DCS : Data Communication System
NOC : Network Operation Center
AHQ : Army Headquarters
OCS : Oracle Collaboration Suite
ERP : Enterprise Resource Planning
SaaS : Software as a Service
PaaS : Platform as a Service
IaaS : Infrastructure as a Service
J2EE : Java Platform 2 Enterprise Edition
SME : Small and Medium-sized Enterprises
CSP : Cloud Service Provider
WAN : Wide Area Network
AWAN: Army Wide Area Network
HQ : Headquarter
BD : Bangladesh
CHT : Chittagong Hill Tracts
BTCL : Bangladesh Telecommunications Company Limited
NTTN : Nationwide Telecommunication Transmission Network
NTP : Network Time Protocol
OS : Operating System
LAMP: Linux, Apache, MySql and PHP
IPS : Intrusion Prevention System
DNS : Domain Name System
OSS : Open Source Software
WSDL: Web Service Description Language
KVM : Kernel-based Virtual Machine
VT : Virtual Terminal
SCSI : Small Computer System Interface
DC : Data Center
UN : United Nations
UEC : Ubuntu Eucalyptus Cloud

IP : Internet Protocol

API : Application Programming Interface

CLC : Cloud Cluster

CHAPTER 1
INTRODUCTION

1.1 Literature Review

Every decade a new, lower priced computer class forms with new programming platform, network and interface resulting in new usage and industry. Though the concept of clouds is not new, it is undisputable that they have proven a major commercial success over recent years and will play a large part in the ICT domain in future days, as future systems will exploit the capabilities of managed services and resource provisioning further. Clouds are of particular commercial interest with the growing tendency to outsource IT so as to reduce management overhead and to extend existing, limited IT infrastructures. More importantly, they reduce the entrance barrier for new service providers to offer their respective capabilities to a wide market with a minimum of entry costs and infrastructure requirements. In fact, the special capabilities of cloud infrastructures allow providers to experiment with novel service types whilst reducing the risk of wasting resources [1], [2].

The Bangladesh Army is the land forces branch and the largest of the three uniformed service of the Bangladesh Armed Forces. The primary mission of the Army is to provide necessary forces and capabilities in support of Bangladesh's security and defense strategies including defense of the nation's territorial integrity against external attack. Control and operations are administered by the Department of the Army of the Armed Forces Division. The civilian head is the Prime Minister, who by law also holds the defense ministry portfolio. In addition to its primary mission the Bangladesh Army is also constitutionally obligated to assist the civilian government during times of national emergency. This role is commonly referred to as aid to civil administration. The current strength of the army is around 300,000 including reservists [3].

For long Bangladesh Army has its own Data Communication Systems (DCS) that comprises its enterprise level network (Army WAN) and few web based applications running over the network. Army network has around 14 Kilo host connecting all Headquarters, units, institutions and establishments of Bangladesh Army covering the entire country. The Core Network Operation Center (NOC) presently located at AHQ IT Directorate. This network provides services like internet, intra-net web portals and few web based enterprise level applications e.g. OCS mailing, Reports and Return management within Army. Gradually these

web based applications/services will be increased under Army ERP solution as per the need. Army WAN is also designed for universal access for both enterprise and non-enterprise users. Appropriate and secure access control mechanism has also been implemented [4].

This paper aims to give a idea about the utilization of the Army Data Centre with cloud computing concept as a high availability IT infrastructure service. The architecture will be designed and built in a modular manner so as to facilitate the ease of deployment and operations. The modular facilities will be standardized to facilitate deployment in multiple locations and even mobile sites to ensure the availability and survivability of the Army IT and data storage facilities under all foreseeable condition in both peacetime and wartime [5].

1.2 Scope of the Research

The recent, rapid advance of networking technologies enabling commanders and their staffs at all levels to employ unprecedented information dominance, virtually instantaneous visualization of the battlefield, and global communications capabilities. Cloud computing in short, remotely storing data and hosting network services that are traditionally provided locally. Apparently, cloud computing could provide more reliable information access and security, simplicity for deploying units, increased possibilities for virtual training, and reduced costs in terms of locally-maintained hardware. However, some challenges include physical security, information assurance and the physical limitations and increased costs of satellite bandwidth exist. While these challenges are relatively simple to overcome in garrison networks or deployment environments.

This paper will examine the military applications of cloud computing, and assess those applications' necessity, feasibility, and potential effectiveness. The military implementation of cloud computing technologies will have a positive overall impact on the military network in terms of leveraging network and fiscal efficiencies. The prevailing system in military can be made more efficient in terms of exchanging information between the different units and Headquarters. For instance data from different Headquarters cannot be easily shared with the units and lowers formations rapidly. When a situation arises, it has to go through a lengthy dispatch system. Also a lot paperwork has to be done to finally get the required information which wastes huge amount of resources and time. Cloud computing can play an effective role in this case.

The objective of the thesis is to provide an cloud computing model that will allow this information sharing very easily, reliably and with appropriate security attached to it without much hassle. Here, we are implementing and solving a specific model problem to implement effective information sharing and network administration in Military.

1.3 Thesis Organization

The aim of this thesis paper is to effectively develop the cloud computing concept in Army IT infrastructure. The thesis has be organized as follows:

1. In chapter one we have just given an overview of the cloud Computing environment. Also the importance of Cloud Computing in military has been highlighted briefly.

2. The 2nd Chapter deals with details definition of Cloud Computing, criteria of choosing a cloud provider, its deployment types and finally the benefits of cloud computing.

3. The heart of the thesis lies in Chapter three. The present state of Network structure of Bangladesh Army is discussed in details. Thereafter we discussed the basic motivation to migrate to Cloud environment. Options available for cloud is also covered in details. Finally the best options available for military has been recommended.

4. Chapter Four discusses the challenges we are going to face in implementing the Cloud Technology. Also possible way-outs are discussed here.

5. The last chapter deals with some recommendations and summarize the total thesis work.

CHAPTER 2
CLOUD COMPUTING OVERVIEW

2.1 Definition of Cloud Computing

Currently, there is no standard definition of Cloud Computing. In this chapter, we shall try define Cloud Computing is. Cloud Computing is Internet-based technology. It provides computational resources via a computer network. It also provides flexible, scalable, and on-demand services to the end users by centralizing the storage and network bandwidth as well as processing memory. Cloud Computing is a computing platform that offers computing power for scientists when they are exceeding institutions' local computing capabilities [6]. Cloud Computing has moved the user from being attached to a single machine to the Internet; therefore, the user is freed from thinking about the file's physical location. For example, the user is no longer concerned about a specific desktop or flash drive, but instead focuses on the availability of Internet connection.

