Final Report

ITU-D
Study Group 1

Question 3/1

Access to cloud computing: Challenges and opportunities for developing countries

6th Study Period
2014-2017

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Preface

ITU Telecommunication Development Sector (ITU-D) study groups provide a neutral contribution-driven platform where experts from governments, industry and academia gather to produce practical tools, useful guidelines and resources to address development issues. Through the work of the ITU-D study groups, ITU-D members study and analyse specific task-oriented telecommunication/ICT questions with an aim to accelerate progress on national development priorities.

Study groups provide an opportunity for all ITU-D members to share experiences, present ideas, exchange views and achieve consensus on appropriate strategies to address telecommunication/ICT priorities. ITU-D study groups are responsible for developing reports, guidelines and recommendations based on inputs or contributions received from the membership. Information, which is gathered through surveys, contributions and case studies, is made available for easy access by the membership using content-management and web-publication tools. Their work is linked to the various ITU-D programmes and initiatives to create synergies that benefit the membership in terms of resources and expertise. Collaboration with other groups and organizations conducting work on related topics is essential.

The topics for study by the ITU-D study groups are decided every four years at the World Telecommunication Development Conferences (WTDCs), which establish work programmes and guidelines for defining telecommunication/ICT development questions and priorities for the next four years.

The scope of work for **ITU-D Study Group 1** is to study "**Enabling environment for the development of telecommunications/ICTs**", and of **ITU-D Study Group 2** to study **"ICT applications, cybersecurity, emergency telecommunications and climate-change adaptation"**.

During the 2014-2017 study period **ITU-D Study Group 1** was led by the Chairman, Roxanne McElvane Webber (United States of America), and Vice-Chairmen representing the six regions: Regina Fleur Assoumou-Bessou (Côte d'Ivoire), Peter Ngwan Mbengie (Cameroon), Claymir Carozza Rodriguez (Venezuela), Victor Martinez (Paraguay), Wesam Al-Ramadeen (Jordan), Ahmed Abdel Aziz Gad (Egypt), Yasuhiko Kawasumi (Japan), Nguyen Quy Quyen (Viet Nam), Vadym Kaptur (Ukraine), Almaz Tilenbaev (Kyrgyz Republic), and Blanca Gonzalez (Spain).

Final report

This final report in response to **Question 3/1: "Access to cloud computing: challenges and opportunities for developing countries"** has been developed under the leadership of its Rapporteur: Mr Nasser Kettani (Microsoft Corporation, United States of America); and three appointed Vice-Rapporteurs: Jules Essoh Kambo (Cameroon), Henri Numbi Ilunga (D.R. of the Congo) and Abdoulaye Ouedraogo (Burkina Faso). They have also been assisted by ITU-D focal points and the ITU-D Study Groups Secretariat.

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Table of Contents

i. Introduction

There is a general agreement that our era has entered the 4th industrial revolution, a revolution that is digital, that will see every industry being digitally remastered. A revolution that brings the physical world and the "virtual" world into one. A revolution that will force every company, every industry and eventually every country to digitally transform.

The 4th industrial revolution is powered by the Cloud. Cloud Computing is at the heart of technological advances that enable the 4th industrial revolution, much like the engine was at the heart of a former industrial revolution.

Cloud Computing represents one of most important advances in computing in history. While some of the fundamentals have been here for a while, recent advances in technologies have made Cloud Computing more pervasive, more acceptable, and most importantly more innovative to address the challenges that Information Technology professionals and business leaders face today.

Cloud Computing comes also at a specific moment of time, at the crossroads of technology innovations and business challenges and opportunities. On the technology front, Cloud Computing is both a catalyst and an enabler of important technological advances such as mobile computing, Big Data, Internet of Things, Machine Learning and AI (Artificial Intelligence), new computer user interactions (such as voice), and many more. On the business front, Cloud Computing is an important technology model that will help address some of the core challenges that businesses and governments face in terms of digital transformation, business transformation, service delivery, agility to meet the needs of constituencies, societal challenges such as Environment, Education, Healthcare, and many more, given the very nature of what the Cloud is in terms of agility, cost, and innovation.

At the core of Cloud Computing are fundamental paradigm shifts: IT Service delivery, Cost model, and Innovation pace:

- **IT service delivery and consumption**: for the last decades, Information Technology (IT) was delivered mostly tailored to the specific needs of each customer be it internally within an organization or externally when IT was outsourced. Each IT project was delivered with its specific resources (hardware, software, storage, network, people, processes, etc.) very tailored to the specific needs of the project, and required the intervention and support of the IT teams. Cloud Computing creates a rupture in this model, as resources are now pooled and shared across projects and organisations, allowing for more optimization; IT teams are less involved since customers can themselves provision the resources they need for their projects, allowing more flexibility. But most importantly, the role of the IT teams in the area of Cloud Computing is evolving from deploying, managing, and updating complex IT resources and projects, into IT governance, data governance, information management, risk management, and innovation, while moving the complexity of the infrastructure management to internal or external professionals/cloud service providers whose job is to provide the service at a much better quality and price point.
- **Cost models**: IT cost models have also evolved. In the traditional IT delivery, each project/customer would purchase its own resources in a CAPEX[1] mode. The Cloud allows for an OPEX[2] model (from a user/customer perspective[3]) that will enable customers to pay for what they consume in an elastic way (much like they would buy electricity), introducing more flexibility into the process, enabling customers to scale up on-demand without the need to go and buy

1 Capital Expenditure.
2 Operational Expenditure.
3 Though the Cloud Service Provider (CSP) is in a CAPEX mode.

more infrastructure resources when they face demand peaks, which is always hard to manage in an Internet world. At the same time , customer purchase behaviour and patterns for IT infrastructure does not scale to the level of large Cloud services providers, who have much bigger buying power and hence optimization capabilities. Indeed, procurement of data center assets (hardware, storage, energy, etc.) is a business process for any single customer; however, it is a strategic supply chain issue for a Cloud services provider.

– **Innovation pace:** In the current delivery model, customers buy IT infrastructure technologies (hardware, software, etc.) from specialized vendors and take a long time to test, integrate, and deploy in their current environment. The cycle from innovation (IT vendor) to consumption (customer) takes several years to materialize. In the Cloud area, Cloud service providers are innovating at a much faster pace and delivering that innovation to the customer overnight without the need for the customers to test and deploy: innovation comes at the fingertips of customers easily and quickly. Also, the Cloud is enabling innovations that are only possible when there is scale in terms of data and computing. Artificial Intelligence for example is now possible and democratized thanks to Cloud Computing.

There is some precedence that one can compare Cloud computing and learn from. Let us take aviation transportation; indeed, the fastest, cheapest, and more secure / safest way to travel miles away, is to use airlines (in some countries high speed trains), instead of driving its own car no matter how fast, big and secure the car is; airlines are indeed "transportation as-a-service". The impact that this industry has had on the whole economy worldwide is amazing including tourism and hospitality, job creation, people movement, trade, etc. Other examples include Electricity production and distribution, financial services, catering, logistics, etc. The impact on society, economy, wealth creation, etc., has always been bigger then industry itself. Cloud Computing is no different.

Any major technology innovation comes with its own opportunities and risks; and while it is important to address the risks, it is also important to understand the opportunities and put in place the right mechanisms to realize them.

These advances create an unprecedented opportunity for every consumer, business, and government; but most importantly for those in developing countries who: 1) can enjoy access to the latest technologies (Cloud innovations are delivered in the Cloud), 2) at a much faster pace than ever (Cloud Innovations are coming faster than on-premises), and 3) can reduce the cost of IT projects (Cloud is much cheaper just on-premises) hence achieving faster digital growth and transformation. In short, they can do more, and do it faster for less. According to a research report from *researchICTafrica.net*[4], "*…the informal sector, which forms a significant part of businesses in Africa as it provides livelihoods to the poor and marginalized, has the potential to enjoy benefits associated with the large-scale hardware and software investments in the formal sector through Cloud services. Although Cloud Computing is dominated by global US-based companies, it has the potential to open up African countries to uncharted offshore markets, thus contributing to economic development and competitiveness, and for African businesses to aggregate international Cloud services to meet local needs*". We believe that using IT services as a support engine to develop and provide other services in all sectors can be very profitable to most African and developing countries.

However, there are also challenges to Cloud adoption. This report looks at those opportunities and challenges and provides guidance that governments can implement to lead with Cloud Computing. The same *researchICTafrica.net* reports that "*The availability, accessibility and affordability of underlying technology is a key determinant of the successful diffusion of Cloud Computing and is currently the major inhibiter to Cloud deployment in developing countries. Other factors that are hindering the growth of Cloud services relate to concerns around security, privacy and surveillance, particularly amongst highly regulated and risk-averse sectors, such as financial services*".

[4] http://www.researchictafrica.net/publications/Evidence_for_ICT_Policy_Action/Policy_Paper_20_-_The_Cloud_over_Africa.pdf.

Several policy makers have looked at Cloud Computing as a *challenge* and focused mostly on *risks* and *issues* facing countries adopting Cloud services. While the study group recognizes these issues, this report also invites policy makers and regulators to consider and answer the following important question: "What are the challenges and how to overcome them to *lead with the Cloud?*"

This report is divided into several core chapters. **Chapter 1** is an introduction to Cloud Computing, with internationally adopted definitions, and some additional clarifications from real life experience. **Chapter 2** provides explanation of the driving forces behind Cloud Computing while **Chapter 3** provides some data with regards to the state of the business, and sets forward the opportunities and challenges for Cloud adoption.

Chapter 4 of the report goes into the details of the four core challenges that need to be addressed to lead to Cloud Adoption: Innovation, Infrastructure, Skills and Awareness, and finally Trust.

Chapter 5 discusses lessons learned from countries that have adopted Cloud while **Chapter 6** provides report group guidance on Cloud Computing policy making.

ii. Background

Cloud Computing has emerged as a major technology trend of this era; ITU and ITU-D specifically has looked at various issues and opportunities to develop reports, policy recommendations, studies that help countries understand and leverage Cloud Computing. Yet, there is still a lot of work to be done.

During the 2014 World Telecommunication Development Conference (WTDC-14) in Dubai, ITU adopted Resolution 2 that established study groups. ITU-D Study Group 1 (SG1) was then tasked to address Question 3/1 to develop a report on "Access to Cloud Computing: Challenges and opportunities for developing countries".

The Question 3/1 Group was tasked to develop a report that specifically looks at what would be required for a developing country to leverage the Cloud. The scope of the study Question was agreed on.

Question/issue for study:

- Discuss infrastructure needs for supporting and enabling access to Cloud services, and highlight best practices for developing such infrastructure.
- Examine definitions and characteristics of Cloud Computing and its future trends.
- What are the features of networks that support effective access to Cloud – computing services?
- Building and developing a sufficient group of existing frameworks to support investment in infrastructure for Cloud Computing, taking into consideration relevant standards recognized or under study in the other two ITU Sectors.
- Costs associated with the adoption of Cloud Computing.
- Develop case studies of successful Cloud-computing platforms used in developing countries.

Expected output:

- Analysis of the factors influencing effective access to support Cloud Computing.
- A set of guidelines, such as policy or technical approaches, among others, for facilitating infrastructure deployment, which could be delivered, inter alia, through training seminars in accordance with the ITU-D programme on capacity building.
- A handbook on infrastructure supporting Cloud Computing in developing countries. This handbook will be the result of study group collaboration between ITU-T Study Group 13 and the Rapporteur Group dealing with this Question as part of ITU-D Study Group 1.
- Draft Recommendation(s), as appropriate and if justified.

1 CHAPTER 1 – Introduction to Cloud Computing

The following section uses the exact definitions provided by ITU and ISO standards that provide internationally agreed references for Cloud Computing. The study group decided to reuse those references and do not deviate. Also, to make it easy for the reader to go through this report, we included the definitions instead of just pointing to another document.

1.1 Definitions, Characteristics

ITU-T and ISO/JTC1 are jointly working on providing a set of standards and guidelines in support of the Cloud adoption; these are ITU-T Y.3500 series.

ITU-T Y.3500 (Cloud Computing – Overview and vocabulary) is the first of the series and provides a comprehensive and important reference vocabulary.

1.1.1 General

Cloud Computing is a paradigm for enabling network access to a scalable and elastic pool of shareable physical or virtual resources with self-service provisioning and administration on- demand. The Cloud Computing paradigm is composed of key characteristics, Cloud Computing roles and activities, Cloud capabilities types and Cloud service categories, Cloud deployment models and Cloud Computing cross cutting aspects that are briefly described in this section.

1.1.2 Key characteristics

Cloud Computing is an evolving paradigm. This section identifies and describes key characteristics of Cloud Computing and is not intended to prescribe or constrain any particular method of deployment, service delivery, or business operation. Key characteristics of Cloud Computing are:

- **Broad network access**: A feature where the physical and virtual resources are available over a network and accessed through standard mechanisms that promote use by heterogeneous client platforms. The focus of this key characteristic is that Cloud Computing offers an increased level of convenience in that users can access physical and virtual resources from wherever they need to work, as long as it is network accessible, using a wide variety of clients including devices such as mobile phones, tablets, laptops, and workstations.
- **Measured service**: A feature where the metered delivery of Cloud services is such that usage can be monitored, controlled, reported, and billed. This is an important feature needed to optimize and validate the delivered Cloud service. The focus of this key characteristic is that the customer may only pay for the resources that they use. From the customers' perspective, Cloud Computing offers the users value by enabling a switch from a low efficiency and asset utilization business model to a high efficiency one.
- **Multi-tenancy**: A feature where physical or virtual resources are allocated in such a way that multiple tenants and their computations and data are isolated from and inaccessible to one another. Typically, and within the context of multi-tenancy, the group of Cloud service users that form a tenant will all belong to the same Cloud service customer organization. There might be cases where the group of Cloud service users involves users from multiple different Cloud service customers, particularly in the case of public Cloud and community Cloud deployments. However, a given Cloud service customer organization might have many different tenancies with a single Cloud service provider representing different groups within the organization.
- **On-demand self-service**: A feature where a Cloud service customer can provision computing capabilities, as needed, automatically or with minimal interaction with the Cloud service provider. The focus of this key characteristic is that Cloud Computing offers users a relative reduction in

costs, time, and effort needed to take an action, since it grants the user the ability to do what they need, when they need it, without requiring additional human user interactions or overhead.

- **Rapid elasticity and scalability**: A feature where physical or virtual resources can be rapidly and elastically adjusted, in some cases automatically, to quickly increase or decrease resources. For the Cloud service customer, the physical or virtual resources available for provisioning often appear to be unlimited and can be purchased in any quantity at any time automatically, subject to constraints of service agreements. Therefore, the focus of this key characteristic is that Cloud Computing means that the customers no longer need to worry about limited resources and might not need to worry about capacity planning.
- **Resource pooling:** A feature where a Cloud service provider's physical or virtual resources can be aggregated in order to serve one or more Cloud service customers. The focus of this key characteristic is that Cloud service providers can support multi-tenancy while at the same time using abstraction to mask the complexity of the process from the customer. From the customer's perspective, all they know is that the service works, while they generally have no control or knowledge over how the resources are being provided or where the resources are located. This offloads some of the customer's original workload, such as maintenance requirements, to the provider. Even with this level of abstraction, it should be pointed out that users might still be able to specify location at a higher level of abstraction (e.g., country, state, or data center).

1.1.3 Cloud capabilities types and Cloud service categories

A Cloud capabilities type is a classification of the functionality provided by a Cloud service to the Cloud service customer, based on the resources used. There are three different Cloud capabilities types: application capabilities type, infrastructure capabilities type, and platform capabilities type, which are different because they follow the principle of separation of concerns, i.e. they have minimal functionality overlap between each other. The Cloud capabilities types are:

- **Application capabilities type**: A Cloud capabilities type in which the Cloud service customer can use the Cloud service provider's applications.
- **Infrastructure capabilities type**: A Cloud capabilities type in which the Cloud service customer can provision and use processing, storage or networking resources.
- **Platform capabilities type**: A Cloud capabilities type in which the Cloud service customer can deploy, manage and run customer-created or customer-acquired applications using one or more programming languages and one or more execution environments supported by the Cloud service provider.

A Cloud service category is a group of Cloud services that possess some common set of qualities. A Cloud service category can include capabilities from one or more Cloud capabilities types. Representative Cloud service categories are:

- **Communications as a Service (CaaS)**: A Cloud service category in which the capability provided to the Cloud service customer is real time interaction and collaboration.
- **Compute as a Service (CompaaS)**: A Cloud service category in which the capabilities provided to the Cloud service customer are the provision and use of processing resources needed to deploy and run software.
- **Data Storage as a Service (DSaaS)**: A Cloud service category in which the capability provided to the Cloud service customer is the provision and use of data storage and related capabilities.
- **Infrastructure as a Service (IaaS)**: A Cloud service category in which the Cloud capabilities type provided to the Cloud service customer is an infrastructure capabilities type.
- **Network as a Service (NaaS)**: A Cloud service category in which the capability provided to the Cloud service customer is transport connectivity and related network capabilities.

- **Platform as a Service (PaaS)**: A Cloud service category in which the Cloud capabilities type provided to the Cloud service customer is a platform capabilities type.
- **Software as a Service (SaaS)**: A Cloud service category in which the Cloud capabilities type provided to the Cloud service customer is an application capabilities type.

1.1.4 Cloud deployment models

Cloud deployment models represent how Cloud Computing can be organized based on the control and sharing of physical or virtual resources. The Cloud deployment models include:

- **Public Cloud**: Cloud deployment model where Cloud services are potentially available to any Cloud service customer and resources are controlled by the Cloud service provider. A public Cloud may be owned, managed, and operated by a business, academic, or government organization, or some combination of them. It exists on the premises of the Cloud service provider. Actual availability for specific Cloud service customers may be subject to jurisdictional regulations. Public Clouds have very broad boundaries, where Cloud service customer access to public Cloud services has few, if any, restrictions.
- **Private Cloud**: Cloud deployment model where Cloud services are used exclusively by a single Cloud service customer and resources are controlled by that Cloud service customer. A private Cloud may be owned, managed, and operated by the organization itself or a third party and may exist on premises or off premises. The Cloud service customer may also authorize access to other parties for its benefit. Private Clouds seek to set a narrowly controlled boundary around the private Cloud based on limiting the customers to a single organization.
- **Community Cloud**: Cloud deployment model where Cloud services exclusively support and are shared by a specific collection of Cloud service customers who have shared requirements and a relationship with one another, and where resources are controlled by at least one member of this collection. A community Cloud may be owned, managed, and operated by one or more of the organizations in the community, a third party, or some combination of them, and it may exist on or off premises. Community Clouds limit participation to a group of Cloud service customers who have a shared set of concerns, in contrast to the openness of public Clouds, while community Clouds have broader participation than private Clouds. These shared concerns include, but are not limited to, mission, information security requirements, policy, and compliance considerations.
- **Hybrid Cloud**: Cloud deployment model using at least two different Cloud deployment models. The deployments involved remain unique entities but are bound together by appropriate technology that enables interoperability, data portability and application portability. A hybrid Cloud may be owned, managed, and operated by the organization itself or a third party and may exist on premises or off premises. Hybrid Clouds represent situations where interactions between two different deployments may be needed but remained linked via appropriate technologies. As such the boundaries set by a hybrid Cloud reflect its two base deployments.

1.2 Cloud is not one size fits all

The standards definitions provided above by the ITU and ISO standards demonstrate if anything that there are various ways to implement and to consume Cloud Computing and as such shows that there is no “one size fits all”. As the Cloud Computing market develops, and customers gains confidence, we will probably see more innovations coming to market and evolutions of some of these definitions.

The market already is providing a variety of Cloud services to implement and consume the Cloud. This report tries to summarize below some of those into categories to simplify the reading:

- **Implementation technologies**: these technologies help organizations to implement Cloud Computing in different forms depending on whether they deploy private Clouds (for themselves, organizations can turn their own IT infrastructure and IT delivery processes using Cloud

Computing concepts), or if they seek to become Cloud service providers (provide Cloud services for others or on behalf of others, for example, some government agencies have established shared infrastructure delivered as a Cloud to various government agencies).

- **Multi-purpose Cloud services**: Some organizations, local and multi-nationals provide a set of Cloud services, in most cases public Cloud services for all. Services can be IaaS, PaaS, SaaS or one of the various categories and capabilities described above.
- **Some of the Cloud services are designed for consumer consumption and some are designed for enterprise (and government) needs**. In most cases, enterprise grade services and consumer grade services are governed by different principles, contractual clauses, service level agreements (SLA), business models, security and privacy rules.
- **Vertically integrated Clouds** are those large-scale services (for example social networks or search engines) that are provided to users running on the vendor's own developed and integrated Cloud infrastructure.
- **Innovative Cloud services** running on multi-purpose Cloud infrastructure. In this category, companies of all sizes, Independent Software Vendor (ISV)s, develop Cloud services for other to use, however, they will need Cloud infrastructure to build and operate their own Cloud services instead of building their own. This category is probably the most dynamic in the market place, since small, medium and large organizations can use ready to use Cloud infrastructure to deliver their own services to their customers, be it for consumers or enterprise grade.

1.3 Watch out, this is not Cloud

The definitions provided by the standards are very important to set the terminology applicable to the Cloud. These are extremely important since there is a lot of confusion in the market place and in the minds of businesses and governments around the concepts of the Cloud. These five (5) characteristics described earlier in subsection 1.1.2: "broad network access", "measured service", "multi-tenancy", "on-demand self-service", "rapid elasticity and scalability", are the founding principles of what Cloud is – and is not.

For example:

1) **Data centers are not Cloud**. While Cloud Computing is built upon data centers to host and provide the services, having a data center does not mean one is running a Cloud. The reality is that data centers have existed for many years as businesses and governments have built data centers over time to run their business. The vast majority does not offer those 5 key characteristics and cannot/should not be considered Cloud.
2) **Web is not Cloud**. For many, there is also a huge confusion between Web/Internet access to services, or even Applications (on mobile devices), and Cloud Computing. The fact that one accesses a service through the Internet or through the Web or through an App, does not mean that the back-end that provisions the service meets the 5 core characteristics and is run as Cloud.
3) **Hosting and/or outsourcing is not the Cloud**. Indeed, Cloud Computing is fundamentally different from "hosting" and "outsourcing". Hosting/outsourcing is an industry practice that allows a business to host his computing and storage resources outside of his own premises / data centers. This practice existed before the era of Cloud and helped businesses to focus on key business priorities while moving the management of some of the IT infrastructure (or more) to third parties. However, moving physical servers or storage to a third-party data center does not mean that the third party is running this service as a Cloud. For example, if the business wants more compute capacity during a peak time, in this model, he will not be able to acquire that as a self-service and on-demand without or even with minimal intervention of the third party hoster. Also, in many cases, in the outsourcing world, computing and storage resources are not necessarily pooled across different tenants/customers. Because pooling of resources is a core pillar in the Cloud, security controls and practices have changed drastically. For example, a single

physical disk in a data center can contain data for several tenants; Data encryption and logical data segregation techniques using virtualization create more security and protection against unwanted and insider data access, since it is hard to target a specific tenant data. In the same way, a Cloud service provider will provide the exact same service to all tenants (customers), while a hoster will provide specifics contracts and services to each customer.

These differences are important to understand since businesses can be confused as they move to the Cloud. Just as importantly, policy makers in some regulated industries need to adjust existing policies that were designed before the era of the Cloud. For example, some policies have been developed to support outsourcing for industries such as financial services; the study group suggests that regulators adapt those policies to allow for banks to adopt the Cloud.

1.4 The hyper-scale Cloud: lessons from real-life

As the industry is building up, as users are adopting, as business and governments around the world are experiencing, interesting trends and lessons can be observed. Some will be described in detail in Section VI of this report.

- As we have seen earlier, users, including businesses and governments, are enjoying different forms of Cloud models: SaaS, PaaS, and IaaS, as well as different forms of Cloud deployment models, to meet their needs. Users and businesses are enjoying several "Clouds" from different vendors. This is an indication that Cloud is not a one size fits all; in fact, users and businesses are combining different approaches to meet their specific needs.
- Some businesses, including in government agencies and departments have modernized their data centers and IT service delivery as private Clouds, including in some cases, consolidating their disparate data centers. This is a good practice (and there are case studies at the end of this report) and those organizations are already realizing some important benefits in terms of cost reduction and increased flexibility and agility.

But realizing the full benefit of the Cloud promise requires some scale. Scale and even hyper- scale allow for a major paradigm shift in many aspects:

- **Procurement**: When there is scale, procurement and supply chain become strategic, rather than a process. Scale requires proper planning and it allows for better pricing negotiations and cost reductions at all levels of HW, energy, network, etc. Proper planning is critical to cater for multiple tenant on-demand increases.
- **Operations**: With scale, operations become highly automated, less dependent on people and manual error prone processes, and innovation in operations becomes strategic. Scale allows for investment in operational efficiencies at all levels: energy efficiency, data center design, hardware design, software design, etc. For example, a security update can be deployed in minutes instead of weeks, different data center cooling techniques can be applied, etc.
- **Security becomes paramount**: With scale, security takes a different dimension. Cloud service providers can invest more in security at all levels: people, technology, processes, operations, and continuous innovation, since the cost of security will be split across so many tenants. Hyper scale Cloud enables improved security as vulnerability detection at one tenant will help protect all other tenants. The hyper scale Cloud is by nature more secure than smaller instances.
- **New Business Models**: Hyper scale allows the Cloud service provider to cater for various business models permitting various pricing modes and innovation in service delivery.

While hyper scale enables the Cloud service provider to better invest, develop, and operate, the reality is that those benefits are in fact allowing the end user or business customer to really realize the Cloud promise. Hyper-scale provides more security, lower costs, more flexibility in terms of on-demand scale, more automated self-service delivery, and more innovation, faster.

2 CHAPTER 2 – The driving forces and benefits of Cloud Computing

While Cloud Computing is not new in its essence as a technology by itself, major technology advances have made Cloud Computing more attractive, economically sustainable, relevant to many, and main stream. Cloud Computing comes at a very specific time of the Technology era. Major technology trends are transforming the way services are consumed, developed, and delivered. Let us dig into a few:

– **Mobility**: The emergence of Mobile technologies has allowed us to become more mobile, allowing us to work anywhere anytime. While, in the early days of technology, workers needed to go to the office to get access to the latest technologies, today the proliferation of new platforms and broadband connectivity has changed the rules; workers enjoy a set of technologies in their personal life that in many cases are more advanced than what they have at work. People want to use our own devices at work. Personal devices and professional devices become one. As one moves from one device to another, smartphone, tablet, laptop, PC, TV, gaming console, she/he expects to be always on and enjoy a continuous experience. This new world of mobility is creating a new set of opportunities for service and product delivery, new working styles, and government e-services such as Education, Healthcare, and City Services.

– **The ecosystem of computing**: The vision that Bill Gates had +40 years ago "*a PC on every desk and in every home*" has achieved amazing results with more than 1.5 billion PCs available so far. And, it is fascinating to see how the mobile phone and tablets have taken that vision even further with Billions of people across the globe using mobile phones and enjoying the power of the Internet. That vision has now moved on with technology advances that are allowing "Smart everything everywhere". Today, our phones, tablets, cars, video cameras in the street, airports, and shopping malls, smart sensors everywhere, fridges, medical devices, watches, shoes, etc., and servers and server farms, are shaping the revolution from the "computer" to the "ecosystem of computing". Especially as these new computing platforms are all connected to the Internet, feeding or consuming information. This world is expecting to see 50 billion of these connected devices in the next 3 to 5 years. This is what some are calling Internet of Things (IoT), the study group prefers to refer to them as "ecosystem of computing" which is a wider concept.

– **Big Data**: The new computing ecosystem world is by essence creating a huge amount of data. According to IDC research,[1] the world has produced in 2011 1.8 zettabytes (ZB). This data has grown at a 45 per cent CAGR from 2010 to 2015. This is not only data created by enterprises or individuals; this is also data created by devices themselves: images created by street cameras, localization information generated by mobile phones, data generated by all sorts of sensors, and data generated by applications. While some see this deluge of data as a challenge in terms of storage and management, the reality lies in the opportunity that resides in this data if one could mine it and transform it into sources of information and intelligence. Experts estimate that only 0.5 per cent of this data is actually analyzed. For example, by analyzing localization data generated from smartphones and mobile stations, a city could have better insight on population movement within the city and hence optimize their transportation system.

2.1 New opportunities for Businesses, Consumers and Governments to adopt Cloud Computing

A close look at these transformational technology trends, one could easily realize that Cloud is in fact the catalyst and the enabler of each of these. Cloud Computing will help store the "data deluge" and provide the capability to analyse and extract intelligence from it faster than ever. The rise of massive data centers that provide both unprecedented cheap storage and computing power, new search and mining technologies and algorithms combined with advances in machine learning and artificial intelligence, will help businesses and government make smarter decisions faster providing better services to their workers, customers, and citizens.

[1] http://d38mhi8jtu7akf.Cloudfront.net/wp-content/uploads/2012/07/IDC-Analyst-Connection.pdf.

In almost all domains, scientists and engineers now have more data than ever. In a few short years, they have gone from scarcity to an incredible richness, necessitating a significant change in how they manage and extract insight from all this data. For example, in astronomy, the *Sloan Digital Sky Survey*[2] in January 2011 released "the largest digital colour image of the sky ever made. This terapixel image is so big and detailed that one would need 500,000 high-definition TVs to view it at its full resolution." In neuroscience, the researchers working to map the connections among the neurons in the brain are finding that the images necessary to make that map for a cube of mouse brain a millimetre on a side require roughly one petabyte of storage; this implies that similar maps of the human brain would require millions of petabytes.

- Cloud Computing makes any smartphone "Smart" These smart devices are in fact great devices with some small storage and small computing power that act as front ends to large scale data centers that provide all sorts of services in real time. Voice, "Apps", social, localization, language translators, personal assistants, etc., are just a few examples of services provided on the smart device connecting to the Cloud.
- Cloud Computing will help to address some of the pressing human challenges such as energy or environmental issues and new generations of drug testing or genomic research in an accelerated manner. Thanks to the "unlimited" computing power and storage that resides in large scale data centers, one will be able to run extremely complex algorithms in a matter of minutes and hours instead of months or years and at a fraction of yesterday's costs.
- The combination of mobility, connectivity, new trends (e.g. Open Data), smarter search, and social computing etc., allowed by Cloud innovators will come up with new ideas to help any company digitally transform, innovate and bring new unprecedented work scenarios to their employees and services to their clients.
- Cloud Computing will help governments become more flexible and agile by delivering new services in a matter of days and weeks at very low cost, reducing the risk of failure. Thanks to using existing PaaS platforms[3], government will be able to build new generations of services focusing on the core business processes and issues du jour rather than purchasing and managing the full stack of the technology including hardware, networking, management, security, etc. that is already taken care of by the Cloud platform.

2.2 Why Cloud and why now?

The business questions are the same for any young entrepreneur or seasoned CEO. How do I differentiate myself from my competition? How do I best deploy my resources and maximize the return on my investment? How can I be agile and nimble? How can I survive and flourish? To answer these questions, a leader must understand and use the disruptive economic and technological forces of his or her time. The Cloud offers small and large companies alike new opportunities to focus on core capabilities, compete in new ways in new markets, reduce capital costs, and increase efficiencies. In fact Cloud computing is the engine to the digital transformation that many businesses and governments are going through.

- More than ever, governments and businesses are expected to deliver services to their clients the way the latter want to consume them – on their preferred device, anywhere anytime.
- Businesses must innovate, differentiate from competitors, bring new products and services to market faster, and connect to their clients in new ways.
- Governments are expected to meet their constituencies' (both citizen and business) needs and expectations, while at the same time controlling budgets and cutting costs to reduce deficits.

[2] http://www.sdss.org/.
[3] Either public or private.

– Governments must make smart decisions, based on real insight from their constituencies, act fast, and become agile and flexible to efficiently serve their constituencies.

Cloud Computing enables cost reduction, flexibility, agility, scale, and innovation.

– **Cost reduction**: with today's pressure on governments and businesses to do more with less, using Cloud Computing, businesses and governments will be able to leverage large scale functioning infrastructure at a cost that is a fraction of what they do today. By using Cloud technologies, in a private set up, businesses and governments will be able to consolidate their investments, their servers and data centers, and use them in a much different way and hence reduce their costs. While probably not at the level of the hyper- scale Cloud yet, the bigger their private Cloud infrastructure is, the bigger the cost savings are. Cost reduction for governments' impacts healthcare cost, digital education cost, and citizen interaction costs. Small and Medium Businesses (SMBs) will be able to get access the latest technology which was previously only accessible to large enterprises at a fraction of cost without having to worry about technical infrastructure that is not core to their business, enabling them to better compete with any other business on the globe, SMBs will be able to create Cloud stores to go global and compete.
– **Flexibility, agility and scale**: Cloud is allowing businesses and governments to become more agile and flexible. With Cloud computing, businesses and governments can build new products and services much faster, in days or weeks (in some cases hours), not months or years as it has been the case so far. For example, by getting insight into what citizens and customers are saying on social networks, government and businesses can become more nimble and provide the right services to their constituencies. The "on-demand IT as-a-Service" nature of the Cloud brings an OPEX financial model, moving away from a CAPEX model that restrains many companies and research institutions from innovating. With this model, researchers in any part of the globe can test their great ideas and algorithms in a matter of hours without the need to invest in hardware and infrastructure.
– **Innovation**: Innovators have always shown us the way. Once again, with the advance of Cloud, innovators and new start-ups are creating a whole set of new innovations, services, applications, and products that will change the way we consume, travel, meet, work, read, and interact. Using Cloud Computing, garage innovators in any part of the world with a PC, an Internet Connection, and a credit card, will be able to bring their brilliant ideas to life for a fraction of cost. The Cloud provides them with latest technologies, but also potentially infinite computing power and unlimited storage at a fraction of cost, so that they can compete with anybody across the globe. These new innovations will also come from established businesses or government. Cloud Computing will help them focus and invest on the core ideas and businesses rather than the technology infrastructure that underlines the solutions and end up consuming up to 70 per cent of the IT budgets and resources. Cloud Computing will help drive transformation of entire business systems. We are also seeing a great innovation acceleration from the large Cloud service providers in the last few years, enabling new technologies such as Artificial Intelligence, deep learning, big data, IoT, new user interfaces (like voice), that are now made possible thanks to the Cloud.

2.3 Challenges for businesses, consumers and governments to adopt Cloud Computing

As discussed earlier, Cloud Computing provides interesting promises to consumers, large and small businesses, and governments. However, many challenges must still be addressed for countries, especially those in the developing world, to realize the full benefits of the cloud computing. The study group believes there are four categories of challenges that are important for government, policy makers, and regulators to consider as they build national plans to leverage Cloud computing.

Several reports and policies have been developed in countries where policy makers have looked at Cloud Computing as a *challenge* and focused on *risks* and *issues* facing countries adopting the Cloud, resulting in policies that primarily impact or regulate data privacy and security. While these are important and must exist, this report provides an additional perspective on the topic and invites

policy makers and regulators to consider and answer the following question: "What are the core challenges and how to address them for a country to *lead* with the Cloud?"

The study group believes that this is the core question that must be addressed given the importance of the topic, the disruptive nature of this technology, and the opportunities it opens.

For consumers the smartphone has been the clear catalyst to the development of consumer Cloud services. The market penetration of the smartphone and the development of 3G/4G and mobile applications are clear indications that consumers have already adopted the Cloud. Consumers use email as-a-service, movies-as-a-service, voice-as-a-service, games-as-a-service. Consumers spend several hours a day consuming Cloud based services to do all sorts of things from communicating, to socializing, to playing, to storing their documents and photos, to booking travel, to finding a restaurant, to learning on MOOCs[4], to getting access to government services. Most of the applications on a smartphone use the Cloud as a back end to provide the service. In fact, consumers are enjoying the Cloud every day without realizing that this is Cloud and necessarily understanding all the implications. Many of these Cloud services are "free" for consumers to use, although different business models exist.

The most successful of these applications are backed by the Cloud to support elasticity, innovation needs, and cost implications. The Cloud in this case enables the producers of those applications to meet their strategic needs: get fast to the market, go global, scale to millions of users in an elastic way, pay as they are successful without the need for up front investments in hardware and infrastructure, fail fast learn fast recover fast, innovate faster, adapt to consumer consumption patterns and feedback, fix bugs and security vulnerabilities and deploy quickly to all users, and monetize their applications using new business models.

[4] MOOC: Massive Open Online Course.

3 CHAPTER 3 – State of the business of Cloud Computing in developing countries

The study group does not have full data as to actual Cloud adoption or Cloud deployment around the world and certainly not in developing countries. The study group believes it would be very useful to develop such a set of metrics to understand the extent to which these technologies are deployed around the world (much like what exists for mobile telephony).

However, early reports from UNCTAD[5] 2013 and ARPTC[6] 2015 provide a good framework and some indications that are good to look at since they are key to enabling Cloud adoption. These indications include such things as bandwidth in both fixed and mobile networks, latency, data center availability (although these numbers are hard to get and are not necessarily accurate), Internet eXchange Points (IXPs), international connections, and existing server infrastructure. The reason being that quality infrastructure is key to Cloud adoption.

However, the infrastructure requirements will vary depending on the nature of the Cloud service. UNCTAD report suggests classifying infrastructure requirements according to the nature of the Cloud service: from basic (e.g. web browsing) to Intermediate (e.g. video conferencing) to advanced (e.g. connected education and healthcare).

Table 1: Phases of Cloud adoption

	Client / Server computing	Internet / Web applications	Cloud Architecture for back-end
Phase 1: Extend Existing Paradigms / Abstractions	Use PCs as terminals	Use browsers as terminals	Use big machines & traditional clusters
Phase 2: Disruptive Technology Matures	Client / Server Databases become viable	Learn how to build scalable web sites	Cloud "industry" starts producing reusable platform components
Phase 3: See Unique Opportunities	Client/Server DBMS* enables use of computing power at client	Protocols allow richer client experience, offline, etc.	Platform as a "Service"
Phase 4: Scenarios & Application Architecture	Development of 3-tier application architectures (client becomes mid-tier)	Multi-dimensional, service-backed, experiences	Multi-tenant, composable services
* DBMS: Data Base Management System			

3.1 Methodology

The regional overview of trends in Cloud Computing have been based on the following parameters.

Technology: Status of ICT and power networks

The prerequisites for a reliable Cloud service include the availability of broadband (wired and wireless) networks and both local and international Internet connectivity.

Also essential is the availability of power distribution networks and a constant electricity supply.

5 UNCTAD: United Nations Conference on Trade and Development.
6 ARPTC : Autorité de Régulation de la Poste et des Télécommunications du Congo.

The indicators presented below are drawn from the UNCTAD report issued in late 2013 and entitled "Information economy report – The Cloud economy and developing countries".

Network availability in a number of developing countries

The results of various studies conducted in Africa show that, of the countries surveyed, 42 per cent have high-speed Internet connectivity in all their major cities, 42 per cent have it in certain cities and 16 per cent are in the process of implementing broadband networks (EDGE/3G, LS-FO and ADSL).

Availability of electricity

On the basis of figures contained in World Bank reports, it emerges that fewer than 20 per cent of localities in African countries have access to an electricity supply.

The average electrification rate is 16 per cent in urban areas and 5 per cent in rural areas.

This constitutes a major challenge when it comes to ensuring the provision, stability and continuity of Cloud services.