To be more specific, a cloud is a platform or infrastructure that enables execution of code (services,applications etc.), in a managed and elastic fashion, whereas "managed"means that reliability according to pre-defined quality parameters is automatically ensured and "elastic"implies that the resources are put to use according to actual current requirements observing overarching requirement definitions implicitly, elasticity includes both up- and downward scalability of resources and data, but also load-balancing of data throughput [6].

In recent years, Clouds have spread dramatically because of its available features. Cloud Computing is thereby defined as:

1. A way to access applications hosted on the web through our web browser.

2. A pay-as-you-go model for IT resources accessed over the Internet.

3. Use of commodity computers, distributed throughout an internet, to perform parallel processing, distributed storage, indexing and mining of data.

4. A style of computing where massively scalable IT-related capabilities are provided 'as a service'across the Internet to multiple external customers.

5. An IT buzzword that assures potential clients that our product is on the cutting

edge of technology.

A simple illustration of Cloud Computing development is shown in Figure 2.1.

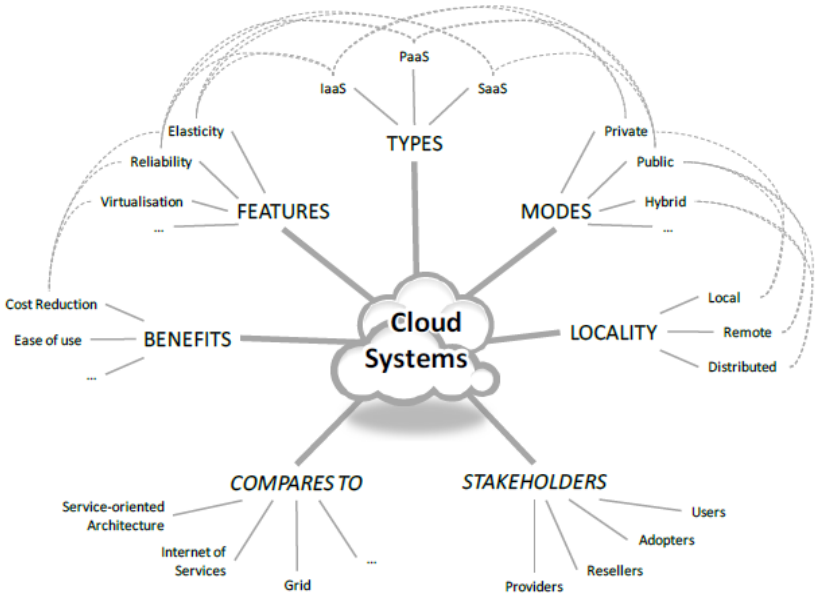

Figure 2.1: A simple illustration of Cloud Computing

2.2 Choosing a Cloud Provider

It must be made clear that Clouds do not generally refer to a specific technology or framework, but rather to a set of combined technologies, respectively a paradigm / concept. Each provider serves a specific function, giving users more or less control over their cloud depending on the type. When we choose a provider, compare our needs to the cloud services available. Cloud needs will vary depending on how we intend to use the space and resources associated with the cloud. If it is for personal home use, we will need a different cloud type and provider. If we are going to use it for business purpose then we should choose different type of cloud provider. If our technological needs change at any point we can purchase more storage space (or less for that matter) from our cloud provider that is pay-as-we-go [4] [7].

There are three types of cloud providers such as Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). These three types differ in the amount of control that we have over our information, and conversely, how much we can expect from our provider to do for us. Briefly, here is what we can expect from each type.

1. Software as a Service. A SaaS provider gives subscribers access to both resources and applications. SaaS makes it unnecessary for us to have a physical copy

of software to install on our computer. SaaS also makes it easier to have the same software on all of our devices at once by accessing it on the cloud. In a SaaS agreement, we have the least control over the cloud. In this model, a complete application is offered to the customer, as a service on demand. A single instance of the service runs on the cloud and multiple end users are serviced. On the customers' side, there is no need for upfront investment in servers or software licenses, while for the provider, the costs are lowered, since only a single application needs to be hosted and maintained. Today SaaS is offered by companies such as Google, Salesforce, Microsoft, Zoho, etc.

2. Platform as a Service. A PaaS system goes a level above the Software as a Service setup. A PaaS provider gives subscribers access to the components that they require to develop and operate applications over the internet. Here, a layer of software, or development environment is encapsulated and offered as a service, upon which other higher levels of service can be built. The customer has the freedom to build his own applications, which run on the provider's infrastructure. To meet manageability and scalability requirements of the applications, PaaS providers offer a predefined combination of OS and application servers, such as LAMP platform (Linux, Apache, MySql and PHP), restricted J2EE, Ruby etc. Google's App Engine, Force.com, etc are some of the popular PaaS examples.

3. Infrastructure as a Service. An IaaS agreement, as the name states, deals primarily with computational infrastructure. In an IaaS agreement, the subscriber completely outsources the storage and resources, such as hardware and software, that they need. As we go down the list from number one to number three, the subscriber gains more control over what they can do within the space of the cloud. The cloud provider has less control in an IaaS system than with an SaaS agreement. IaaS provides basic storage and computing capabilities as standardized services over the network. Servers, storage systems, networking equipment, data center space etc. are pooled and made available to handle workloads. The customer would typically deploy his own software on the infrastructure. Some common examples are Amazon, GoGrid, 3 Tera, etc [1].

2.3 Deployment Types

Similar to P/I/SaaS, clouds may be hosted and employed in different fashions, depending on the use case, respectively the business model of the provider. So far, there has been a tendency of clouds to evolve from private, internal solutions (private clouds) to manage the local infrastructure and the amount of requests e.g. to ensure availability of highly requested data. This is due to the fact that data centers initiating cloud capabilities made use of these features for internal purposes before considering selling the capabilities publicly (public

clouds). Only now that the providers have gained confidence in publication and exposition of cloud features do the first hybrid solutions emerge. This movement from private via public to combined solutions is often considered a 'natural' evolution of such systems, though there is no reason for providers to not start up with hybrid solutions, once the necessary technologies have reached a mature enough position [1]. We can hence distinguish between the following deployment types.