Speeds and latency

According to the UNCTAD report, the minimum acceptable speeds for Cloud service provision are as follows:

Table 2: Minimum acceptable speeds for Cloud service provision

Basic Download: 750 kbps Upload: 250 kbps Latency: 160 ms	Intermediate Download: 751–2 500 kbps Upload: 251–1 000 kbps Latency: 159–100 ms	Advanced Download: >2 500 kbps Upload: >1 500 kbps Latency: <100 ms
Single-player gaming	ERP/CRM	3D video streaming
Text communications (E-mail, instant messaging)	HD video streaming	HD videoconferencing
Basic video/music streaming	Multi-player gaming	Super HD video streaming
Web conferencing	Online shopping	Connected education/ medicine
Web browsing	Social networking (multimedia/interactivity)	Group video calling
VoIP (Internet telephony)	Videoconferencing	Virtual office

The very outcome of this report suggests the following:

- Cloud adoption is dependent on available quality Internet broadband infrastructure, especially for advanced workloads and scenarios. This covers things such as latency and throughput both on Mobile and Fixed. In fact, in developing countries, as mobile internet is more developed than fixed, Cloud services that are delivered through mobile are more widely adopted than those available on fixed line.
- Lack of legislation and regulation creates uncertainty for wider Cloud adoption. Legislation such as data privacy provides from clarity for the while ecosystem, including Cloud service providers, Government, customers and consumers.

– The number of local data centers is not an indication to the Cloud adoption. As the Cloud is by design a consolidation of Data centers, a large number of DCs is not necessarily a good indication. Instead, another indication could be the number and size of DCs and potentially their energy consumption.

The detailed figures are provided in **Annex 1** of the report. The Study Group decided to provide the figures in annex to simplify the reading of the report.

4 CHAPTER 4 – Foundational pillars towards Cloud adoption

As for any new and disruptive technology, there is a clear adoption cycle and Cloud Computing is no exception. One can easily observe in **Figure 1a** that the adoption of new technologies is getting faster over time. **Figure 1b** shows the time it took various technologies to reach the first 50 million users.

Figure 1a: Diffusion of innovations curve (1)

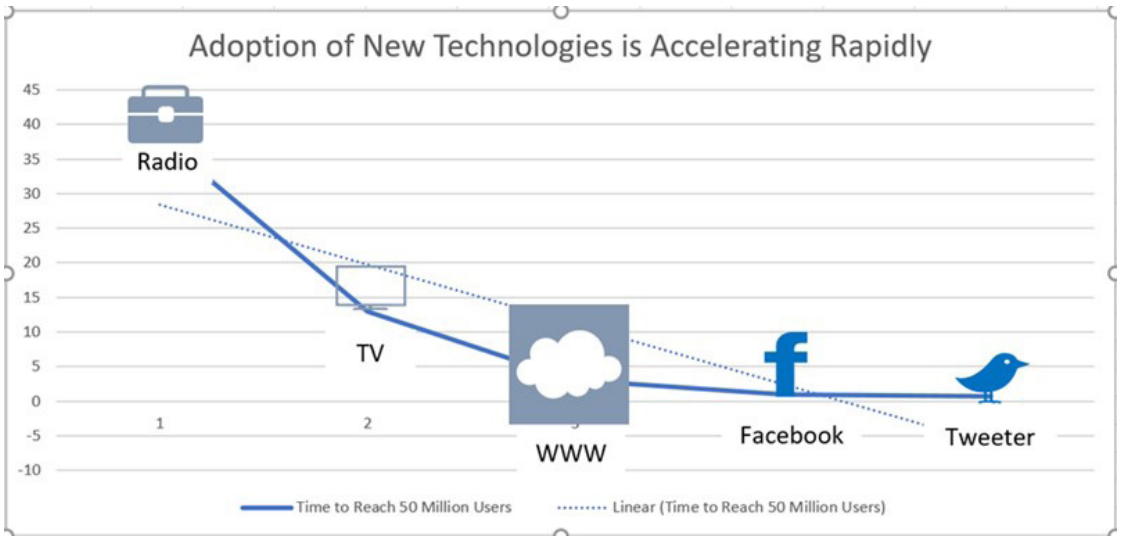
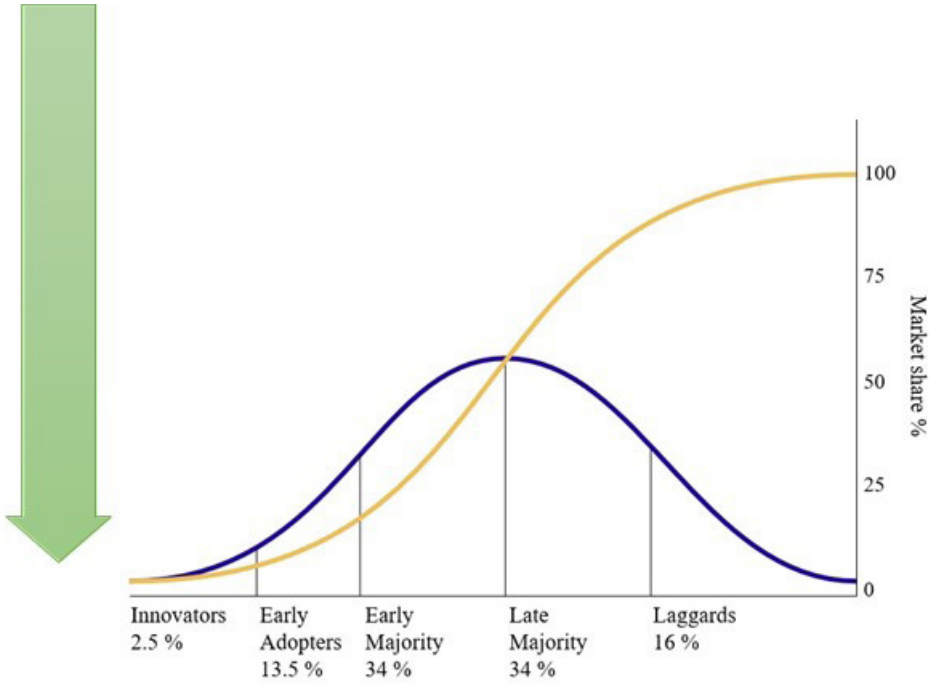


Figure 1b: Diffusion of innovations curve (2)



Like for any major disruptive technology, there are core challenges that prevent adoption at scale. Cloud Computing is no different. Addressing these challenges is required to drive Cloud adoption and help countries benefit.

1) **People:** People are key to market adoption for any technology. The market needs people to understand the technology, understand how to use it, how to innovate with it and how to reinvent businesses and transform using the technology. The market needs also business leaders

who can understand how to leverage the technology to transform their business. And we need policy makers who understand the technology and its policy implications so they can make well informed decisions on key policy issues to lead with the technology. **Section 4.1** of this report addresses the opportunity to develop the right skills and provide recommendations about the skills, but also suggests programs that can unlock the development of these skills.

2) **Infrastructure:** Like any other technology, infrastructure is key to adoption, especially in developing countries. For cars, you need roads, for Internet you need broadband, for Mobile you need backbones, for aircraft you need airports, etc. For Cloud Computing, infrastructure is also needed, although this is not about new infrastructure since the Cloud relies mostly on the Internet and broadband networks. We have dedicated a full chapter to discuss all elements of that infrastructure and provide guidance and recommendations on policies to develop such an infrastructure.

3) **Innovation and Content:** The next important building block to Cloud adoption resides in the development of the content. In this case, it is about local content, relevant content, local and relevant innovations that will eventually drive customer adoption. The Cloud and the underlying infrastructure are enabling technologies and tools that will drive national and businesses digital transformation. An entire section is designed to provide guidance on this important aspect.

4) **Trust:** Finally, consumers, businesses, and government are only going to use technology that they trust. Cloud Computing is no exception. While we think it is important that policies must be developed in this space, this report does not provide detailed policies. Instead, it provides guidance about what those policies should be and what they need to address. We believe that Trust is a key component that engages all parties.

4.1 People: Skills development and awareness

In order to take full advantage of the potential benefits of Cloud Computing, it is essential that people develop the relevant skills and knowledge needed to support and contribute to this industry. A new generation of workers all over the world is preparing to enter the wide range of sectors that are increasingly reliant on Cloud Computing. As these areas – from technology to healthcare to government to finance – continue to introduce innovative uses of Cloud Computing services, they will require workforces that are comfortable developing new applications to run on the underlying Cloud infrastructure, designing user interfaces, performing statistical analysis on large data sets, and monitoring network security. Policy-makers, too, may find themselves wanting to develop new skillsets for regulating Cloud Computing and enabling its growth and development, as well as for creating the educational infrastructure and environment for their citizens.

With businesses and governments turning to Cloud providers for centralized provision of their infrastructural and network maintenance demands, individuals entering the workforce may see overall demand decrease for roles such as system administrators and network operators. However, while the emergence of Cloud Computing may allow for the consolidation of jobs in some of these areas, it will also create significant opportunities for growth and employment in several other fields by expanding the accessibility of scalable computing resources. Six areas of particular focus and opportunity brought to the fore by Cloud Computing services include:

– **Data science:** The growth of Cloud Computing brings with it many novel opportunities for the collection of vast stores of data that can be mined to yield important insights about topics ranging from business operations to the spread of disease, the behaviour of financial markets, the transportation flows of congested cities, the use of public services, and individuals' social interactions. The availability of scalable storage means that organizations can hold on to more data for longer than ever before. To take advantage of these stores of data, and what they can teach us about individuals, cities, and nations, workers will need to possess data analysis skills such as knowledge of statistics, social network analysis, complexity theory, and mathematical modelling. Practice cleaning, querying, and testing large data sets is a critical component of developing

this skillset, underlining the importance of making data available for training and educational purposes. Since the fundamental methods of data science are applicable across a range of different industry sectors, these skills may be incorporated in sector-specific training programs as well for people studying medicine, transportation, policy, and business. Of particular importance is the development of skills related to artificial intelligence and machine learning that will enable people to harness the stores of data made available by the Cloud and use them to develop new and innovative services and technologies. Cultivating skills and techniques related to artificial intelligence will be essential for cultivating a workforce that can fully leverage the potential of Cloud technology and realize its societal benefits and opportunities for technological innovation.

- **Security:** Cloud Computing relieves customers of the need to provide all of their own computer security services in-house by shifting many of those responsibilities to Cloud providers. This is beneficial for small organizations without the time or resources to devote to a dedicated security team. However, it also places considerable pressure on the major Cloud providers to keep their security measures and practices up-to-date since they are responsible for the security of so many customers' data. Accordingly, the rise of Cloud Computing will bring with it greater demand for security expertise and skilled security engineers. Given the size and significance of the data stores they must protect, these security workers will need not just to learn security basics by rote, but also how to develop threat models, adapt to new threats, apply risk management frameworks to computing networks, and perform rapid incident response. The security jobs associated with Cloud Computing may also call for data science skills to help analyze network access logs and identify anomalies and suspicious activity in large-scale computing environments. Developing training programs that combine elements of these skillsets in relevant ways should also be a priority.
- **Privacy:** The growth of Cloud Computing brings with it serious concerns about not just the protection of data from breaches but also the privacy policies, rules, and regulations governing that data. The Cloud model enables significant efficiency and scalability benefits, but it also requires figuring out reasonable, balanced privacy norms and agreements for sensitive data that is stored and managed remotely by third parties. Therefore, training people with skills that pertain to data privacy, including technical mechanisms for ensuring and auditing data management policies as well as legal frameworks governing the privacy protections of individuals and organizations, will be crucial for implementing Cloud Computing effectively and smoothly. Trained privacy professionals are vital to ensuring that users, companies, and policy-makers trust Cloud service providers and are comfortable having their data handled by third parties. Importantly, the privacy skills those professionals must possess encompass not just technical knowledge about how to restrict the uses and sharing of data, but also social and political frameworks about different cultural expectations for and contexts of privacy.
- **Front-end web development:** Roles for front-end web developers will continue to expand and increase in importance with the proliferation of Cloud Computing and web-based access opportunities. While web development is already a thriving employment market in many places, the growth in Cloud Computing creates opportunities for the development of web-based products and services by people who may not have previously had access to the requisite infrastructure for hosting and managing an online business. These roles include both interface design and web application development. Relevant skills for these jobs are development languages, usability techniques and design patterns, web-based security techniques, end user testing, and design and development for mobile devices. There will be some overlap between the web development and security skills relevant for Cloud Computing workers, and it may be beneficial to provide opportunities for combined programs and training modules.
- **Application development:** Software engineering jobs will continue to grow with the opportunities afforded by Cloud Computing, providing a new set of low-cost, scalable resources to entrepreneurs and developers interested in application development. As with those pursuing front-end web development skills and training, application developers will want to develop coding and design skills needed for developing applications to run on mobile devices, as well as personal computers and tablets. Ramping up educational offerings focused on coding, design, and testing, will help

prepare future generations of application developers to take full advantage of Cloud Computing infrastructure and engage in a global market for technology and digital content.

- **Architecting and developing for the Internet of Things:** Cloud Computing brings with it many opportunities for advances and innovation in connecting new devices to the Internet of Things (IoT). To take advantage of the opportunities presented by IoT technologies, it will be important to emphasize training programs that marry the skills required to build and design those devices, such as cars, airplanes, and medical equipment, with the skills required to build and design secure software, artificial intelligence algorithms, and user-friendly applications. This will likely involve combining the security and application development skillsets relevant to Cloud Computing with more traditional engineering disciplines, including mechanical engineering, biomedical engineering, and aerospace engineering. Integrating these fields will help prepare workers and entrepreneurs to spread the advances of Cloud Computing to a wide variety of different sectors and technologies.
- Policy-makers will play a vital role in creating, funding, and encouraging the educational systems that will impart these skills to their citizens. Online courses and interactive activities will be necessary to provide education and skills training at scale for the next generation of workers all over the world. Standard classroom-based, instructor-led learning will not be sufficient to scale to meet the growing business needs created by Cloud Computing. Online education will grow rapidly within corporate environments, governments, and academic institutions, and this growth is likely to lead to changes in vendor certifications. Increasingly, employers and vendors will recognize verified online course completion certificates in hiring and training decisions.
- In many cases, policy-makers may find that their efforts to build up the technical infrastructure needed to enable Cloud Computing can also serve a dual purpose in enabling online training opportunities. Providing people with wider access to an array of global educational modules and materials is an important consequence of improving a nation's connectivity and technical infrastructure. Increased access to online education will mean that many students will end up studying courses developed in other countries that are not taught in their native languages. This means that foreign languages, in particular English proficiency, will be another critical skill for workers to develop in order to pursue training and education, as well as job opportunities. Policy-makers should therefore also focus on access to affordable, effective language training opportunities starting at the earliest stages of schooling as a part of a comprehensive Cloud Computing skills strategy.
- For policy-makers actively engaged in regulating Cloud Computing, data storage, and infrastructure installations, it may also be valuable to pursue some training in some aspects of computing, including networking, data protection and portability standards, and incident reporting models. Understanding the underlying protocols and network architecture will help inform important policy decisions about data governance, trans-national data flows, and security measures. Familiarity with international standards on security, privacy, and portability will provide policy-makers with a frame of reference for how their peers regulate and how those decisions can be most effectively aligned in a global economy. Looking at how different governments have approached incident reporting and analysis models can help policy-makers formulate how they wish to treat security incidents and incident response within their own jurisdictions.
- A variety of different education and training programs will be needed to provide diverse populations and workforces with these skills. To reach students in traditional educational environments, policy-makers may want to encourage the development of innovative curricular modules and degree that can be combined with existing educational initiatives at all age levels. To reach members of the workforce who are no longer in school, policy-makers may look to online training courses, partnerships with industry, and mid-career certificate programs to provide people currently in the workforce with additional skills that may increase their opportunities and ability to take on roles related to cloud computing. Reaching audiences outside traditional educational and workforce pathways focused on technology may require additional forms of outreach, including partnering with vocational schools, developing widely publicized talent

searches to identify people with relevant skills, and providing scholarships and pathways into traditional training programs for people with unconventional backgrounds. Policy-makers will want to ensure that they focus on developing cloud computing skills training modules across a variety of these different platforms in order to facilitate the growth of a large, diverse, and wide-ranging workforce in this area.

4.2 Innovation

The core promise of Cloud Computing is that it can enable innovation at lower cost and greater scale for a larger population to take advantage of across the world. That innovation is made possible by the flexibility of Cloud resources and the cost savings that come with a Cloud deployment model, but enabling robust innovation requires more than just technical infrastructure and offerings. Without the support of policy-makers and policies that promote the skills, intellectual property protections, and trade agreements needed to make use of Cloud Computing, the promise of Cloud Computing to enable innovations will go unfulfilled. As policy-makers invest in skills and infrastructure development, they should also ensure that they are creating a regulatory framework in which people will be able to innovate and bring solutions to market that enable their businesses to become global.

To make the entrepreneurial opportunities of Cloud Computing a reality, the Study Group suggests that governments lead by example, by delivering their own services to citizens using Cloud infrastructure and adopting "Cloud first" policies that make use of Cloud services by default for government projects and vendors. National and local governments are often significant customers, and their business is likely to attract considerable interest from Cloud service providers and serve as a starting point for introducing their citizens to the services and introducing the providers to their local markets. Government adoption also sends a strong signal to citizens about how trusted and secure Cloud services are by authority figures. By making a public statement that the government believes Cloud Computing is secure, cost-effective, and efficient, policy-makers can help individuals and small businesses feel comfortable trusting their business to these providers.

Beyond adopting Cloud services themselves, governments can also encourage innovation in computing by making data available from civil services and public utilities – for instance, energy consumption, public transportation arrival times, census and income surveys, employment patterns, disease cases, crime reports, and others. Making data available to citizens to analyse is useful in encouraging people to pursue and practice the data analysis skills so central to many facets of the growth in Cloud Computing. It also provides people with opportunities to try to harness that data for the development of new applications and Cloud-based services, such as tools to track the arrival of buses and trains, or monitor the spread of disease, or aggregate and analyse crime numbers across a region. By providing citizens with concrete opportunities to engage in developing civic-minded technologies, governments can help drive greater Cloud-centred innovation across an entire population.

The innovation enabled by Cloud Computing is inherently global. Cloud services and connectivity enable entrepreneurs to work with customers all over the world. But the availability of this global market for innovation is dependent on policy-makers encouraging the people in their country who develop local content and applications to reach out to a global audience. This is particularly important for innovators in small countries with limited populations who would otherwise be unable to grow a significant customer base. To do this, it will be important for policy-makers to ensure not only that their populations have the language and technical skills to succeed in serving international customers, but also that their governments have put in place appropriate intellectual property protections, cybercrime policies, and data security regulations. To the extent that these intellectual property regimes can align with international regulations, they will be most effective at encouraging and enabling international innovation and business. Similarly, cybercrime and security policies that encourage international cooperation with criminal investigations and enable the free flow of data across national borders are likely to help enable international development and business opportunities for local entrepreneurs.

Innovators, start-ups, ISVs, and any business using the Cloud to deliver a service is by design, capable to address global markets. However, policies that forces for example for data residency or special data privacy, will limit the ability of the innovator to go global or at least will increase significantly his cost of doing business.

4.3 Infrastructure

Lack of adequate infrastructure is certainly the main challenge for developing countries. Realizing the opportunities for innovation and potential benefits of Cloud Computing requires robust computing and networking infrastructure to provide reliable connectivity across a range of devices and applications. Because Cloud Computing services are dependent on network access, building resilient, high-speed, reliable networks is an essential component of driving Cloud adoption. Different Cloud deployment models may require different network architectures – for instance, a private Cloud service necessitates that users and providers share a single, trusted network, while public Cloud services would allow users and providers to operate on separate networks, often connected through the public Internet – but these models require certain common infrastructure elements and features to support effective access to Cloud Computing services. Creating an enabling regulatory environment to facilitate investment in the infrastructure resources needed to support Cloud Computing is a crucial role for policy-makers looking to encourage Cloud adoption – without these fundamental infrastructural components, access to Cloud Computing is likely to be too limited, expensive, and inconvenient for the economic opportunities of Cloud services to be fully realized.