1. Private Cloud. Private cloud are typically owned by the respective enterprise and/or leased. Functionalities are not directly exposed to the customer, though in some cases services with cloud enhanced features may be offered this is similar to (Cloud) Software as a Service from the customer point of view. Example: eBay.

2. Public Cloud. Enterprises may use cloud functionality from others, respectively offer their own services to users outside of the company. Providing the user with the actual capability to exploit the cloud features for his / her own purposes also allows other enterprises to outsource their services to such cloud providers, thus reducing costs and effort to build up their own infrastructure. As noted in the context of cloud types, the scope of functionalities thereby may differ. Example: Amazon, Google Apps, Windows Azure etc.

3. Hybrid Cloud. Though public clouds allow enterprises to outsource parts of their infrastructure to cloud providers, they at the same time would lose control over the resources and the distribution / management of code and data. In some cases, this is not desired by the respective enterprise. Hybrid clouds consist of a mixed employment of private and public cloud infrastructures so as to achieve a maximum of cost reduction through outsourcing whilst maintaining the desired degree of control over e.g. sensitive data by employing local private clouds. There are not many hybrid clouds actually in use today, though initial initiatives such as the one by IBM and Juniper already introduce base technologies for their realization.

4. Community Cloud. Typically cloud systems are restricted to the local infrastructure, i.e. providers of public clouds offer their own infrastructure to customers. Though the provider could actually resell the infrastructure of another provider, clouds do not aggregate infrastructures to build up larger, cross-boundary structures. In particular smaller SMEs could profit from community clouds to which different entities contribute with their respective (smaller) infrastructure. Community clouds can either aggregate public clouds or dedicated resource infrastructures. We may thereby distinguish between private and public community clouds. For example, smaller organizations may come together only to pool their resources for building a private community cloud. As opposed to this, resellers may pool cloud resources from different providers

and resell them. Community Clouds as such are still just a vision, though there are already indicators for such development.

Cloud Market Types	Types of Offerings	Examples
Software-as-a-Service	*Rich Internet application web sites *Application as Web sites *Collaboration and email *Office Productivity *Client apps that connect to services in the cloud	*Flikr *Myspace.com *Cisco WebEx office *Gmail *IBM Bluehouse
App-Components-as-a-Service	*APIs for specific service access for integration *Web based software service than can combine to create new services, as in a mashup	*Amazon Flexible Payments Service and DevPay *Salesforce.coms's AppExchange *Yahoo! Maps APQ *Google Calender API *zembly
Software-Platform-as-a-Service	*Development-Platform-as-a-service *Database *Message Queue *App Servicer *Blob or object data stores	*Google App Engine and BigTable *Microsoft SQL server Data Services *Engine Yard *Salesforce.com's Force.com
Virtual-Infrastructure-as-a-Service	*Virtual Servers *Logical disks *VLAN networks *Systems Management	*Akamai *Amazon EC2 *CohesiveFT *Mosso(from Rackspace) *Joyent Accelerators *Nirvanix Storage Delivery Network
Physical Infrastructure	*Mangaed Hosting *Collocation *Internet Service provider *Unmanaged Hosting	*GoDaddy.com *Rackspace *Savvis

Table 2.1: Cloud Computing Deployment Types

2.4 Cloud Computing Benefits

Important characteristics of Clouds include scalability, flexibility, elasticity, interoperability, and reliability of on-demand services. The client (user) strives for such characteristics. Besides the payment based on usage which offers a cost effective solution, the CSPs offering Clouds services likewise benefit in return for paying for such services.

2.4.1 Scalability

One of the most important characteristics is scalability also known as *the power of scale* which is gained from the virtualization that the Cloud builds upon. Without having such virtualization, the Cloud could not exist in its current shape with unlimited scalability by having the illusion of the unlimited resources availability, flexibility, and elasticity which save a lot of configuration, updating, and maintenance effort. Cloud users employ the hosted applications on the Cloud on top of the SaaS layer which eliminates the expenses of updating, maintaining, and securing applications while still allowing the user to benefit from the massive ability of the Cloud's scalability in user number and file size.

2.4.2 Reduced Cost

Cloud Computing storage and delivery services have significantly reduced the cost thus presenting a valuable solution during the current financial crisis to enable the institutions

to maintain the quality of services. Cloud Computing with virtualization is decreasing the expense of capital by increasing virtualization of the resources. This procedure removes operational expense by automating the requested service.

2.4.3 Increased Storage

With the massive Infrastructure that is offered by Cloud providers today, storage and maintenance of large volumes of data is a reality. Sudden workload spikes are also managed effectively and efficiently, since the cloud can scale dynamically.

2.4.4 Flexibility

This is an extremely important characteristic. With enterprises having to adapt, even more rapidly, to changing business conditions, speed to deliver is critical. Cloud computing stresses on getting applications to market very quickly, by using the most appropriate building blocks necessary for deployment. It provides a user interface which contains all the services that can be delivered. Delivering the services via Cloud Computing increases the resource utilization and availability. In addition to cost reduction, the Cloud can save time, energy consumption, and effort in building infrastructure. Furthermore, doing the mobile computational process on the Cloud can save a mobile's battery. We can easily get the needed solutions from Clouds. Further, the Cloud offers massive data processing and sophisticated applications which can solve the computational needs of a wide range of scientific disciplines, such as e-science and climate research due to the numerous virtual data centers that they provide as servers. In addition, the Cloud collaboration tools and application have attracted scientists who desire to share their information and imitate others. Cloud Computing offers a robust and fast computing environment. Moreover, using Cloud Computing Infrastructure with its remote management ability creates communication, collaboration, and resource sharing abilities with other institutions. There are a number of reasons to attribute Cloud technology with lower costs. The billing model is pay as per usage; the infrastructure is not purchased thus lowering maintenance. Initial expense and recurring expenses are much lower than traditional computing.

CHAPTER 3
CLOUD COMPUTING IN ARMY: HARDWARE AND SOFTWARE NETWORK

3.1 Bangladesh Army Network Infrastructure : Present Status

Bangladesh Army has its own Data Communication Systems (DCS) that comprises its enterprise level network (Army WAN) and few web based applications running over the network. Army WAN has around 14,000 host connecting all Headquarters, units, institutions and establishments of BD Army covering the entire country. The Core Network Operation Center (NOC) presently located at AHQ IT Directorate is the hub of this massive network. Utilization of this network is now limited to services like internet, intranet web portals and few web based enterprise level applications e.g. OCS mailing, Reports and Return management within Army. Gradually these web based applications / services will be increased under Army ERP solution as per the need. Army WAN is also designed for universal access for both enterprise and non-enterprise users. Appropriate and secure access control mechanism has also been implemented [4], [8].