4.3.1 Features of networks that support effective access to Cloud Computing services

Cloud Computing services depend on users having reliable network access. Often, that access must extend across multiple different devices and a relatively wide geographic boundary so that users are able to use those services regardless of where they are, what devices they use to access them, or what networks they are connected to. Reliable, widespread network access of this nature is best achieved by building networks that have the following features:

- **Stable energy sources:** In order for users to access Cloud services they must be able to connect to the network, and keeping that network up and running at all times requires stable, secure energy generation and delivery infrastructure. Without a steady power supply, the Cloud servers and network routers will offer only intermittent access to end users, creating considerable inconvenience and interruptions. The power supply should also be able to scale with the demands placed on the network, providing sufficient capacity for peak usage times.
    - The energy supply becomes extremely critical when it comes to local data centers; in fact, data centers require a massive amount of energy to operate and, unfortunately, that energy has to scale with the growth of the data center; the more users and services you have, the more servers and storage you add, the more energy is required to operate. Developing and operating data centers that are energy friendly requires a great expertise. At the same time, it is only through scale that one can achieve the benefits of the Cloud.
    - The more reliable the underlying energy infrastructure of the network and the local data centers if any, the more users will be able to rely on Cloud services and use them to drive new opportunities and innovation. Encouraging the development and adoption of renewable or green power sources can also help motivate investments in data centers and Cloud infrastructure as there is increasing focus on minimizing the environmental and climate impacts of these resources.
- **Resilient architecture:** Just as it is important that the energy supply for the network and local data center be reliable and resilient to any interruptions, outages, or interference, it is also important that the network architecture be able to withstand and recover from periods of heavy traffic, natural disasters, or malicious attacks. Developing a resilient network means ensuring that

there is redundancy in the critical infrastructure components, so that failure of one server or connection does not lead to widespread outages. Resilience also requires network components that are engineered to recover rapidly from failure and return to regular operations even after a period of interruption. Resilience is also an important component of the logistics and supply chain infrastructure required for Cloud Computing networks.

- **High-speed broadband access:** High-speed broadband access is required for Cloud Computing, to allow large volumes of data to flow quickly between providers and users. Broadband access encompasses several different components, including intra-data centre connectivity, backhaul and interconnection infrastructure to transport data to the network backbone, and last-mile connectivity to reach individual users, businesses, and homes. Each of these types of broadband infrastructure may be implemented by different entities and make use of different technologies, depending on cost constraints, technical requirements, and regulatory restrictions. A wide variety of technologies can be achieved over telephone lines (or DSL) or via satellites, as well as cable television connections and dedicated fiber-used to provide broadband access, including fibre optic cable, coaxial cable, satellite technology, and wireless networks, ranging from personal routers to the Wireless Gigabit Alliance (WiGig) of high-capacity wireless networks suitable for data centres. Cloud services typically require numerous different broadband technologies that all work together, across the data centre, backhaul, and last-mile networks. The more seamless the integration of these technologies, and the greater the variety and bandwidth of the available broadband infrastructure, the wider the range of Cloud services, applications, and opportunities that end users will be able to experience and develop.
- **Mobile-device based access:** Ensuring reliable mobile-device based access is an increasingly important feature of Cloud Computing networks. Providing ubiquitous wireless access for mobile devices that utilize regulated spectrum resources is therefore essential for developing networks that can support and enable Cloud Computing services without interrupting daily workflows. Mobile access can provide valuable last-mile connectivity to users when they are in transit, as well as to users whose primary online access modes may be through mobile devices. Encouraging investment in mobile access infrastructure is therefore a matter of both availability and convenience for users—it is a means of offering access to Cloud services to people who are largely reliant on mobile devices, as well as a means of ensuring that people who require regular access to Cloud services can reliably connect even when they are not at home or at work.
- **Flexible capacity and architecture:** Much of the promise and potential of Cloud Computing services stems from their rapid and easy scalability. Network infrastructure must facilitate this, allowing for flexibility in the traffic capacity and allotment of resources to different users and workloads as their needs change. Similarly, networks must be able to provide for a diverse set of different network configurations to allow for the full range of Cloud implementations and deployment models, from private Clouds to public and hybrid models.
- **Automated provisioning of network resources:** Scaling the network to meet fluctuating demand and providing additional capacity or new configurations should be a smooth, immediate process to facilitate Cloud services. Network components should ideally be able to respond to these fluctuations and adjustments automatically, so that network resources can be provisioned according to users' needs without requiring manual interference or reconfiguration.

4.3.2 Energy

Sufficient, steady power supply is a crucial component of Cloud Computing infrastructure. Power has always been an important component of computing machinery, for Cloud Computing, however, it is especially necessary that power be provided reliably to keep networks up and running at all times. Without network access, users lose access to Cloud services and may have no local copy of their data or information to revert to. This means that it is important not only that that power is available to users' devices and their local, last-mile connectivity infrastructure, but also to the broader geographic area and the networking hubs that they rely on for connectivity to outside networks. For this reason, Cloud Computing gives individual users a much greater stake in their 'neighbours' energy supplies and

the consistent provision of power across their region as a whole. This collective, communal interest in the development of reliable energy supplies needed to support a robust networking infrastructure requires coordination across local utilities organizations and mutual support and reinforcement to ensure resilience of power generation and distribution infrastructure. Since the reliability of the network is central to the effectiveness and utility of Cloud services, the reliability and redundancy of the energy infrastructure powering that network is paramount.

Although reliability and resilience are critically important for developing energy infrastructure to support Cloud Computing, these services do not themselves necessarily require more energy than other forms of computing, but rather a steadier, stable supply. Ultimately, in fact, Cloud Computing can provide significantly improved energy efficiency over standard, localized computing models by centralizing computing resources. This allows for more efficient use of processing and storage resources, reducing the need for each individual device or organization to consume as much energy in dealing with these tasks separately. For instance, in a case study analysis performed using the Cloud Energy and Emissions Research Model (CLEER), a research team found that shifting email, spreadsheet processing, customer management systems, and other software tools to Cloud-based computing services operated through centralized off-site servers could reduce U.S. businesses' computing energy usage by 87 per cent.[7] Realizing these gains in energy efficiency, however, requires a sufficiently stable power supply to allow users to trust that they will not lose access to their network, otherwise they may not be willing to support the consolidation of computing resources via Cloud services, regardless of potential energy benefits.

While reliability is paramount for power sources that underlie Cloud networks, infrastructure providers are increasingly interested in making use of green or renewable sources of energy when they invest in new Cloud resources. There has been a significant trend towards building more environmentally friendly data centres that make use of technologies such as solar panels and fuel cells to mitigate the costs of power consumption as well as environmental impacts. Encouraging investment in developing and making available green energy sources may therefore also serve as a step towards encouraging investment in developing and making available Cloud infrastructure and services.

4.3.3 Broadband

Cloud Computing services require the ability to move large amounts of data easily and instantly between users and providers. The backbone of this rapid, high-volume transportation is a robust broadband network that provides dedicated resources with sufficient capacity to support peak data loads. Similar to energy provision, broadband infrastructure planning must take into account not just local infrastructure but also the larger network within which an individual region is situated and the quality of the network at every point along the likely paths for data to travel from centralized, Cloud data centers to individual users and customers. Broadband infrastructure development is therefore a process that requires careful and extensive collaboration between neighbouring regions, as well as between the private sector and policy-makers.

Assessing the quality of the broadband network is not just a question of speed or bandwidth, the maximum rate at which data can be transported over the network. Several other important factors impact the network's performance and can play a major role in determining the viability and convenience of certain Cloud services. These performance factors include:

- **Latency:** The time required for information to traverse the network, from sender to receiver.
- **Jitter:** The variation in latency for information on a network at the receiver's end, or the irregularity in the time required for information to arrive at the receiver.

[7] U. Irfan. "Cloud Computing Saves Energy." Scientific American. June 12, 2013. Available from http://www.scientificamerican.com/article/Cloud-computing-saves-energy/.

– **Throughput:** The actual rate of data transmission over a network, taking into account not just the available bandwidth but also other limitations on traffic transmission.

For voice and video services, in particular, latency and jitter can have a significant impact on user experience. Developing robust broadband infrastructure to support Cloud Computing therefore requires not just implementing a network with adequate bandwidth to support a variety of diverse Cloud services but also paying attention to the other network performance metrics, besides speed, that contribute to the network's quality of service. Regular measurement and assessment of these different performance metrics plays an important role in identifying and fixing any bottlenecks or performance problems happening at the network layer.

The resilience of broadband infrastructure also plays a major role in determining its success at supporting Cloud services. Since ubiquitous availability is a key feature of Cloud Computing, the broadband network must be able to handle failed components or outages without shutting off access to users' data and processing services for extended periods of time. This means architecting a broadband network with redundant resources, flexible configurations, and automated ability to reroute around failures. It also means Cloud providers will need to account for these issues in their redundancy planning and illustrates why Cloud providers will generally want to be able to provide redundancy on different network segments and in multiple geographic regions.

4.3.4 Elements of network architecture

There are at least of the network architecture that need attention to address the need of Cloud Computing: these are spectrum and Internet eXchange Points (IXP).

While wired/fibre and wireless broadband infrastructure is important for supporting Cloud services it can also be expensive and often requires considerable time to build out. For these reasons, numerous forms of high capacity broadband access—including fibre, coaxial cable, and satellite connectivity—may be impractical or too costly for some regions to provide full coverage or to offer in the immediate future. Terrestrial wireless connectivity, both for backhauling and for mobile/portable devices, can provide a valuable supplement to wired/fibre broadband and offers regions with minimum wired infrastructure a cheaper, faster way to begin utilizing Cloud services and building out ad hoc networks that take advantage of the ubiquity of mobile devices.

Even regions that do have solid wired/fibre broadband infrastructure may have something to gain from investing in wireless, mobile-device-centred networks to augment their wired connections. Since wired/fibre broadband networks are unlikely to provide complete coverage, mobile and wireless networks can broaden the ubiquity of Cloud Computing connectivity, allowing users to access Cloud services from a wider range of places and devices—for instance, while traveling or commuting. Spectrum-related issues are addressed in depth in the final report of the ITU-D/ITU-R Joint Group on WTDC Resolution 9.[8] Providing access to spectrum resources is a vital step towards developing wireless and mobile networks capable of supporting Cloud services. These networks can serve both as additional resources in areas with significant wired/fibre broadband connectivity, increasing the ubiquity of Cloud services and the ease of access, or as a less resource-intensive infrastructural precursor to wired/fibre broadband in regions that are just beginning to develop Cloud Computing infrastructure.

With mobile technology continuing to grow in popularity, and wireless connectivity becoming an increasingly important component of both personal and business computing, wireless networks supported by sufficient cost-effective access to spectrum should be an integral element of any infrastructure development aimed at supporting Cloud Computing. Developing mobile and wireless networks that can support the demand of Cloud services requires the allocation of spectrum resources for network connectivity. Since spectrum is usually a regulated resource, this is an area where

[8] https://www.itu.int/pub/D-STG-SG01.

policy-makers have a particularly vital role to play in encouraging the roll out of network infrastructure and subsequent adoption of Cloud services. Allocating spectrum to mobile and wireless networks can be done in a number of ways and need not involve redirecting spectrum from other critical uses.

– Three options for policy-makers interested in encouraging investment in developing spectrum infrastructure for Cloud services are allocating spectrum for private licensed use in this area, enabling license-exempt or unlicensed use of certain bands of spectrum, and enabling opportunistic sharing of allocated but unused spectrum resources (reference to SG 1 Res 9 activity would be good here). In the first model, regulators may be able to allocate, or reallocate, specific dedicated bands of spectrum to the development of mobile and wireless networks—these bands may be unused, or underutilized in their current allocation, and offer service providers an opportunity for building out higher-capacity networks with more reliable service. The second model for encouraging investment in spectrum infrastructure involves permitting Cloud network providers to use certain bands of spectrum under license exempt rules similar to what we have in the 2.4 ISM bank and 5 GHz bands where the policy ensures coexistence of different networks using the license exempt spectrum. For instance, in many countries spectrum bands regarded as unusable for long distance communications have long been exempt from licensing requirements, so long as the devices making use of those bands operate within given power output restrictions. As communications technologies have matured, network providers have increasingly found ways of making use of spectrum bands that were previously considered unusable and many new technologies and standards have been developed and flourished in license-exempt bands, including Wi-Fi, Bluetooth, and RFID. Freeing up blocks of spectrum for license-exempt use can therefore provide a valuable opportunity for innovation and development of new network infrastructure technologies to support Cloud services. Finally, policy-makers may wish to explore policies that would enable opportunistic sharing of allocated spectrum resources by allowing mobile network operators to take advantage of unused frequencies, or white spaces, to provide connectivity to users without interfering with the regular provision of services on those frequencies[9]. This form of spectrum sharing provides high efficient use of assigned spectrum. A good example is the use of TV white spaces (refer to ITU-D Study Group 1 Resolution 9 use cases).

Network reliability and resilience are crucial to the successful provision of Cloud services, and one common mechanism for strengthening these characteristics – as well as reducing costs to local service providers – is the establishment of Internet Exchanges, or Internet Exchange Points (IXes, or IXPs). In many regions, these institutions serve as focal points for exchanging Internet traffic across different networks, the formation of partnerships between the operators of those networks, and the coordinated cost-saving and mutual support of neighbouring service providers. An IXP serves as a physical point of interconnection between multiple Internet services providers and content delivery networks. An IXP allows these companies to exchange traffic directly with each other rather than sending that traffic through upstream providers. This can result in significant cost savings for service providers since they typically pay their upstream providers to carry traffic for them but are usually able to exchange traffic via an IXP free of charge by mutual agreement.

Use of IXPs can also provide benefits to network latency and bandwidth. Since the interconnection occurs directly, at a common physical facility, there is no need for traffic to move through other regions to complete the exchange to another autonomous system, potentially reducing the latency of the exchange. IXPs can also increase the apparent bandwidth of a network in regions where connectivity to major upstream providers is typically slow and expensive. In those areas, direct exchange with nearby local service providers may enable much faster transmission of data by cutting out the need to make use of the limited long-distance connections. Interconnecting directly with other Internet service

[9] For an example of regulatory recommendations in this area, see, for instance, "Suggested Technical Rules and Regulations for the Use of Television White Spaces", a Technical Report by the Dynamic Spectrum Alliance, available from http://www.dynamicspectrumalliance.org/assets/submissions/Suggested%20Technical%20Rules%20and%20Regulations%20for%20the%20use%20of%20TVWS.pdf.

providers also offers individual network providers a greater number of potential paths to reach individual customers, boosting the redundancy and resilience of the network, as well as routing efficiency.

The structure of IXPs also encourages local collaboration and community building across service providers in the same region to support each other's infrastructure and customers. IXPs are designed to be mutually beneficial to all participants, and they are often set up locally in informal and not-for-profit arrangements that sometimes grow to include many more members and support greater capacity. The initial establishment of an IXP need not be a lengthy or resource- intensive process, making it a plausible investment for a region just beginning to develop its Cloud Computing infrastructure.[10] By encouraging local collaboration among service providers, it can also help build partnerships that will later on serve to facilitate stronger negotiating positions and relationships with more established providers in other regions.

4.3.5 Best practices and recommendations for developing Cloud infrastructure

Developing the necessary infrastructure to support Cloud services is an ongoing process that requires the active involvement of policy-makers, private industry, and local communities, as well as continued assessment and re-evaluation to align with emerging technologies, policies, and trends. Best practices for the development of these infrastructure components include:

- Foster regional engagement and cooperation: Building out network infrastructure is essentially a community-based activity and requires the involvement and input of interconnecting network providers. Establishing strong partnerships with local government and industry partners who are already developing infrastructure, or are interested in doing so, can be a great asset both in terms of gathering knowledge and for forming institutional partnerships in the form of Internet Exchanges, or encouraging the development of unified technical standards and policies that promote greater interconnectivity.
- Start by developing low-cost, mobile-based infrastructure: The scale and expense of Cloud wired/fiber broadband infrastructure can be discouraging for regions that are just beginning to build out support for Cloud services. Where these costs are prohibitive, it makes sense to focus on the allocation of spectrum resources to mobile networks using licensed, unlicensed, and shared access models, or the establishment of low-cost mechanisms such as Internet Exchanges that can boost performance and resilience with relatively small up-front investment. These changes, though small and inexpensive in comparison to laying fiber-optic cable to every home in a particular region, can have far- reaching impacts on users' ability to take advantage of Cloud services. These impacts may, in turn, help users and providers realize the opportunities of Cloud Computing and encourage greater investment in more ambitious infrastructure projects later on.
- Emphasize resilience and availability of infrastructure: Without network connectivity, Cloud services are inaccessible and users will quickly lose patience with them, regardless of efficiency or cost benefits. Consequently, the most important characteristic of the critical infrastructure elements, including energy source, broadband network, and wireless networks, is availability of service. To ensure that these infrastructure components are as reliable and stable as possible, it is important to emphasize redundancy in their design, as well as fault-tolerance and quick recovery times. Partnerships among local service providers to identify alternative routes and provide reinforcement for network hardware can also contribute to the overall resilience and stability of the underlying network.
- Tailor infrastructure needs to local demand for services and devices: Different user groups may have very different requirements for Cloud services and infrastructure development should be tailored to meet the needs of particular populations. Users who rely almost exclusively on mobile devices for network access, for instance, may require different infrastructural priorities

[10] For more details on the implementation of low-budget regional IXes, see, for instance, Remco van Mook's RIPE presentation, "The $1,000 Internet Exchange". September 2015. Available from https://ripe71.ripe.net/presentations/30-1000-dollar-exchange-ripe71.pdf.

– and capacity – than those who work primarily from devices connected to wired broadband networks. Similarly, groups that use primarily text- based services may have very different network performance requirements than those who make use of substantial video or voice-based applications. Infrastructure development plans should take into account what kinds of services and devices are most popular for the targeted users and prioritize support of those functions, while also trying to make it possible for those users to explore other services and connectivity options.

– Promote continued use and testing of infrastructure in development: While developing and implementing new Cloud infrastructure components, it is important that users and providers be regularly making use of the new infrastructure as it is established and providing feedback on its usability, quality of service, and reliability. This will enable an infrastructure development process that is responsive to the needs and concerns of Cloud users and providers. It will also help ensure that there is demand for infrastructure as it is being built out, and give users an opportunity to acclimatize themselves to Cloud services and begin exploring potential benefits in the early stages of the development process, ideally driving broader adoption.

– Allow for flexibility and future updating of infrastructure: Cloud Computing is a rapidly changing field with new technologies emerging and new services and functions being developed. It is impossible to say exactly what the Cloud Computing landscape will look like a decade from now, but the infrastructure investments required to support Cloud Computing should last much longer than that.

Accordingly, Cloud infrastructure should, to the extent possible, leave open the possibility of future updates, reconfigurations, and adjustments. This may mean providing additional traffic capacity beyond what is needed at present, building in automated means for updating network infrastructure components, or planning regular reassessments of whether existing infrastructure meets users' needs. This may also mean regularly reviewing and updating supply chain and logistics infrastructure to make sure it continues to meet the needs of the network and support new technologies and developments.

4.3.6 Cost models and implications for developing local Cloud infrastructure

Cloud Computing infrastructure is an investment. The potential economic benefits of Cloud services are significant and the infrastructure investments should therefore be viewed in the context of providing a platform for future economic growth, innovation, and technological entrepreneurship. However, it is not necessary to make enormous financial investments up- front to begin realizing the benefits of Cloud services. On the contrary, low-cost initiatives to grow local network infrastructure, including the establishment of regional Internet Exchanges that bring together service providers in a particular area, and the relaxation of restrictions on unused spectrum to enable broader wireless and mobile connectivity, can have a significant impact and provide a good starting point for assessing the potential benefits of a larger infrastructure investment.

Local partnerships can also help manage the costs of developing infrastructure, by allowing multiple organizations and policy bodies to share the costs of building infrastructure that will then benefit a larger population. This is the basis for the widespread development of IXPs in Europe and Asia—the cost-savings that robust, close-knit local partnerships can provide to all parties by cutting out extraneous middlemen and eliminating unnecessary transaction costs. Local collaboration and mobile networks can play an important role in mitigating the costs of developing Cloud infrastructure and enabling a gradual investment strategy that allows for the realization of Cloud Computing benefits even as infrastructure is being developed. Ultimately, significant investments in Cloud infrastructure may well be warranted to realize the full potential of these services, but that is likely a long-term goal, to be undertaken after there is clear evidence of the efficiency and cost-saving benefits of increased reliance on the Cloud.

4.4 Trust

Customers will only use technology they trust and Cloud computing is no exception. Cloud Computing relies on the trust established between users, providers, and regulators. Since Cloud services often necessitate the sharing of common computing resources, and the remote storage and processing of data and sometimes sensitive or personal information, users must be able to trust that their data is as secure and protected—if not more so—than it would be stored locally on their own premises. Similarly, policy-makers must be able to feel confident that their citizens' information is being handled according to the appropriate laws and policies in place in their regions, even when that information is being transferred and stored outside their jurisdiction. Finally, Cloud providers must have confidence that they are facing stable policy regimes governing the treatment and use of their customers' data, otherwise they will not have incentives to offer their services to those customers. Enabling the trust relationships between these three groups, across jurisdictional boundaries, cultural divides, and political systems, is crucial for creating an enabling environment for Cloud services. Policy-makers and Cloud providers and customers alike all have important roles to play in establishing the trust needed to make Cloud Computing viable and beneficial for everyone involved. The following four principles should govern the development of trusted Cloud Computing services:

- **Security and protection:** Customers must trust that their content is kept protected and safe from hackers and unauthorized access. Security is the foundation on which anything in the Cloud is built. Cloud service providers should take specific actions to secure their customers' information. They should apply security controls and best practices such as those found in international standards. Cloud services providers should ideally comply with these standards to create trust with their customers
- **Privacy and control:** As customers are moving their data to the Cloud, they should also have confidence that their data is not only safe (secured and protected by the Cloud service provider), but they should be able to know the privacy rules that govern their data, especially from the Cloud service provider. Users want to know who has access to their data and when, where it is stored, what happens to their data when the leave the service, if they take back their data when they leave the service. Ideally, users should control access to their data and where it is stored. They should own their own data and can take it with them upon contract termination. Additionally, customers may request that their data be deleted by service providers. Policy makers should act privacy laws as it is the case in many countries. According to ITU, 82 countries have adopted some kind of privacy or data protection law as of 2015. Even when such laws exist, they are not well enforced in many countries. It is also recommended that when developing new privacy laws, countries should align as much as possible to existing laws in other countries; in that case, Cloud service providers will be able to comply with the laws without jeopardizing their economic model as they reach out to more countries.
- **Compliance:** Users who have compliance obligations to applicable laws and regulations or to specific international standards in their respective countries, should be able to comply even in the case they use a Cloud service provider. In that case, the Cloud service provider might have to comply with some of these policies or standards, but in any case, provide evidence to the customer that will help him comply with his obligations. Compliance obligations can never be passed all along to the Cloud service provider, who acts in most case as only part of the supply chain, but should in no case have rules that limit its customers from meeting their compliance obligations.
- **Transparency:** Transparency is key to building trust. Transparency is also about how the Cloud service provider is transparent in all aspects of Security, Privacy and Compliance. Users, especially enterprises and governments, like to know what is happening with their data; they are made aware of who can access it and under what circumstances, as well as how it is protected, transferred and deleted. When possible, Cloud providers should respond to lawful requests for customer data by redirecting the requesting agencies to obtain the requested data directly from their customers.

4.4.1 Policy and regulatory mechanisms to enable effective access to Cloud Computing services

- **Invest in IT infrastructure:** Cloud Computing requires robust, ubiquitous and affordable network access. Policy-makers need to provide incentives for private sector investment in broadband and mobile infrastructure and laws that promote universal access to those networks. Mechanisms to promote the investment infrastructure include development of a national broadband plan and devoting government resources to improving and expanding both fixed and mobile network access.
- **Promote free trade:** Cloud Computing needs to operate across national boundaries to maximize the benefits it can deliver with regard to efficiency and cost-savings. Its potential for enabling economic growth depends on a global market that transcends barriers to free trade, including preferences for particular products or providers. Policy-makers can promote free trade by developing government procurement regimes and efforts that remove barriers to cross border data flow, including countries' requirements and preferences for particular products, as well as by joining the World Trade Organisation (WTO) Agreement on government procurement.
- **Encourage interoperability and international harmonization of rules:** The smooth flow of data around the world, e.g., between different Cloud providers and data centers, is essential to realizing the economic value of data. This requires efforts that promote openness and interoperability. Governments should endorse industry Cloud Computing standards, including taking in to consideration relevant standards recognized under ITU-T SG13, and help accelerate their development where appropriate, while working to minimize conflicting legal obligations on Cloud providers. By promoting standards developed through voluntary, international, industry-led processes, policy-makers can help enable robust, global Cloud services.
- **Protect intellectual property:** Protection of patents, copyrights, trade secrets, and other forms of IP that underlie the Cloud, or are used in applications and contents shared in Cloud services, is necessary to promote continued innovation, technological advancement, and investments. Policy-makers can protect intellectual property by promoting laws that provide strong incentives for investment and clear protection and vigorous enforcement against misappropriation and infringement in line with the World Intellectual Property Organization Copyright treaty.
- **Combat cybercrime:** Policy-makers should ensure that legal systems provide an effective mechanism for law enforcement, and for Cloud providers themselves, to combat unauthorized access to data stored in the Cloud, and address extraterritorial offenses with the rule of law. In particular, policy-makers can help battle cybercrime by promoting laws compliant with the Budapest Convention on Cybercrime (e.g., comprehensive computer crime legislation).
- **Promote security:** Users need assurance that their data is safe while running applications in the Cloud and while in storage and in transit to/from the Cloud. Since security technology changes rapidly, Cloud providers must be able to implement cutting-edge cybersecurity solutions without being required to use specific technologies. Policy-makers can help enable secure Cloud services by promoting clear, technology-neutral electronic signature laws; general security audit requirements for digital data hosting.
- **Ensure data privacy:** The success and adoption of Cloud Computing depends on users' belief that their information will not be used or disclosed in unexpected ways. At the same time, to maximize the benefit of the Cloud, providers must be free to move data through the Cloud in the most efficient way. Policy-makers can help ensure that these two goals do not conflict by promoting policies based on international privacy principles, such as the Organization for Economic Co-operation and Development (OECD) Guidelines and the Asia-Pacific Economic Cooperation Privacy (APEC) Principles, as well as reasonable guidelines for privacy breach notifications.

4.4.2 Transparency

Crucial to the adoption of trusted Cloud services is the principle that users know what data is being collected about them and how that information is being used. To that end, there are several important

guidelines for developing the essential transparency regime that allows users to trust the Cloud services they rely on and feel confident they know how their content is being used.

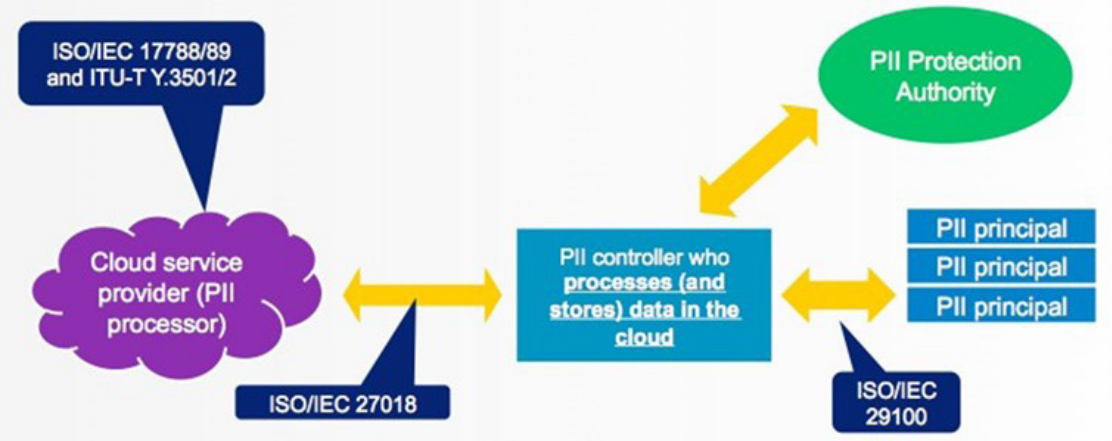
- **Resist improper or overly broad law enforcement requests:** Whenever possible, Cloud providers should disclose (or redirect) requests to Cloud customers directly so that customers can feel comfortable they are aware of when their information is being disclosed and to whom. If users do not trust that they will have some visibility into this process when possible, they may choose not to use Cloud services altogether and thereby deprive themselves—and their communities—of the potential economic and innovation benefits those services could provide.
- **Provide Cloud customers with information on where their contents may be stored and processed:** Cloud users should be given full information on the location of their data and its processing so they have visibility into the different legal regimes that may govern that data and the opportunities for lawful access by other parties during the transmission, storage, and processing stages.
- **Publish comprehensive transparency reports:** Transparency reports on how and when Cloud service data is accessed help reassure customers that they are aware of lawful access attempts and are being kept informed by their Cloud providers. This open communication between providers and users is essential to maintaining trust among all of the involved parties.

4.4.3 Standards

Cloud providers and customers must be able to meet applicable laws, regulations, and key international standards. Regular independent third party audits can help certify compliance with industry standards and build trust among users, providers, and regulators. Key international standards governing the protection of personal identifying information (PII) in the Cloud include:

- **ISO/IEC 17788/89 and ITU-T Y.3501/2:** Framework, definitions and reference architecture for Cloud Computing jointly published by ISO/IEC JTC-1 and ITU-T.
- **ISO/IEC 27018**: Based on the universally recognized standard for IT security ISO/IEC 27000, ISO/IEC 27018 provides specific guidance for the protection of PII by Cloud service providers acting as processors.
- **ISO/IEC 29100**: Privacy framework with internationally standard terms and considerations for PII.
- Adding the relevant standards recognized under ITU-T SG13.

Figure 2: Standards



5 CHAPTER 5 – Lessons learned

Cloud Computing is gaining maturity, acceptance and deployments across the world, but different nations are at different stages of adopting Cloud technologies and have taken different paths to enabling those technologies in various forms. Besides commercial organizations, many governments around the world are enjoying the benefits of Cloud Computing, but their different experiences and different results in this domain offer several lessons for others about the relative merits of a range of regulatory approaches. A survey[11] was conducted ITU-T Study Group 13 on cloud computing scenarios in developing countries.

5.1 Australia

In 2014, the Australian government also adopted a Cloud First Policy[12] similar in nature to those of the United States and the United Kingdom. As part of the policy, the government issued a formal Cloud Computing policy document intended to aid government agencies with the administration, implementation, and procurement of Cloud services as well as provide guidance on meeting privacy and security requirements. Australia's motivations for adopting the Cloud first policy included cost savings, reductions in carbon emissions, improved security, and greater productivity, speaking to the wide range of benefits that Cloud services can bring to organizations in both the public and private sectors.

Like the United States and the United Kingdom, Australia also took several concrete steps to make it easier for government officers to procure Cloud technologies by altering a pre-existing dual approval process that had previously been required for agencies who wanted to relocate their Cloud IT infrastructure in another country. To encourage Cloud adoption, the Australian government decided that only approval of an individual agency head is needed for this, removing a major bureaucratic obstacle to Cloud deployment.

5.2 Bhutan (Kingdom of)

In the middle of 2013 the Prime Minister of Bhutan wanted to transform the way the Government did business and instructed the Department of Information Technology & Telecom to come up with a strategy to move the Government onto a paperless platform within one year. This ambitious target set by the Prime Minister was only possible if the Government was to adopt a cloud solution as the development of an indigenous solution and its deployment would not be possible within such a short timeframe. Furthermore, most Government agencies were, at that time, plagued by unreliable electronic communication platforms that frustrated users and were regularly victims of hacking, viruses, and spam. The department quickly made its assessment and proposed a solution to adopt a commercial Cloud platform to the Government. While the adoption of the strategy to transform the way the public sector did business was straightforward, and the advantages of cloud solutions gave the impression that the implementation would be as easy, there were a number of challenges that were not apparent during the inception. These include

- Resistance to change. Including resistance coming from political parties that used arguments such as data sovereignty
- User resistance to adopt a new way of working delaying the take up of the project. Change management is required.
- Lack of consistent availability of Internet bandwidth at the agencies affected user experience.

Cloud computing has the potential to greatly benefit developing countries to leap frog and avoid many stumbling blocks to using ICTs for development. Bhutan was able to avoid many pitfalls and deploy

[11] Document SG1RGQ/262, "Liaison Statement from the ITU-T SG13 to ITU-D SG1 Question 3/1 on the results of the questionnaires on cloud computing scenarios in developing countries", ITU-T Study Group 13.

[12] http://www.finance.gov.au/Cloud/.

a state-of-the-art online collaborative suite across the government in a few months. There are still some policy issues such as data sovereignty, which will need to be resolved to fully capitalize on the benefits of cloud computing in developing and developed nations alike.

5.3 Burkina Faso

Burkina Faso has developed an initiative to implement in a government owned data center a Cloud environment to serve the needs of the various government agencies and citizens.

The benefits of this initiative are clearly around cost optimization and reduction, since many government agencies will benefit from using a shared infrastructure. A shared infrastructure will also create agility and flexibility for the government to address pressing projects. This project will reach these objectives, when the 5 key pillars of the "Cloud Computing" ("broad network access", "measured service", "multi-tenancy", "On-demand self-service", "rapid elasticity and scalability") are actually implemented beyond the joint data center which in itself is a major progress.

5.4 China (People's Republic of)

Cloud Computing is used in China's e-Government Cloud platform to reduce repeated Investment and to reach the intensive development of e-Government. Big data technology is used to promote the intelligent application of e-government services. China has also achieved certain progress and gained experience in applying Cloud Computing technologies to smart tourism through telecommunication networks. China's tourism industry started relatively late and the overall information technology level is still at a rather primitive stage. In the new era where information and communication technologies are evolving by leaps and bounds, how to promote tourism with ICT support and fully implement smart tourism is a major challenge facing the tourism industry in China. Cloud Computing technologies allow users to access various applications and services anywhere through terminals and this feature fits in well with the DIY travel style which is characterized by a large number of DIY tourists in widely distributed areas. All services that DIY travellers require can be obtained through "Travel Service Clouds" irrespective of whereabouts of the traveller or the availability of information resources at the expected destination.

In this way, access to applications could be simplified and requirements for the user terminal reduced. Users can access powerful computing, storage and application resources through various smart terminals, which in return may help improve substantially the experiences of DIY travellers so that they find their travels pleasant and rewarding. The widely-available Cloud-based travel information services not only result in the reduction of the investment for software and hardware but also effectively decrease resource consumption in terms of information management and service provision, allowing small and medium-sized travel agencies to focus on their core services.

China has also used Cloud Computing in Smart City initiatives. As the building of smart cities entails high demand for the storage of data, huge volumes of information enquiries from the public, needs for integrated management of multiple systems and sharing of resources by multiple users, the traditional single computer or network application mode can hardly support these demands. Cloud computing can allocate computing resources in a dynamic manner, store and share colossal amount of information, a capacity which offers a new opportunity to the development of smart city. Cloud computing was very used to help in traffic management, to develop a medical platform, to develop and education platform, for smart community, China has seen Cloud computing delivering harmonized and efficient platform, Highly efficient management of services/resources allocation, better Security control management. According to China, "Cloud computing is not only the key for smart city construction, it is also where the 'smartness' lies".

5.5 India

Some regions in India have developed similar approaches to consume the Cloud using a government developed and owned data center to run citizen services. These approaches focus on the development of infrastructure to support Cloud services and provide local businesses and public sector organizations with the storage and server space needed to drive development of Cloud-based technologies.

In 2006, India approved its National e-Governance Plan for rolling out various mission mode projects with a vision to make all government services accessible to the common man in his locality, through common service delivery outlets, and ensure efficiency, transparency, and reliability of such services at affordable costs to realise the basic needs of the common man. In tune with this decision, several departments in government of India as well as states have initiated process for augmenting or deploying IT infrastructure facilities. The state of Maharashtra has leveraged the concept of Cloud Computing. The Cloud infrastructure has been built by the ministry of Department of IT whose competence lies in IT related field. Called MahaGov Cloud – a government owned private Cloud setup by Department of IT, government of Maharashtra, and the initiative seeks to provide IaaS, PaaS and SaaS Cloud services to various departments in government of Maharashtra. The initiative has quietly transformed the way IT services are provisioned by the government.

Today, the MahaGov Cloud has been implemented in the State data center and is extensively used by departments for website and application hosting. The Cloud has created a synergy in the field of e-Governance in the state so that services can now be introduced quickly and efficiently. The long incubation periods for the e-Governance project due to the complex procurement processes has now been reduced. The departments which previously used devoted lots of time and energy to the procurement as well as sizing of ICT infrastructure are now fully concentrating on their services to the citizens. The government of India also came out with the Cloud initiative “Megh raj” for the e-Governance activity of the whole country.

However, this initiative does limit the choice of Government agencies who might want to use technologies that are not available in that infrastructure.

5.6 Korea (Republic of)

In October 2013, the Ministry of Science, ICT and Future Planning (the “MSIP”) of Korea proposed an Act on the Development of Cloud Computing and Protection of its Users (the “Cloud Computing Development Act”) which aims to facilitate the use of Cloud Computing by public institutions, to promote the Cloud Computing industry and to build a safe user environment. After in-depth review procedures including public hearings and stakeholder meetings, in March 2015 the law was passed by the National Assembly and came into force from September 2015. The Cloud Computing Development Act consists of four main pillars, which are ‘General Provisions’, ‘Creation of Basis for Development of Cloud Computing’, ‘Facilitating Use of Cloud Computing Services’, and ‘Enhancement of Reliability of Cloud Computing Services and Protection of Users’.

The most significant and prioritized objective of the Act is promoting the introduction of Cloud Computing in the public sector. To achieve this objective, the State agencies and other public authorities shall endeavor to introduce Cloud Computing to their software system, the head of each State agency or other public authority shall submit a forecast on the demand for Cloud Computing projects from affiliated agencies to the Minister of the MSIP at least annually, and the government shall endeavor to encourage public institutions to use Cloud Computing services provided by Cloud Computing service providers for their work process. The Cloud Computing Development Act in Korea is expected to provide a robust base for the development of Cloud infrastructure that will serve as a key component of innovation and convergence for the successful realization of the creative economy and a software-oriented society in the Republic of Korea by expanding Cloud utilization in the public sector, promoting the Cloud industry, and providing a safe user environment. Also, it is expected to

create new opportunities for Cloud-based convergence services across a variety of fields including finance, healthcare, education and security.

5.7 Singapore

Singapore is building up a Cloud ecosystem through the leadership of the Infocomm Development Authority of Singapore (IDA), in collaboration with industry players and with the support of a strong policy framework. The objectives set out for Cloud are to sharpen the overall economic competitiveness of Singapore through catalysing demand and adoption of Cloud Computing in key industry verticals, and increase vibrancy of ICT industry through the development of a Cloud ecosystem. Singapore's government Cloud or G-Cloud aims to provide a Cloud infrastructure for the Whole-of-government. The strategy is to be flexible and leverage on the merits of available Cloud models. Commercially available public Cloud offerings are used to benefit from the lower cost of computing resources. For example, the Ministry of Education's iCONnect system is an email system for teachers built on a public Cloud. Likewise, to better serve the security and governance needs of most public agencies, a private G-Cloud was implemented as well.

Besides working with other government agencies to attract Cloud players to Singapore, In October 2011, IDA launched the SaaS Enablement Programme (SEP) to provide funding support for SaaS enablement projects in specific industry verticals in Singapore. SEP was launched to (a) lower the barriers for traditional model software vendors for SaaS enablement; (b) expedite the SaaS enablement process; and (c) upgrade the capability of software vendors in SaaS enablement. Successful applicants qualify for co-payment funding support for the qualifying costs, capped at 30 per cent of total of all qualifying costs and up to $50,000. Since its launch, some 20 awards were given for supporting SaaS-enablement of software in the construction, precision engineering, manufacturing, and healthcare sectors.