Enterprise network of Bangladesh Army is known as Army Wide Area Network, in short Army WAN / AWAN. AWAN is expanded to all the formations including CHT. Present Data Center of AWAN is located at AHQ IT Directorate. Formations WANs are connected to the Data Centre using secure BTCL and NTTN E-1 links. Each Major Garrison has BTCL internet gateway and Bandwidth Manager. Development of this army WAN is going on by phases [9].

Finally Army has planned for a state-of-the-art tier 3 level Data Center which will replace current Data Center and with earlier one to be used as Disaster Recovery site. Then it will scale out nicely with Army's computing need in future. The aim of Bangladesh Army is to complete tire -3 data center by 2015 . Present Army WAN Network Infrastructure is shown in Figure 3.1.

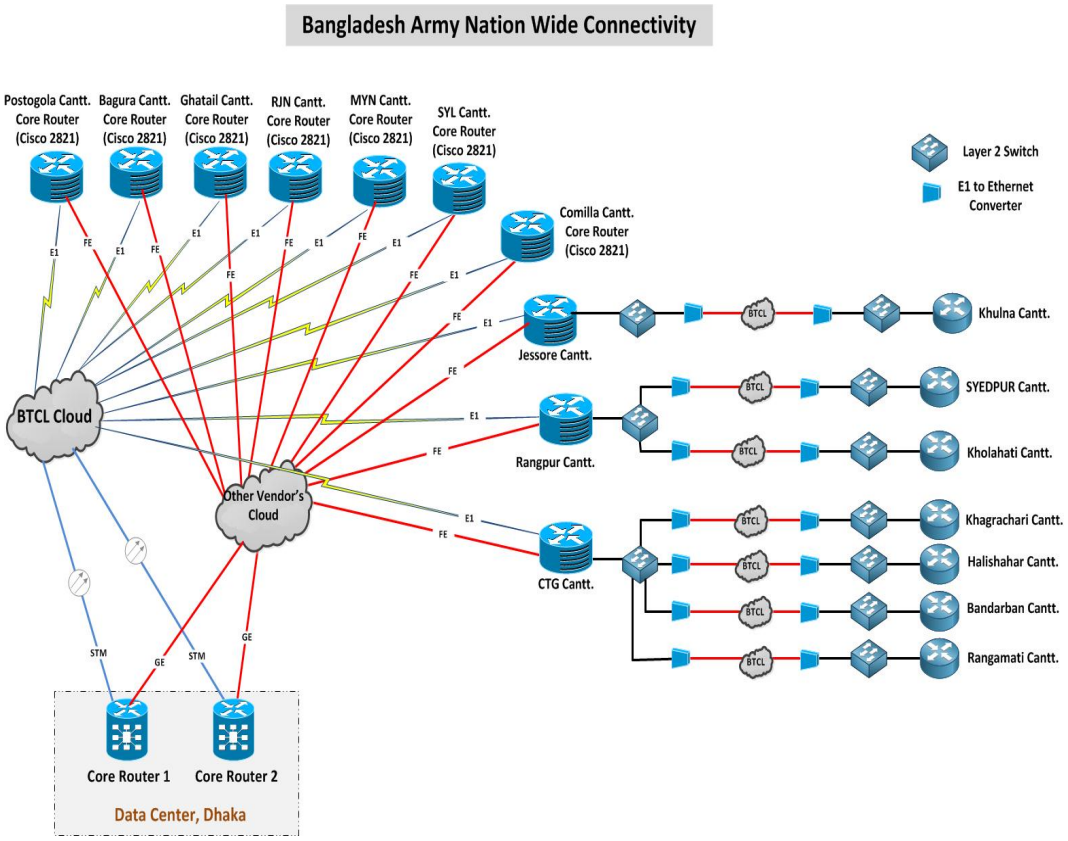

Figure 3.1: Present Army WAN Network Infrastructure.

3.2 Development of Data Center

3.2.1 Transformation Of Army WAN

The latest development of Army is construction of 500 Tera Byte Data center which is located in Dhaka Cantonment [4], [8]. Characteristics of data center includes following:

1. Firewall with Intrusion Prevention System (IPS) deployed to secure network from external and internal threat.

2. Manual configuration of communication is replaced with Dynamic Configuration System to establish accountability, avoid configuration conflict and to reduce admin overload.

3. Network Time Protocol (NTP) deploy to maintain standard timings in AWAN.

4. Domain Name System (DNS) deploy in formation for faster access to information.

5. Proxy Server deployed in formation for faster browsing and to access legitimate web sites.

6. Network Device Monitoring and Connectivity Graphing is deployed to reduce down time and to enhance reliability. It will provide a standard platform to host the various IT applications that are necessary for the Army to efficiently perform its role.

7. The project includes the IT infrastructure for the computing, storage, backup, restore and networking components of the Army Data Center and associated infrastructure / passive components like raised floor, cooling system, fire control system, access control system, environmental monitoring system, electrical power system, water detection system etc.

8. This project aims to build the Army Data Center as a high availability IT infrastructure service. The architecture will be designed and built in a modular manner so as to facilitate the ease of deployment and operations. The modular facilities will be standardized to facilitate deployment in multiple locations and even mobile sites to ensure the availability and survivability of the Army IT and data storage facilities under all foreseeable condition in both peacetime and wartime.

A simple illustration of Army WAN is shown in Figure 3.2.

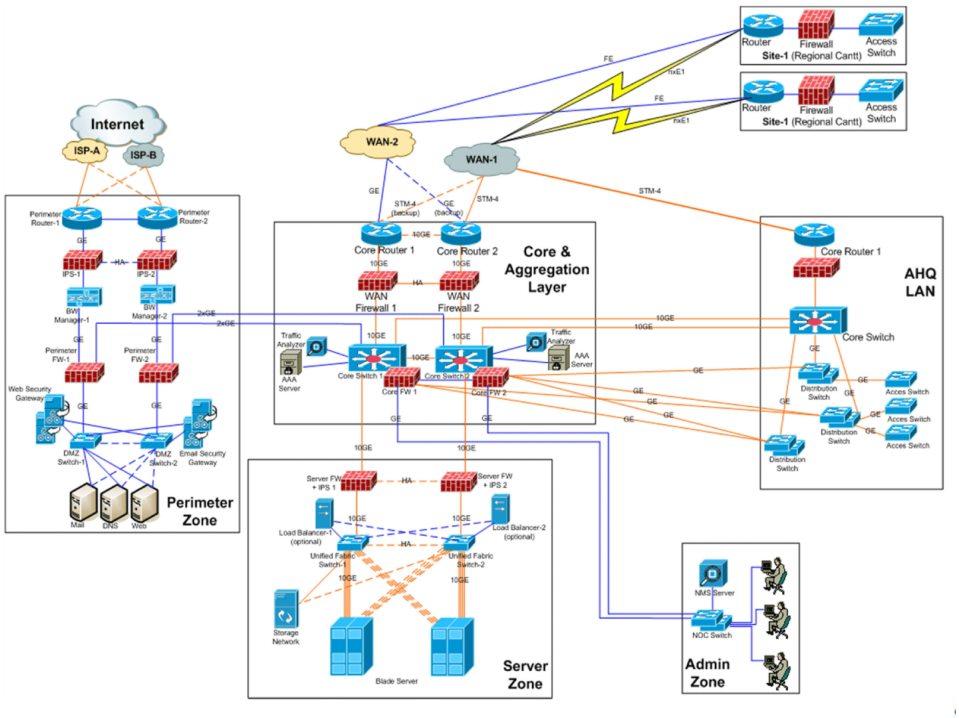

Figure 3.2: A simple illustration of Army WAN.

3.2.2 Motivation for Migrating to Cloud Computing

Some factors have been corroborated in many analyst reports about the major barrier to getting started with cloud. Security concerns are the most important fear among IT decision-makers for both public and private cloud, especially public cloud. Other factors, such as lack of technology, maturity, lack of personnel skill sets, organizational challenges and difficulty integrating with existing infrastructure will likely decrease over time as cloud success stories circulate [1].

In BD Army we are planning to implement cloud as we have our own IT infrastructure and data center. With secure network and secure data center it will very feasible to implement cloud in BD Army. We can consider few points regarding migration of cloud computing. Those are as follows:

1. It's important to understand that when Bangladesh Army adopt the cloud, they do not have to change their IT infrastructures considerably to enjoy the benefits. Our formations network that are connected through fiber optic cables and high bandwidth and proposed data center is quite compatible enough to support cloud computing.

2. Transforming the way IT works in the organization is going to take time and most customers (Bangladesh Army) will not be ready to put key IT services or applications into the hands of an external service provider straight way. Most are likely to adopt a hybrid approach and use a mix of on-premises systems and run others in the cloud. But these systems will need be fully integrated and work together and there are good opportunities for service provider here to provide assessment and adoption support as well as consultancy and planning and migration services.

3. Physical security are more fully addressed, and if the concepts of cyber are effectively operationalized in a more comprehensive doctrine .

4. A cloud infrastructure is the configuration of hardware and software that enables five essential characteristics: on-demand self-service, meaning a user can connect as needed automatically; broad network access, with minimum hardware requirements; resource pooling; rapid elasticity, meaning capabilities can be automatically scaled transparent to the consumer and according to demand; and measured service, or a charge-per-use basis.

5. The traditional IT delivery model is focused on the development, maintenance, and operation of computing hardware and software, the cloud computing model focuses on providing IT as a service. Service providers and service consumers interact over an Internet Protocol (IP)-based network. As we have our own infrastructure so it is very simple to migrate to cloud computing,

6. The military implementation of cloud computing technologies will have a positive overall impact on the military network in terms of leveraging network and fiscal efficiencies.

7. Using this modern technique an additional layer on the existing system will enable the commanders and their staffs at all levels to employ unprecedented information dominance, virtually visualization of the battlefield and global communication capabilities.

8. For organizations like BD Army whose core business is not information technology, the maintenance of an IT infrastructure is quite expensive. Recruiting suitably skilled staff and arranging their training and certifications, software licenses and hardware infrastructure need huge upfront investment and continuous maintenance and management responsibilities. By implementing cloud we can reduce the maintenance cost of an IT infrastructure.

9. Establishing core data centers for BD Army that are more standardized enables the Army to command and control the network and secure it better. It also provides a consistent environment to develop applications that would be less expensive to operate and maintain in the long run and for soldiers to access and discover information.

10. If we have some or all IT systems and applications residing in the cloud, we do not need to have as many or perhaps even any servers on premises. As well as not having to purchase these systems, we also do not need to pay to have them supported and maintained. The potential for reduction in running costs of the server room alone are enormous as less hardware means less power and cooling too.

11. Another issue is command and control of a cloud. Bangladesh Army needs to be able to turn services on and off and to perform critical tasks if systems come under attack. Any cloud offering has to recognize public-key infrastructure credentials and provide access to the correct, and only the correct, information. Now we have to do study on engineering-related difficulties of implementing such technology for the BD Army with present IT infrastructure.

12. Another attractive point of the cloud is its ability to enable a mobile work force. The military is interested in that for several reasons, including flexibility and being able to tie identities to information regardless of network or access point.

13. The cloud environment provides the opportunity for our work force to engage this vast information we have in a completely different manner than we are doing it today. It is no longer needed to be sitting at desk to perform any task.

14. With the advancement of automation in technology BD Army going to use many system and software which will enhance the efficiency of military. With cloud-based applications, it is much easier to keep software up-to-date than it would be with on-premises software. When updates and upgrades are needed, they will be implemented by the service provider.

15. Instead of the massive disruption these would have caused not to mention the need for IT staff to set- up and manage the whole project, the process is automated with zero disruption to the end user and no down time. The cost of managing software in this way is a fraction of what it would be with on-premises implementation.

16. When it comes to hardware. If much of the computing power and the storage capacity is in the cloud, then there will be no need for ongoing maintenance, management and support of those resources in individual cantt. In many or most cases, customers (Bangladesh Army) will keep major servers on-premises, but additional storage capacity may well go to the cloud and the less hardware there is to keep well-maintained and running, the less a burden it is on the IT function and the business as a whole. As we have data center so feasibility of storage capacity is excellent.