Regulatory changes around the adoption and use of Cloud technologies have also reverberated with many regulated industries such as Financial services where. Central Banks in many countries are relooking at reviewing national outsourcing policies and regulations for banks in the light of Cloud Computing. These heavily regulated industries are often not as able as other private sector entities to make agile decisions about new technologies and innovations, so regulatory changes and encouragement are of particular value for them. Similarly, changes in government procurement processes are likely to have particularly significant impacts on those sectors that deal most directly with regulators.

For those governments who have adopted an approach to develop their own Cloud infrastructure, they eventually they limit the choice of those Government agencies who might want to use technologies that are not available in that infrastructure. It does also force the Government to operate a complex Cloud infrastructure, which is not necessarily the key role of the government to do so. Finally, from the IT security point of point, while a joint infrastructure is in theory more secure than a separate set of data centers, it does create put more pressure on the government to apply state of the art security practices as this infrastructure then becomes a single point of failure and a natural target for malicious cyberattacks.

5.8 United Kingdom

The United Kingdom has developed a Cloud first policy for public sector information technology[13] that requires the government to use the Cloud as the primary mechanism to consume IT or deliver citizen services. Under this policy, Cloud-based products should be the first options explored by the central UK government when considering purchase and provision of new services. To make the purchase and selection of Cloud-based options easier for government entities, the UK government developed a digital market called the G-Cloud[14] to help support the procurement of Cloud services. G-Cloud

[13] https://www.gov.uk/government/news/government-adopts-Cloud-first-policy-for-public-sector-it.
[14] https://digitalmarketplace.blog.gov.uk/.

Programme Director Denise McDonagh has credited the G-Cloud with helping the UK government make considerable savings in the budget for public sector IT services. The UK has also revised the Information and Data Classification policy to enable deployment of Cloud technologies while still meeting the security requirements of the country.

By adopting a deliberately Cloud-oriented procurement policy and simultaneously revising the classification and security policies to enable widespread Cloud deployment, the UK has developed a regulatory framework with sufficient flexibility and clear guidance to enable policy-makers to prioritize Cloud as both a means of improving government efficiency and serving as a role model for the private sector. Since government procurement decisions often drive private firms' design and development of products and services, the UK government's decisions have far-reaching impacts across the country, not just within the public sector.

5.9 United States of America

The United States government Chief Information Officer also issued a Cloud First Policy in 2011,[15] with the objective of reducing government IT spending by 75 per cent. He explained the rationale for the policy in the following statement: "*To harness the benefits of Cloud Computing, we have instituted a Cloud First policy. This policy is intended to accelerate the pace at which the government will realize the value of Cloud Computing by requiring agencies to evaluate safe, secure Cloud Computing options before making any new investments*."

This approach, similar in nature to the UK framework, has the dual benefit of improving government efficiency and saving taxpayer dollars while also driving private sector innovation and security best practices. Since governments are major customers for many technology firms, public sector decisions about how to prioritize IT spending have a significant influence on the private sector as well. In the US, as in the UK, the government's willingness to recognize that Cloud security measures can be as good – if not better – than those protecting locally stored data was a crucial enabler of Cloud adoption and helped drive greater cost savings, stimulate innovation, and engender public trust in the Cloud.

[15] https://www.dhs.gov/sites/default/files/publications/digital-strategy/federal-cloud-computing-strategy.pdf.

6 CHAPTER 6 – The way forward

Cloud Computing is at the heart of the technology enablers of the 4th industrial revolution that our era is going through. Cloud Computing has reached a maturity, acceptance, and consumption level that should create a favourable environment for any government to adopt pro Cloud policies. Realizing the power and potential while addressing the challenges of Cloud Computing is the question that this report is trying to address. We defined a framework that considers four important challenges to be addressed that will help develop the Cloud in any specific country: **Skills**, **Innovation**, **Infrastructure**, and **Trust**. It is believed that these are the founding pillars to leverage the Cloud opportunity and address the core challenges posed by the Cloud.

Hence, for those governments interested in attaining the benefits of Cloud computing for their own use but also for their businesses and innovators, in terms of efficiencies, lower costs, innovation, etc., the study group suggests the following guidelines, under the main of which is to adopt a Cloud 1st policy.

A Cloud 1st Policy is a "posture" that recognizes the Cloud as a clear technology platform for the country and an opportunity. It will provide a framework for the country to look at challenges and blockers as opportunities for development and policy making.

For example, a Cloud 1st policy is an indication that government will prefer the usage of Cloud Computing as a way to procure any piece of technology and to deliver any service that uses ICT to government constituencies that uses ICT. It also sends a strong message to private firms about the value of these services and the public trust that has been placed in them, driving private sector development, adoption, and innovation centred on the Cloud as well.

A Cloud 1st policy does not mandate that governments must use the Public Cloud as the only means to consume ICT, instead it gives priority to Cloud solutions and encourages reform of entrenched bureaucratic processes that may be hindering the adoption of more efficient, environmentally friendly, and secure technologies.

A Cloud 1st policy, set also complementary actions for governments seeking to enable Cloud deployment include:

- Define a procurement policy for government agencies to use and procure the Cloud as preferred choice, and revise existing procurement policies to prefer the Cloud. Unfortunately, many government procurement policies around the globe do not permit the procurement of Cloud services even when there is no other blocker and the government agency is willing to use the Cloud. For example, a pay-per-use or on-demand payment is not authorized in many procurement policies that prefer fixed hardware and software licensing costs. The same goes for procurement audits that request to audit licenses and/or physical assets rather IT consumption.
- Develop a set of policies to implement security and privacy that will embrace the Cloud as the main delivery mechanism. For example, define an information and data classification policy that provides agencies for the means to embrace the Cloud. The Information Classification will help agencies classify their data, and then apply specific security controls depending on the level. The UK experience is a great best practice model that can be used as a reference by other countries.
- Develop architectural guidelines and recommendations for government agencies to embrace the Cloud. Together with the Information Classification, these guidelines will help Agencies decide on which Cloud deployment models are best for them to use, public Cloud, private Cloud, or hybrid Cloud.
- For those business scenarios that require the use of government owned data centers, develop strategies to consolidate government own data centres and data center investments into smaller sets, hence reducing government spending while increasing sharing amongst government agencies and improving management and security.

– Create a level playing field for Cloud service providers, regardless of where they store data, and who owns the infrastructure (government or private sector), that will ensure the government will procure robust, secure, state of the art Cloud services, that meet the needs of the government. For example, the government can demand compliance to Cloud service providers to comply with recognized International Standards such as those defined by ITU, and ISO, etc.

A Cloud 1st policy is also a posture to address the 4 core challenges raised in this report: infrastructure, trust, innovation and skills.

The main infrastructure element required to use Cloud Computing is basically broadband since the Cloud uses mainly the Internet to access the back-end infrastructure. We encourage policy makers and regulators to keep developing policies and regulations that support the development of broadband. We encourage the ITU to develop a Cloud Infrastructure Readiness Index that provides a good perspective for all the stakeholders where each country is in term of infrastructure readiness to use the Cloud at scale. This will also help policy makers and investors to take the right policy and investments decisions that will support the development of a Cloud ecosystem. The benefits of developing such an ecosystem span every sector of industry and range from positive energy and sustainability impacts to improved online security for sensitive data and greater opportunities for innovation and small business development.

The other core element to promote the usage of Cloud Computing is the establishment of a stable and open trust system that enables users, governments and Cloud service providers to work together and promote the usage of Cloud Computing. Without a firm foundation of trust, the efficiency and cost savings provided by Cloud Computing cannot be realized because customers, organizations, citizens, and governments will be wary of shifting their operations and interactions to the Cloud. We provided a framework to look at this trust system and made specific recommendation for policy makers to develop such system of trust.

For individuals and businesses to take advantage of Cloud infrastructure, it is essential that policy-makers provide opportunities for them to acquire the relevant technical skills. Training a workforce for the future that will be able to leverage the opportunities of the Cloud should be a top priority for regulators. These efforts should include both traditional in-person educational programs as well as remote and online learning initiatives that are accessible to people beyond the typical student populations.

Finally, we believe that governments have the opportunity to lead by example by using the Cloud as a way to deliver effective and efficient services to their constituencies. We believe the Cloud is the most effective way for government to do so, since Cloud Computing will enable governments to reduce costs, be flexible and agile and innovate to support their constituencies. By adopting cloud technologies, and encouraging others to follow suit, by imbuing students and mid-career workers with the skills necessary to leverage these technologies, by building the necessary network infrastructure, and by reducing regulatory barriers to the development and growth of high-tech innovations, policy-makers can pave the way for a more efficient, more sustainable, and more prosperous future.

Abbreviations and acronyms

Various abbreviations and acronyms are used through the document, they are provided here for simplicity.

Abbreviation/acronym	Description
AI	Artificial Intelligence
CAGR	Consolidated Annual Growth Rate
CAPEX	CAPital Expenditure
CEO	Chief Executive Officer
CLEER	Cloud Energy and Emissions Research Model
CSP	Cloud Service Provider
DBMS	Data Base Management System
DC	Data Center
HW	Hardware
IaaS	Infrastructure as a Service
ICT	Information and Communication Technology
IDC	International Data Corporation
IoT	Internet of Things
ISO	International Standards Organization
ISV	Independent Software Vendor
IT	Information Technology
ITU	International Telecommunication Union
IXP	Internet eXchange Point
JTC1	Joint technical Committee
MOOC	Massive Open Online Courses
OECD	Organization for Economic Co-operation and Development
OPEX	Operational Expenditure
PaaS	Platform as a Service
PC	Personal Computer
PII	Personal Identifying Information
SaaS	Software as a Service
SG	Study Group
SW	Software
UNCTAD	United Nations Conference on Trade and Development.

(continued)

Abbreviation/acronym	Description
WTO	World Trade Organization

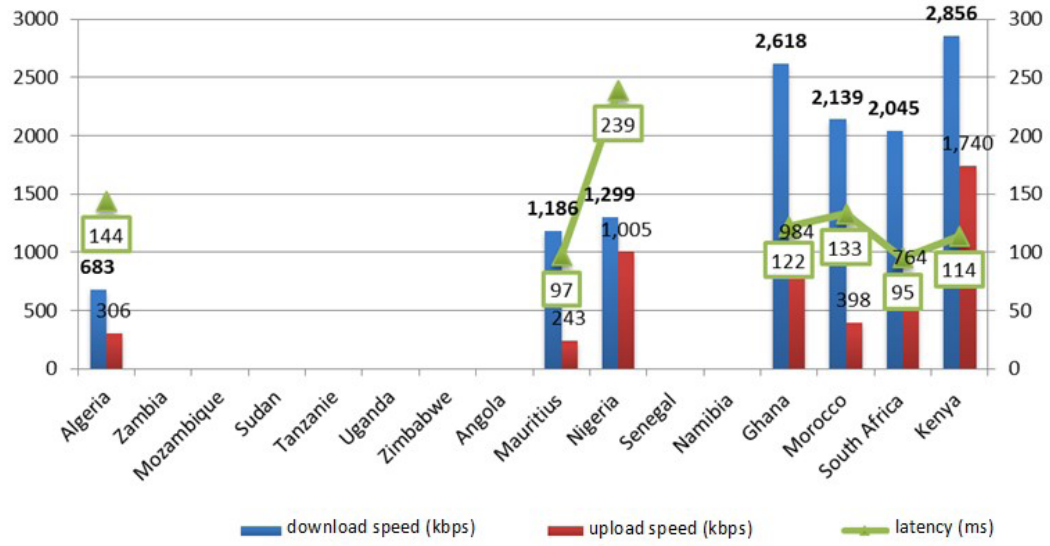
Annexes

Annex 1: State of the business of Cloud Computing in developing countries

This annex provides data analysis coming from UNCTAD[16] 2013 and ARPTC[17] 2015 reports that provide some indications that are good to look at since they are key to enabling Cloud adoption. Cloud indicators in developing countries:

Africa

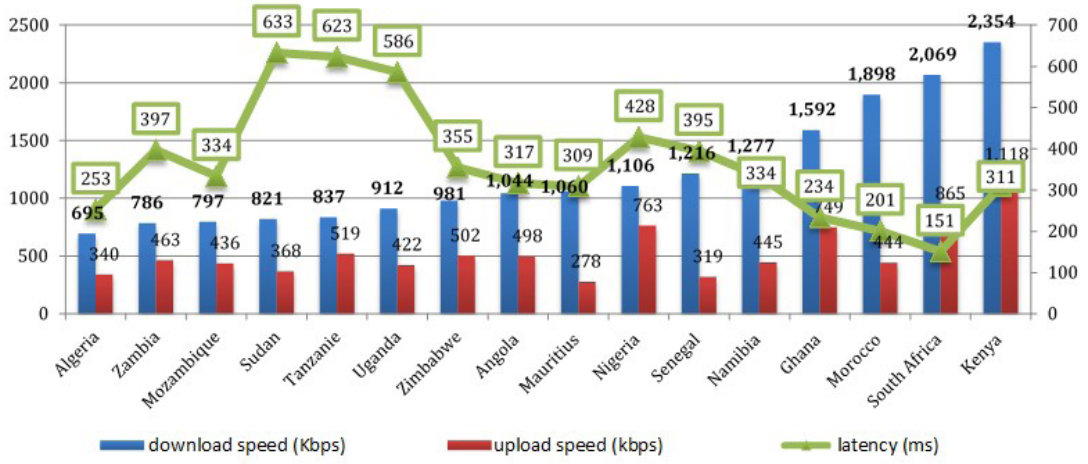
Figure 1A: Reported speeds and latencies on fixed networks



- The speed and latency indicators are favorable for the provision of basic Cloud services.
- The latency in Nigeria is high by comparison with the required limit, whereas Kenya and Ghana are able to develop intermediate Cloud services.
- The latency in South Africa is favorable to the development of advanced Cloud services; however, the reported speed is below the threshold required for such services.

[16] UNCTAD: United Nations Conference on Trade and Development.
[17] ARPTC : Autorité de Régulation de la Poste et des Télécommunications du Congo.

Figure 2A: Reported speeds and latencies on mobile networks



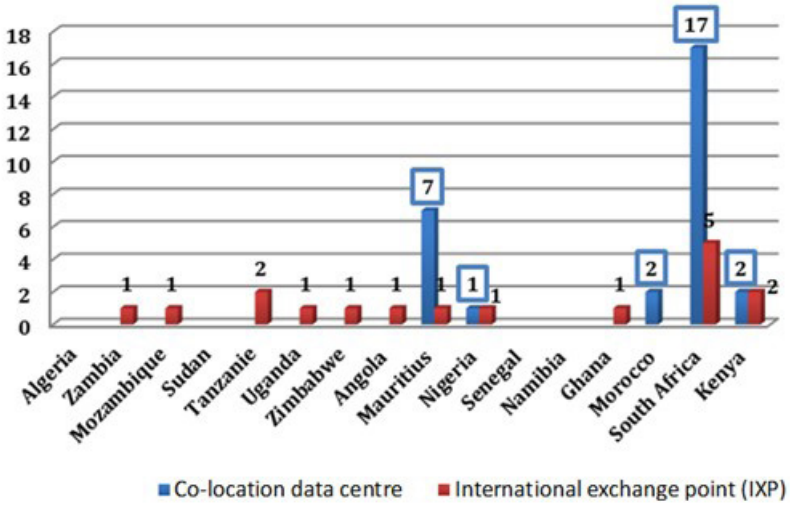
- Of all the countries listed, only South Africa is able, in terms of speed and latency, to offer basic and intermediate Cloud services.
- Where speed is concerned, basic Cloud services can be developed in almost all of the countries listed, subject to latency being reduced to a maximum 160 ms.

Existence of data centers and exchange points

Data centers: South Africa reports 17 data centers, followed by Mauritius, whereas the majority of countries have no data center or a maximum of two.

Exchange points: South Africa has five exchange points, the average for the other countries being one.

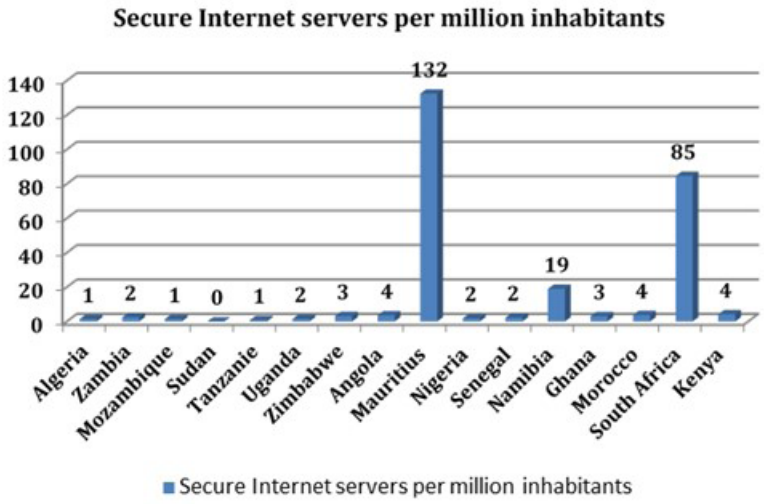
Figure 3A: Exchange points



Secure Internet servers per million inhabitants

Mauritius has the greatest number of secure servers per million inhabitants, followed by South Africa and Namibia. The other countries listed have an average two to three secure Internet servers per million inhabitants.

Figure 4A: Secure Internet servers per million inhabitants



Regulation: Existence/adoption of Cloud legislation

From surveys conducted in a number of African countries it emerges that 55 per cent of the countries consulted have data-protection legislation, while the other 45 per cent do not.

It is interesting to note that almost half of the countries surveyed have no data-protection legislation.

Trends

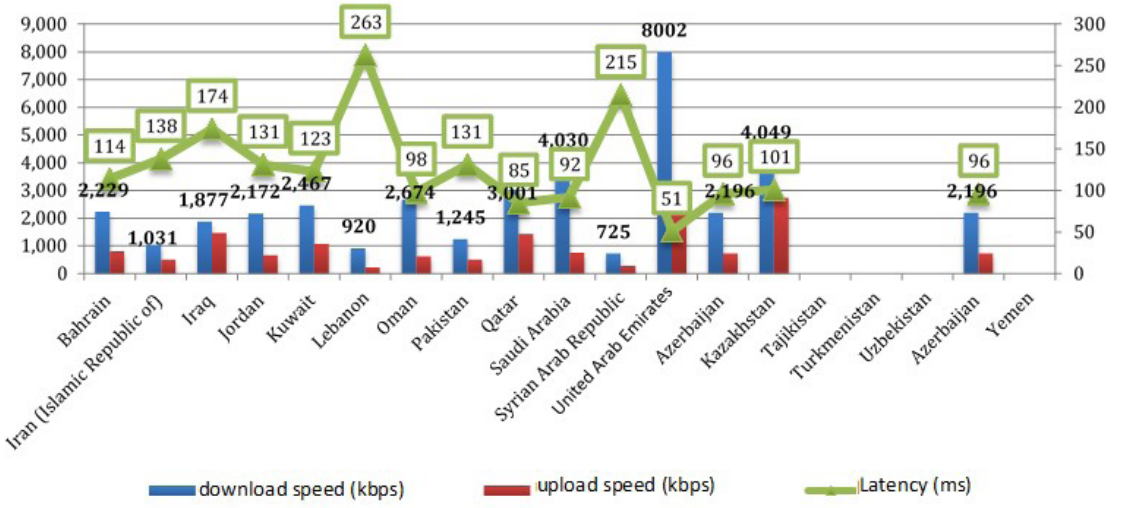
In most of the African countries surveyed, the indicators that are favorable to development of the Cloud computing market need to be improved if there is to be any expectation of meeting the challenge of operating Cloud computing services.

The improvements to be made are essentially in the following areas:

- Availability and coverage of broadband networks
- Speed
- Availability and provision of electricity and water supplies
- Telecommunication network latency
- Number of data centers and exchange points
- Data-protection regulation/legislation.