3.3 Integration of Cloud Computing Concept with Army WAN Infrastructure

The recent, rapid advance of networking technologies and the applications of cloud computing technologies will have a positive impact on military networks. This will provide more reliable information access and security, simplicity in deploying units, increased possibilities for virtual training. This will also reduce the cost in terms of locally maintained hardware and software.Bangladesh army has its own established network. Cloud services inherently transmit customer data across uncontrolled internet connections that are susceptible to monitoring and interception. So we can start cloud without any security risk. Cloud services typically reside within a shared infrastructure with multiple customers' data residing on the same physical and logical storage media. This increases the risk of data spillage across logical (customer) boundaries either by intentional manipulation of the shared infrastructure by a malicious actor, or unintentional spillage due to administrator error in system configuration or data manipulation operations. But BD Army is going to implement tier -3 data center by 2015. So security of storage of data can be efficiently reduced.

3.4 Options Available for Implementing Cloud Computing

An organization that is considering implementing the cloud technologies can have several choices for using cloud computing technologies:

1. Licensed / Enterprise private cloud solutions.
2. Specially tailored solutions.
3. Private cloud based on open source.
4. Public Cloud.

Nowadays, most organizations have an existing IT infrastructure usually based on licensed versions of private cloud solutions (like it is a case with Corporate IT at University of Copenhagen that uses VMware). The advantages are a number of available features and the support options. The organizations that need to provide their users with special and tailored solutions, or need very large or non-standard software installations could go for self-developed implementation. That requires time and effort for implementation, but at the end there is a solution that can greatly fit the needs. This solution's vulnerabilities are the level of expertise needed for designing, deploying and maintain the solution, and keeping it up to date with trends and advancing both in organization's are of interest, and with systems and software used for implementation [7].

There are options for using Open Eucalyptus and Open Nebula which is based on options like open source based solution and with available options. But services like database service and queuing services should be implemented by organization itself. It also need a system administrator expertise and a high level of control of network topology.

For organizations like army just starting with cloud computing, and its existing features available it may be more appropriate to implement solutions using a private cloud provider [10].

3.5 Designing and Choosing a Solution

Choosing which pattern is suitable for the organization depends on the usage pattern. An analysis should be performed to find out the appropriate choice of solution. Presently Army have its WAN connectivity in all formations but there are places for army for doing tactical and operational work which need more reliable and secured network. It should be accessible from different places in peace and war time. That is one of the reason for choosing UEC based on Eucalyptus. Private cloud needs current hardware. To mitigate all the work

for manual firing up the instances, or services installed on those instances, an independent scripting language could be implemented for the purpose of automation.

Comparing Public vs. Private clouds - private clouds are more customizable, but have greater installation cost, and lower flexibility. Keep the software platform, hardware and knowledge updated. This has a advantage of monitoring and analyzing costs, available features and complexity compared to the budget, needs and internal resources available. So choosing a solution for cloud computing is a challenge for BD Army. As in military the data protection is very much necessary and cost for secure data is getting large day by day, so we need to go for private cloud computing.

But a third party solution provider is required for implementing cloud over our existing IT infrastructure. The vendor can provide design according to our choice. Solution should be designed to include two or several providers, and standardizing is helpful in obtaining some sort of independence. Moving an organization's data to a cloud provider brings the issue of exporting the data, and all the providers are more than happy to supply the organization with the tool that can perform the export. However, it is equally important to consider the measures required in order to get the organization's data back again for in-sourcing or just changing a storage provider. But as we have our own data center so storage provider is not required at all [11].

Ubuntu private cloud with Eucalyptus is chosen for the implementation for several reasons. Firstly, it is Open Source Software (OSS), which was one of the requirements for the project. In academic and educational environments, OSS solutions are mainly used for the sake of interchangeability between different organization (instead of being limited by using different proprietary software), and because of socio-organizational reasons. Eucalyptus cloud software incorporated, is suitable since it is designed and suited to support private cloud solutions from a small starting point, and then scaling up/out as needed. This bundling of the Ubuntu Server Edition with Eucalyptus and other applications makes it very easy to install and configure [7].

Moreover, our Army organization have an existing virtualization infrastructure based on VMware, a Eucalyptus based solution can seamlessly overlay on top of an existing ESX/ESXi environment by transforming VMware based hypervisor environment into an Amazon AWS-like on-premise private cloud.

3.6 Major UEC/Eucalyptus Components

UEC/Eucalyptus is an on-premise private cloud platform, designed as a distributed system - a modular set of five simple elements. Linux based processes that interact with each other

form the cloud layer. The components are:

1. Node Controller (NC).
2. Cluster Controller (CC).
3. Walrus Storage Controller (WS3).
4. Storage Controller (SC).
5. Cloud Controller (CLC).

Each element is acting as an independent web service that exposes Web Service Description Language (WSDL) document defining the API to interact with it [7].

3.6.1 Node Controller (NC)

Eucalyptus supports several hypervisors: KVM and Xen in open source version, and VMware (ESX/ESXi) is Enterprise Edition. Kernel-based Virtual Machine (KVM) is a virtualization solution for Linux on hardware that contains virtualization extensions. In Eucalyptus, KVM is chosen as preferred hypervisor. VT enabled server capable of running KVM is having Intel VT or AMD-V virtualization extensions. Allowing multiple operating systems to run concurrently as virtual machines on a host computer, hypervisor manages the execution of the operating systems of the virtual machines, called instances. The NC is running on each UEC node and is controlling the instances on the node. NC is communicating with both the operating system and the hypervisor running on the node, and Cluster Controller. It gathers the data about physical resource availability on the node and their utilization, and the data about instances running on that node, and reports the data to the Cluster Controller.

3.6.2 Cluster Controller (CC)

A cluster is a collection of machines grouped together in the same network broadcast domain. CC is the entry point to a cluster. It manages NCs and instances running on them. It is communicating with Cloud Controller and Node Controller, receiving requests for deploying instances from CLC, and deciding about the NCs they will be used for deploying them. It also controls the virtual network available to the instances, and collects information on NCs, reporting it to CLC.

3.6.3 Walrus Storage Controller (WS3)

WS3 is equivalent to Amazons S3. It is implementing the S3-like functionality: bucket based storage system with put/get storage model (create and delete buckets, create objects, and put or get those objects from buckets). WS3 is storing the machine images and snapshots. It is a persistent simple storage service (using S3 API compatible REST and SOAP APIs) storing and serving files.

3.6.4 Storage Controller (SC)

SC is providing the persistent storage for instances on the cluster level, in form of block level storage volumes. The instances are using ATA over Ethernet (AoE) or Internet SCSI (iSCSI) protocol to mount the virtual storage devices. SC allows creation of block storage similar to Amazons Elastic Block Storage (EBS), and creation of storage volumes, attaching, detaching and creation of snapshots.

Major UEC/Eucalyptus components are being illustrated in Figure 3.3.

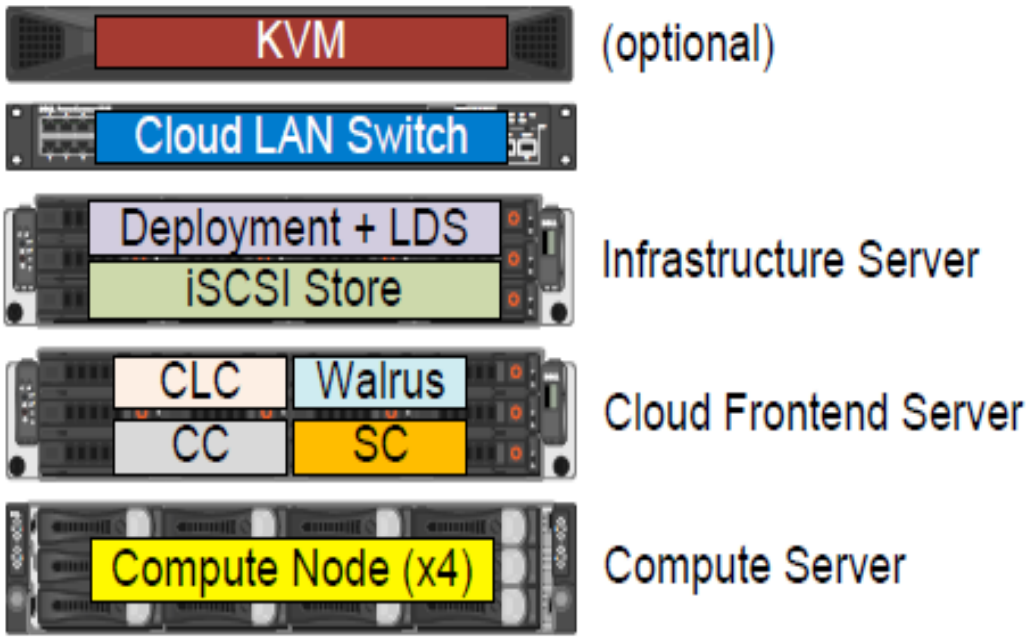

Figure 3.3: Major UEC/Eucalyptus components.

3.6.5 Cloud Controller (CLC)

CLC is the entry point to Eucalyptus cloud, and is equivalent to Amazons EC2. It gathers information on the usage and availability of the resources in the cloud. It is the frontend for

managing the entire UEC infrastructure. It has both web interfaces for administrators managing an infrastructure (such as images, users, groups, storage, network, and clusters), and the web 16 services interface (EC2/S3 compliant) for end users (client tools). It monitors the running instances, and the availability of resources on components of the cloud infrastructure. Based on the information on the infrastructures load and resource availability, it arbitrates the available resources, dispatching the load to the clusters.

3.7 The Network

Generally, a network solution can be viewed from two aspects: physical network infrastructures, and Eucalyptus network. A physical network infrastructure, that designates the networking between components, can be designed in several ways: from the simplest, where all of the components are on the same network. Which is possible with our IT infrastructure. Proposed solution guideline for implementing cloud in Bangladesh Army integrating with the existing system infrastructure is shown in Figure 3.4.

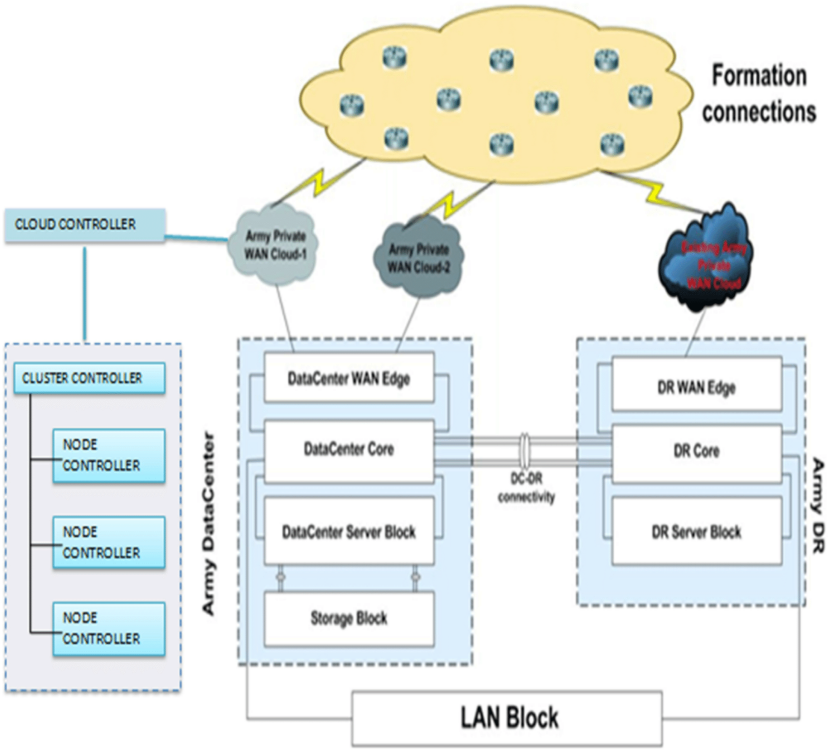

Figure 3.4: Proposed Cloud Network infrastructure.

CHAPTER 4
CHALLENGES OF CLOUD COMPUTING IN ARMY

4.1 Challenges Ahead

Every new concepts or ideas are needed to be tested and verified for operational efficiency. For implementing the new concept of cloud computing in Bangladesh Army we may face lot of challenges or difficulties. This chapter mainly focuses on the challenges and their mitigation procedures [12], [13].