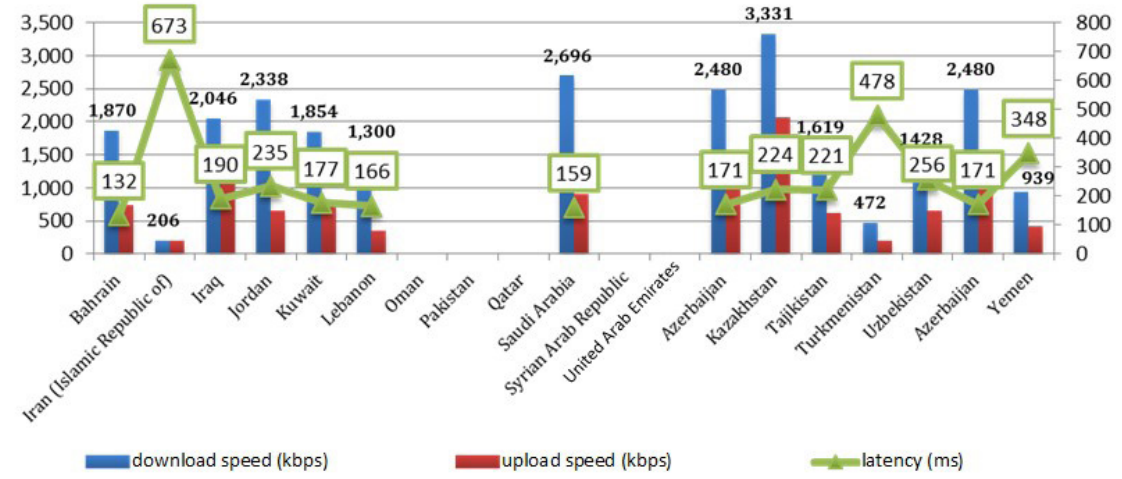
Middle East and Central Asia

Figure 5A: Reported speeds and latencies on fixed networks



Where fixed networks are concerned, the speed and latency indicators in countries such as the United Arab Emirates, Saudi Arabia, Qatar and Kazakhstan are favorable to the development of the Cloud market for all services.

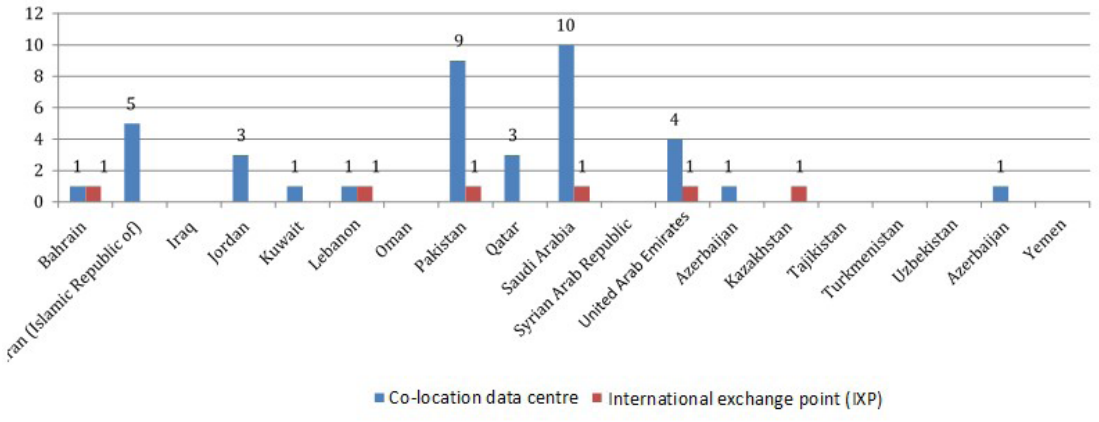
Figure 6A: Reported speeds and latencies on mobile networks



On mobile networks, the speed and latency in Bahrain and Saudi Arabia are favorable to the development of basic and intermediate Cloud services, whereas in the other countries the latency remains high by comparison with the upper limit specified for basic Cloud services.

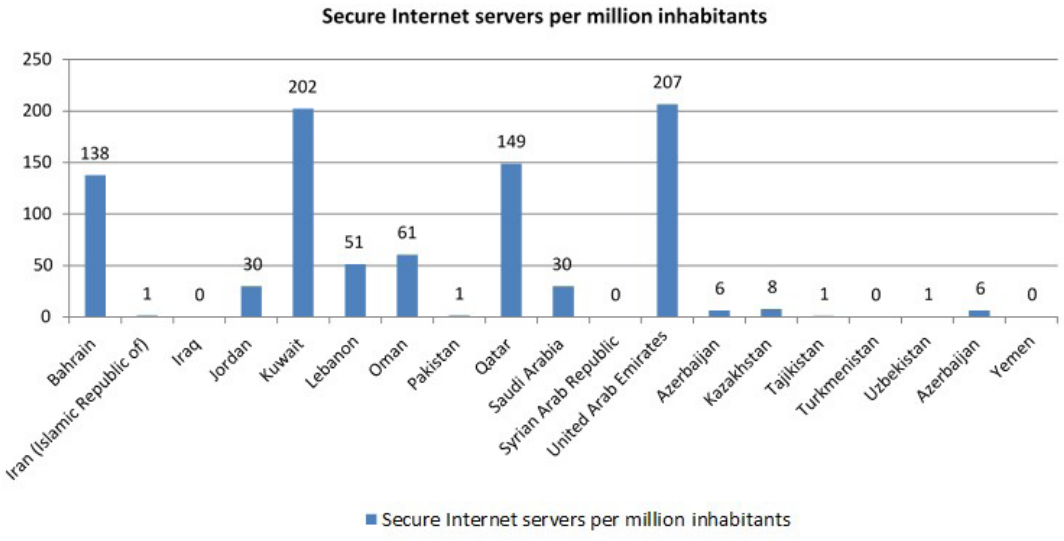
Existence of data centers and exchange points

Figure 7A: Existence of data centers and exchange points



- Saudi Arabia has ten data centers, followed by Pakistan with nine
- Most of the countries have one data center and one IXP.

Figure 8A: Secure Internet servers per million inhabitants



- The highest number of secure servers per million inhabitants is in the United Arab Emirates.

Trends

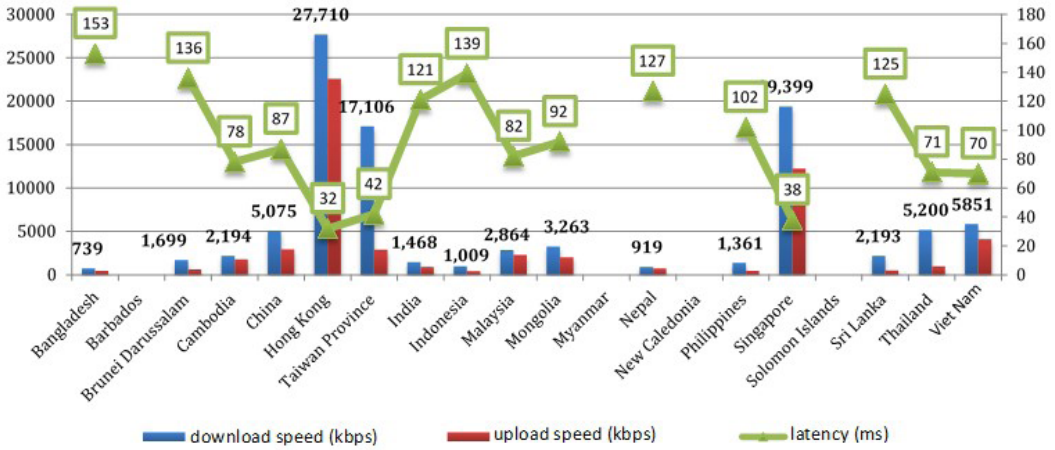
In most countries of the Middle East, the indicators that are favourable to development of the Cloud computing market need to be improved if there is to be any expectation of meeting the challenge of operating Cloud computing services.

The improvements to be made are essentially in the following areas:

- Speed
- Telecommunication network latency
- Number of data centers and exchange points.

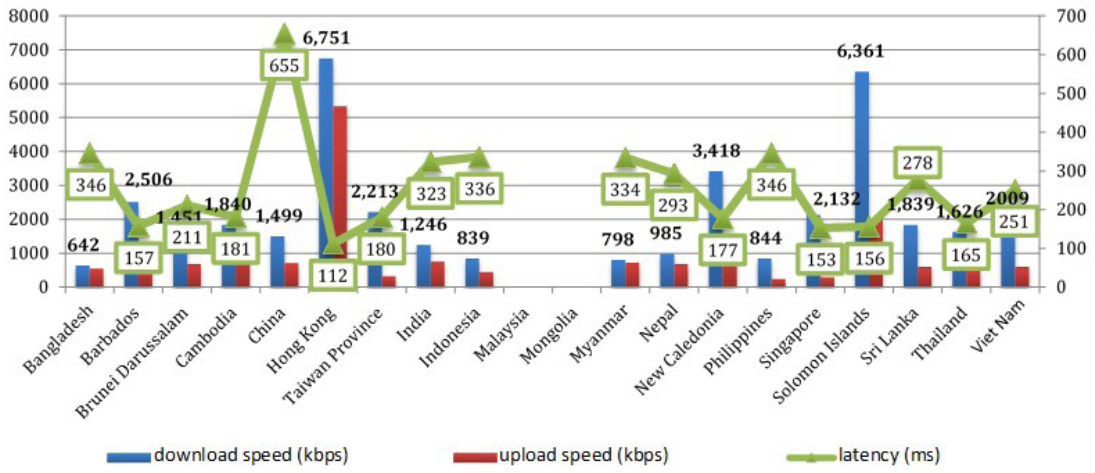
Asia-Pacific

Figure 9A: Reported speeds and latencies on fixed networks



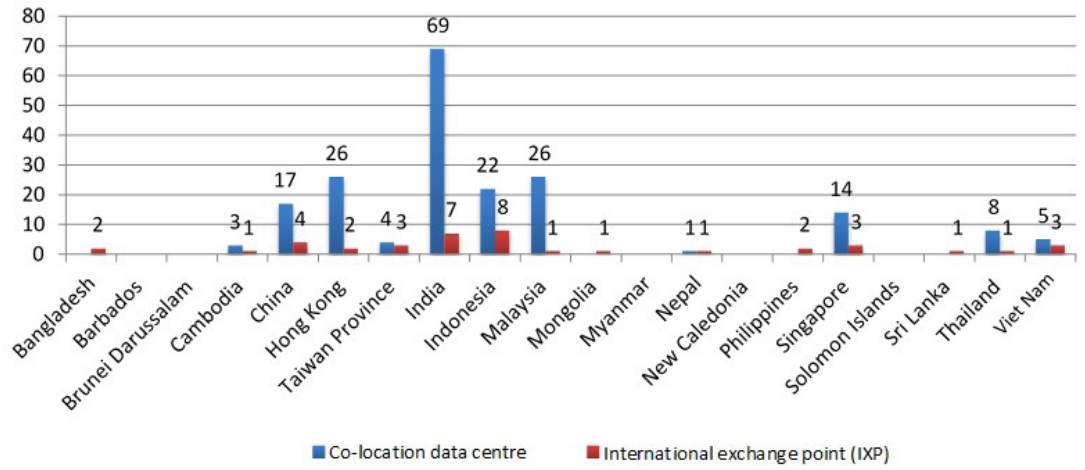
- On fixed networks, the speed and latency indicators in almost all the countries are favorable to development of the Cloud market, at least where basic services are concerned.
- With the exception of Bangladesh, all of the countries are able to develop intermediate Cloud services.
- Favorable indicators for advanced Cloud services are found in countries such as People's Republic of China, Hong Kong (SAR of China), Taiwan (Province of China), Malaysia, Mongolia, Singapore, Thailand and Viet Nam.
- The highest speeds and lowest latencies are found in Hong Kong (SAR of China) and Taiwan (Province of China).

Figure 10A: Reported speeds and latencies on mobile networks



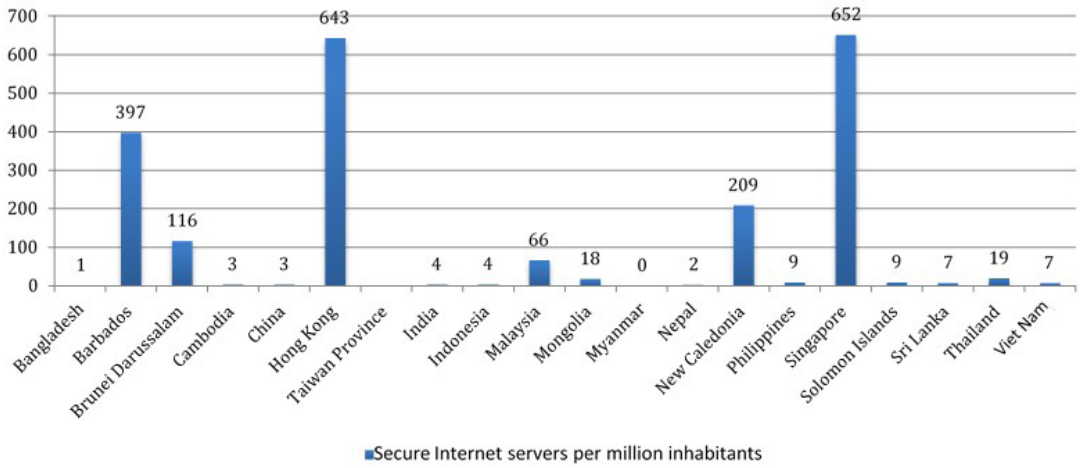
- On mobile networks, only four countries out of 20 have a latency that is favorable to the development of basic Cloud services, namely Barbados, Hong Kong (SAR of China), Singapore and Solomon Islands.
- Generally speaking, the latencies are high on mobile networks in the Asia-Pacific region.

Figure 11A: Existence of data centres and IXPs



The highest number of data centres in the sub region is found in India.

Figure 12A: Secure Internet servers per million inhabitants



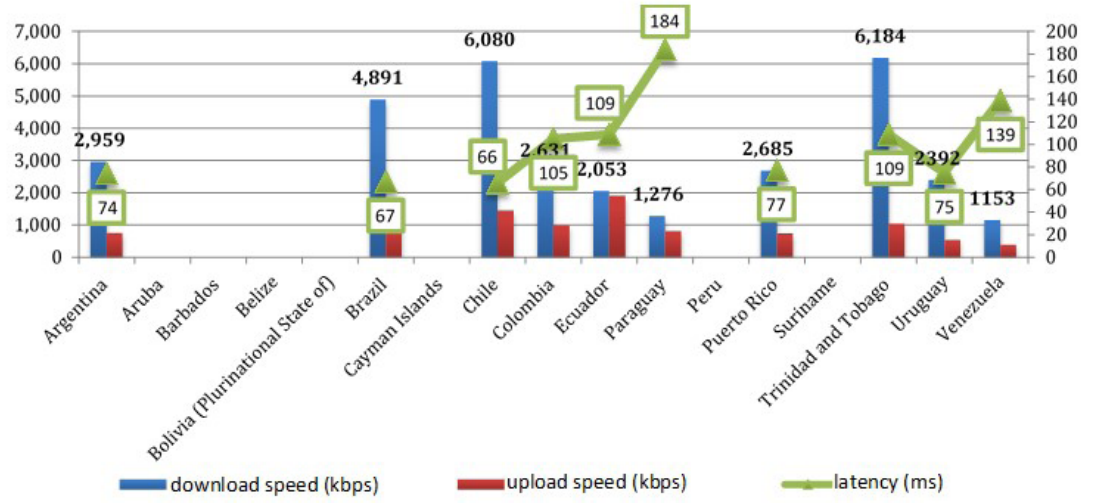
Three countries have over 350 secure Internet servers per million inhabitants, with Singapore in top position with 652 servers, followed by Hong Kong (SAR of China) with 643.

Trends

- In most countries of the Asia-Pacific region, the speed and latency indicators on fixed networks are highly favorable to development of the Cloud computing market.
- Generally speaking, the latency on mobile networks will need to be improved if Cloud services are to be offered.

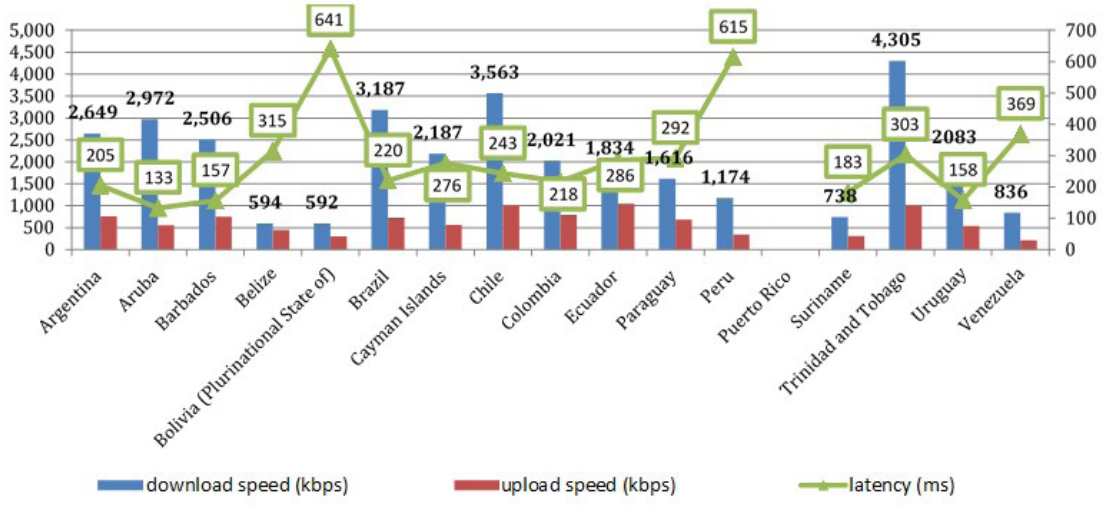
Latin America

Figure 13A: Reported speeds and latencies on fixed networks



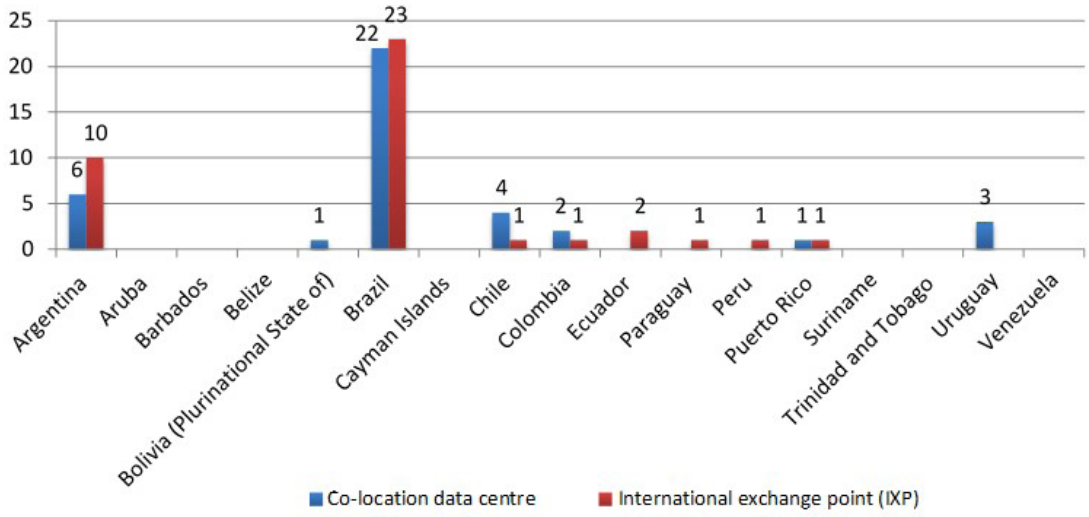
- On fixed networks, the speed and latency indicators in almost all the countries are favorable to development of the Cloud market for all basic services.
- Favorable speeds and latencies for the development of intermediate and advanced Cloud services are found in Chile, Brazil, Argentina and Puerto Rico.