4.1.1 Data Protection and Security

The basic difference between implementing cloud computing in a corporate office and in military is the security factor. It demands more security in case of military. Because in military their are some classifications of documents. Few of them are RESTRICTED, CONFIDENTIAL, SECRET and TOP SECRET. Some classified documents are not secured to be transmitted by line. Those needs physical delivery or hand to hand delivery. Presently for top classified documents signal dispatch service is not used since data may be corrupted or stolen during transmission. So a strong security arrangements is needed. Firewalls both hardware and software needs to be incorporated and access level to be set for various users.

4.1.2 Data Recovery, Availability and Destruction

Military data are highly classified and valuable. It may be strategic, national and tactical data. So a proper recovery method in case of disasters, natural calamity or enemy interventions should be chalked out properly. Cloud can play pivotal role in this regards. Because with cloud, data can be accessed from any suitable location with minimum hardware arrangement. Also if the server is being captured by enemy the cloud data can be totally destroyed remotely so that it doesn't fall into the hands of enemies. Redundancy is the basic feature of cloud. So in case of any natural disaster if the main server is destroyed then data can be effectively recovered. Also military demands high portability of data. Due to various types of employment in home and abroad data must be readily available everywhere [**?**]

4.1.3 Management Capabilities

The basic feature of cloud-based service is their ease of use. But constant technical support is needed. When we use cloud-based services, we will be entrusting a lot of our office data to the service's servers, so it's only right for us to have a service representative to consult in case things go wrong. Before we go with any cloud-based service, we must be sure that adequate technical support from the provider is available. The best solution lies in training the military personal adequately to maintain cloud server. This also ensures that security is maintained at highest level [10].

4.1.4 Ownership and Access of Data

In case of enterprise cloud solution, the application, the hardware and the operating system will be owned by the cloud provider. Cloud subscription gives us the access to the functionality of the application or function that we use. We have to ensure that the contract allows for access to the back-end data, either directly or via the provider offering an export capability. The main advantage for Bangladesh Army is owing a one terabyte data center which will be completely handled by the Army personnel.

4.1.5 Compliance and Migration Strategy

Organizations considering using cloud services should perform a gap analysis between the specific requirements identified in relevant regulations and the set of controls provided by the cloud service. Using cloud computing services for data and applications subject to compliance regulations requires a high degree of transparency on the part of service providers. Defining a migration strategy involves understanding the various migration options available, establishing job priorities, and evolving a strategy that offers a fine balance between costs and meeting job priorities. Also at ground level operators and clerks need to be trained in using the cloud service effectively. System administrators must explain to the clients how data migration will be implemented. This is the most important task for cloud computing because this will not only deal with the future efficiency of the application but also the security of the data. A detailed plan in this regards with a corresponding time frame should be expected from the provider at the very initial stage.

4.2 Overcoming the Challenges

A proverb says 'Where there is a will there is a way'. The most important challenge is to change our vision towards the globalization through information technology. We must re-

member that all the major information technology infrastructures, such as Internet, are being invented for military purpose. The United States Army has incorporated cloud computing technology. But the concept they are using are much of broader aspects since they have numbers of foreign missions and bases situated around the globe. For an Army like ours we can take the maximum benefit of cloud computing in terms of resource sharing and data optimization. In preceding paragraphs we had discussed some of the challenges we are likely to face while implementing cloud computing facilities in our Army. To overcome the security aspects we must incorporate firewall both hardware and software at different tier. The challenges of data recovery, availability and destruction can be overcome by trivial characteristics of cloud computing. Then comes the matter of management and administration. A good number of IT qualified officers are being graduated from MIST every year. The potential officers with good caliber can be employed as system administrator at various formation IT Cells. They can in turn arrange suitable training for the soldiers in IT field. So we need not to go for any outsourcing. In case of ownership of data, there is no problem since the high capacity central data center is just some way away to be completed. Migration system from present infrastructure of Army WAN to cloud facilities is very simple, easy and cost effective. Only some minor incorporation of software configuration is necessary. Details of this is already covered in details in chapter three of this paper [14].

CHAPTER 5
CONCLUSION AND RECOMMENDATION

5.1 Conclusions

Our research work is intended to drive the BD Army toward changes required to dramatically improve the delivery and operation of IT, via an enterprise cloud environment, that provides tangible benefits to the military community. This research shows that the military applications of cloud computing technologies will have a positive overall impact on the military network by leveraging network and fiscal efficiencies, but some technical challenges on the network such as security, bandwidth limitations and fully operationalizing doctrine will remain.

By moving its real-time intelligence system to the cloud, the Army will improve situational awareness for soldiers in combat. The Army can plan to speed up the process by equipping combat troops with small cloud computing systems that can quickly analyze extensive video footage and other intelligence to warn soldiers of impending threats. The tactical edge cloud nodes, combined with advanced analytical tools being developed, will automatically collect, process and analyze the video within seconds, providing commanders with better situational awareness and improving their ability to make informed decisions quickly. Migrating to a cloud can bring several benefits: improve redundancy; improve capacity; ensure good quality of service for users who are geographically dispersed; and improve agility by providing intelligence to soldiers on the battlefield, where they need it most [15].

5.2 Recommendations

At the end of our extensive thesis work we like to suggest following recommendations for adoption in BD Army:

1. Cloud computing opens up the world of computing to a broader range of uses and increases the ease of use by giving access through any internet connection. However, with this enhanced ease also come hitches.

2. Security is a great threat for implementing cloud in military. If BD Army is

considering using the cloud, be certain that we identify what information we will be putting out in the cloud, who will have access to that information, and what we will need to make sure it is protected.

3. In cloud we have less control over who has access to our information. We also must be aware of the security risks of having data stored on the cloud.

4. The cloud is a big target for malicious individuals and may have disadvantages because it can be accessed through an unsecured internet connection. So we need some quality IT infrastructure to maintain the security of connection on which cloud will be connected.

5. Presently BD Army has own IT infrastructure AWAN with some quality security measures and the DC which is a state-of-the-art tier 3 level. So it is very logical and time-demanding for BD Army to go for cloud computing.

6. Cloud computing will increase the speed of both operational and official activities. Additionally, we can add third party cloud service provider to our own cloud to establish connection with our troops who are deployed in various mission of UN.

7. For implementing cloud we should know our options in terms of what type of cloud will be best for our needs. After all feasibility study we find private cloud is best suited for us and with all the IT infrastructure it is very economical to implement cloud. It is very important to choose what type of provider will be most useful to us, and what the reputation and responsibilities of the providers we are considering.

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