Figure 14A: Reported speeds and latencies on mobile networks



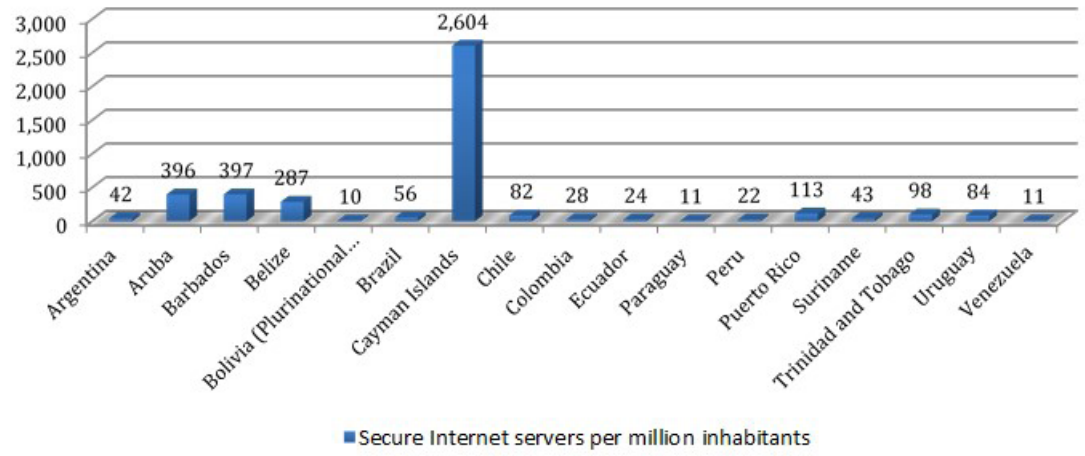
On mobile networks, only Barbados and Chile have speed and latency indicators that are favourable to development of the Cloud market.

Figure 15A: Existence of data centres and exchange points



The highest number of data centers and exchange points is found in Brazil.

Figure 16A: Secure Internet servers per million inhabitants



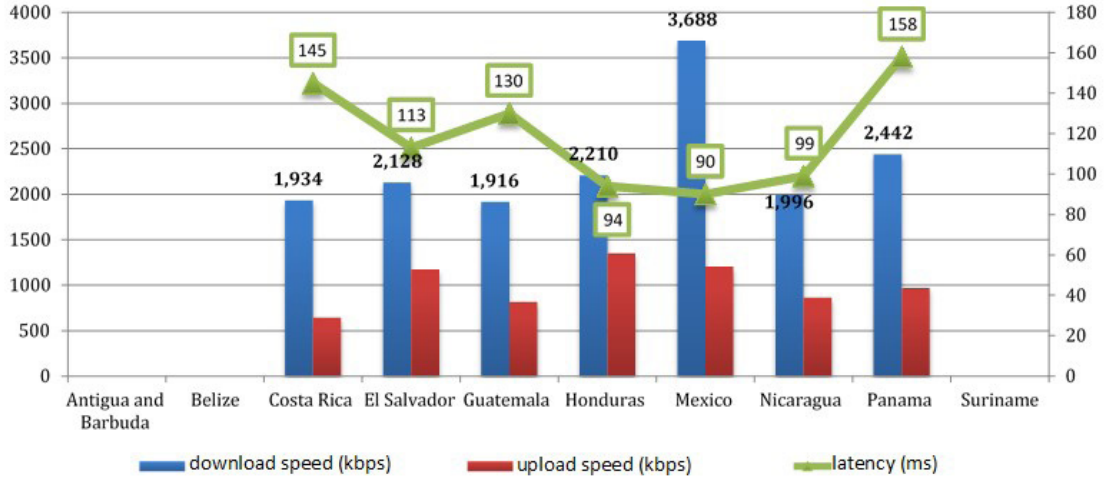
The highest number of secure Internet servers per million inhabitants is found in the Cayman Islands.

Trends

- In most of the countries of Latin America, the speed and latency indicators for fixed networks are highly favorable to development of the Cloud computing market.
- Generally speaking, the latency on mobile networks will need to be improved if Cloud services are to be offered.

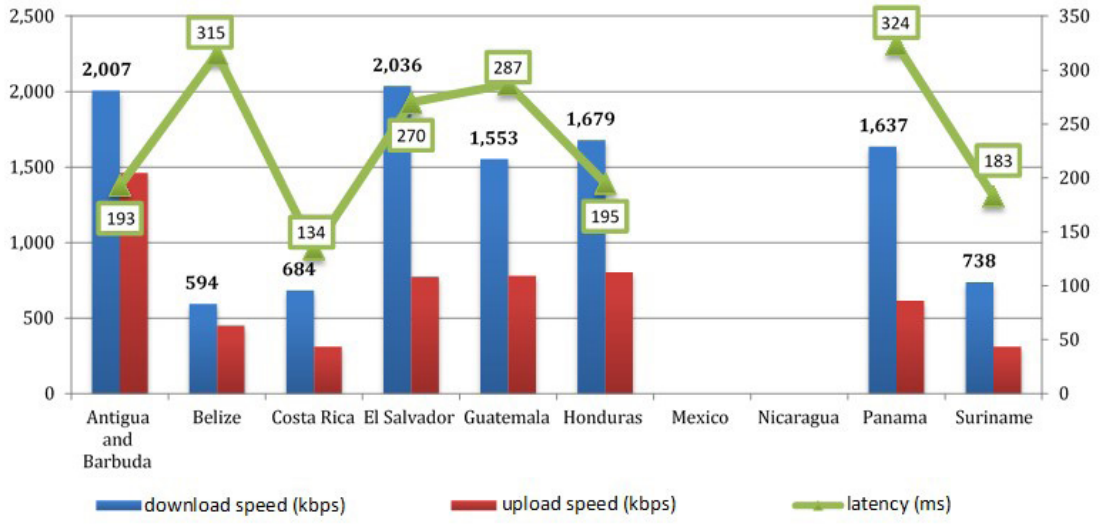
Central America

Figure 17A: Reported speeds and latencies on fixed networks



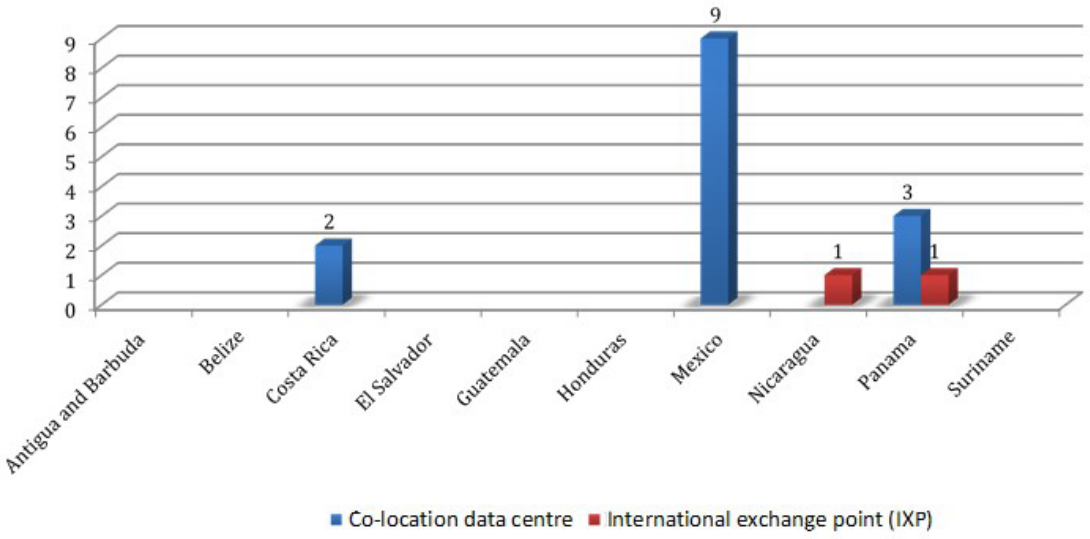
- On fixed networks, the speed and latency indicators are favorable to development of the Cloud market for basic and intermediate services.
- Only in the case of Mexico are the indicators favorable to the development of advanced Cloud services.

Figure 18A: Reported speeds and latencies on mobile networks



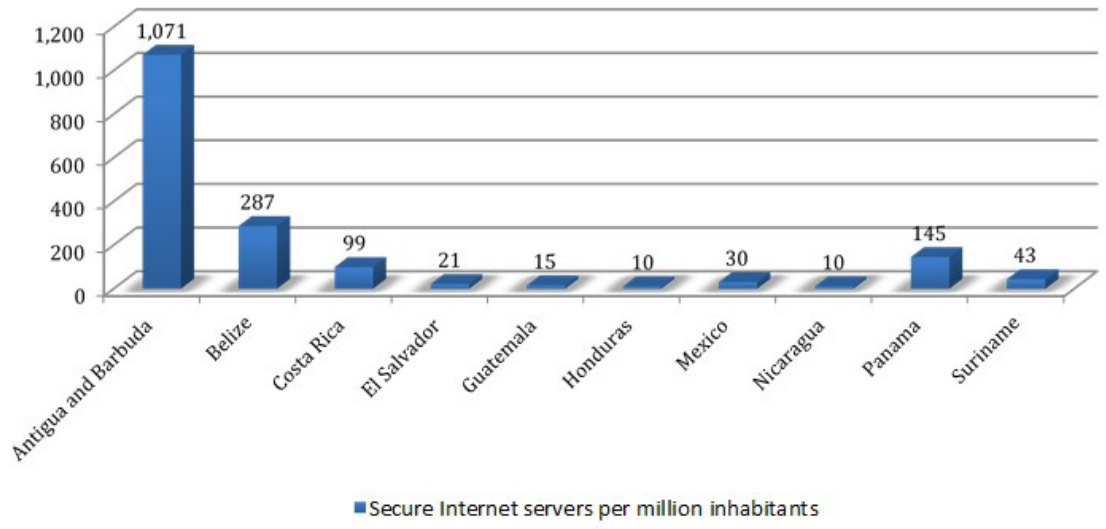
- On mobile networks, only Costa Rica has a latency that is favorable to basic and intermediate Cloud, but with a speed that is inadequate for their development.
- The other countries have high latencies that are unfavorable to Cloud services.

Figure 19A: Existence of data centers and exchange points



- Most of the countries of the sub region have neither data centers nor exchange points.
- A number of data centers are located in Mexico (nine), Costa Rica and Panama.
- Nicaragua and Panama each have one exchange point.

Figure 20A: Secure Internet servers per million inhabitants



- Antigua and Barbuda has 1071 secure Internet servers per million inhabitants.
- Each of the countries has a number of secure Internet servers.

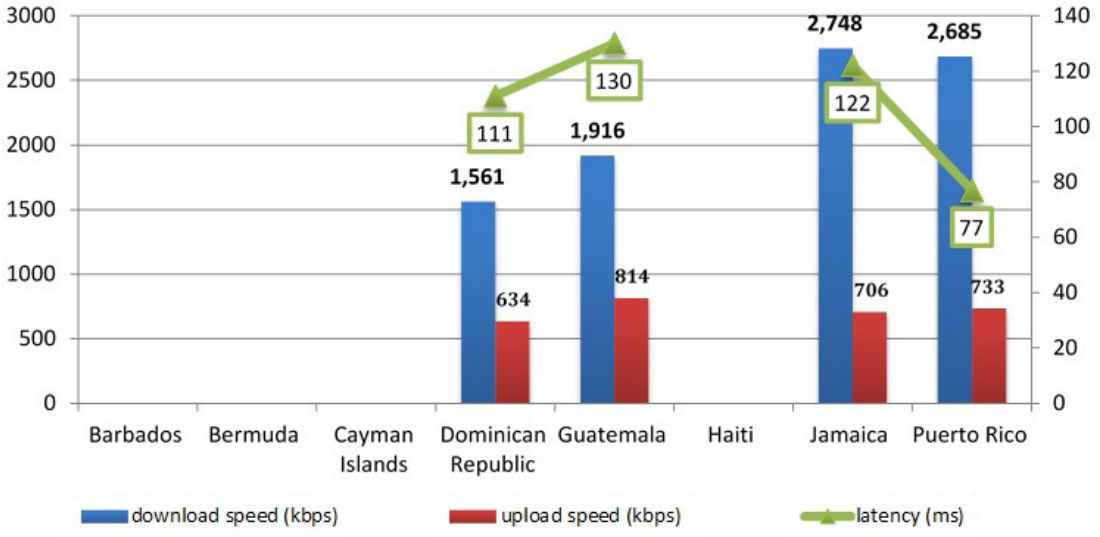
Trends

- In most of the countries of Central America, the speed and latency indicators on fixed networks are highly favorable to development of the Cloud computing market for basic and intermediate services.
- Latency and speed will need to be improved to enable the development of advanced Cloud services in certain countries.

– Generally speaking, the latency on mobile networks will need to be improved if basic Cloud services are to be offered.

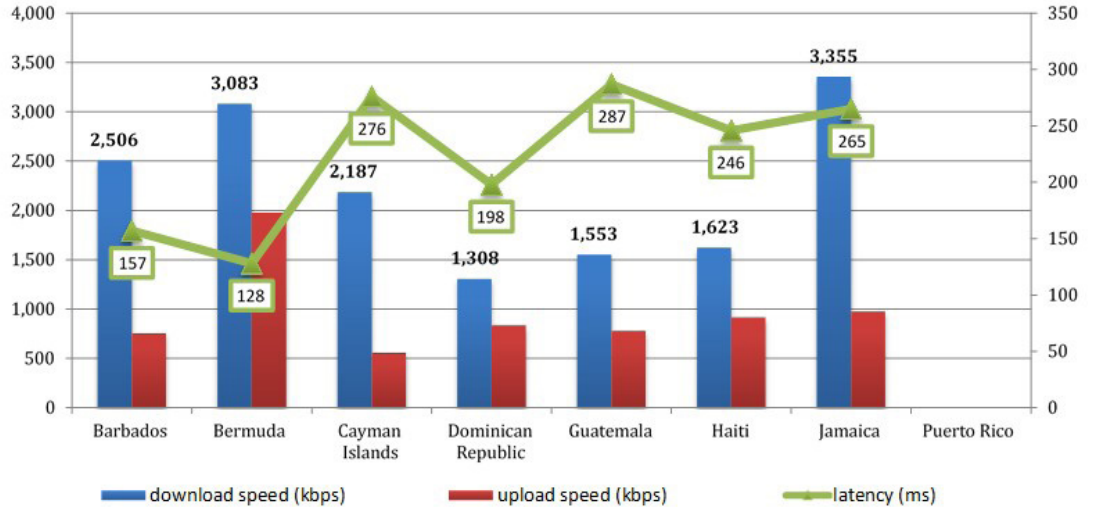
Other countries in the Americas

Figure 21A: Reported speeds and latencies on fixed networks



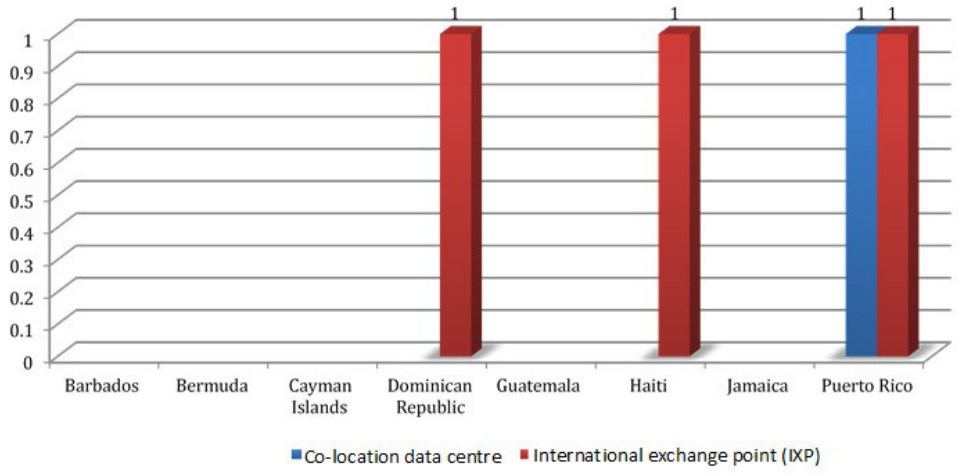
On fixed networks, the speed and latency indicators within the countries are favourable to development of the Cloud market for basic and intermediate services, as well as for advanced services except in the case of Puerto Rico.

Figure 22A: Reported speeds and latencies on mobile networks



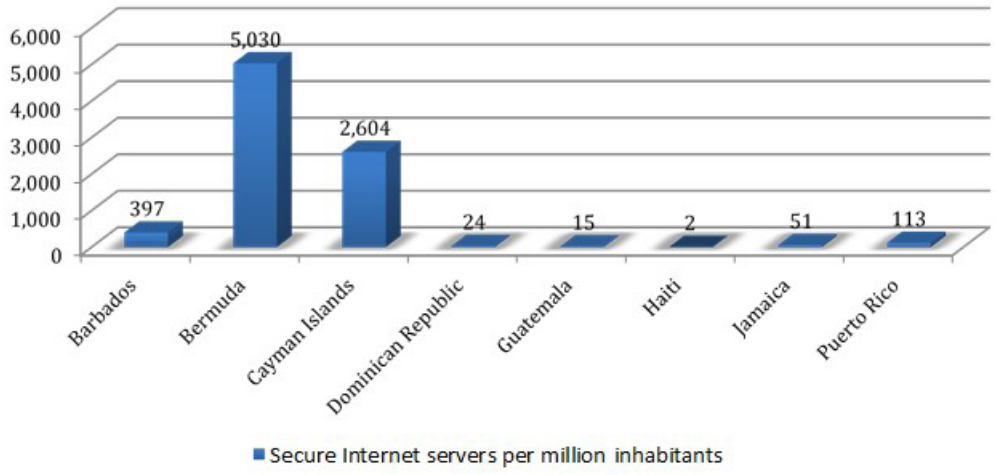
– The mobile network speeds are favorable to Cloud services, except that the latency is high for most of the countries, with only the indicators for Bermuda and Barbados being favorable to basic and intermediate Cloud services.

Figure 23A: Existence of data centres and exchange points



– Most of the countries of the sub region have neither data centers nor exchange points, apart from the handful of countries shown above which each have one data center and one exchange point.

Figure 24A: Secure Internet servers per million inhabitants



All of the countries have secure Internet servers, with Bermuda having the largest number and Haiti the smallest.

Trends

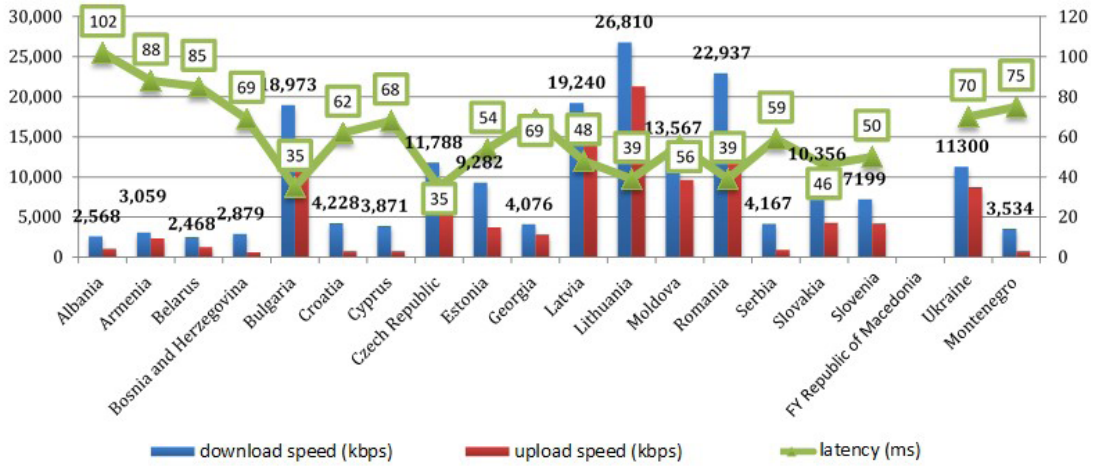
– In developing countries of the Americas region, the speed and latency indicators on fixed networks are highly favorable to development of the Cloud computing market for basic and intermediate services.

– Latency and speed will need to be improved to enable the development of advanced Cloud services in certain countries.

– Generally speaking, the latency on mobile networks will need to be improved if basic Cloud services are to be offered.

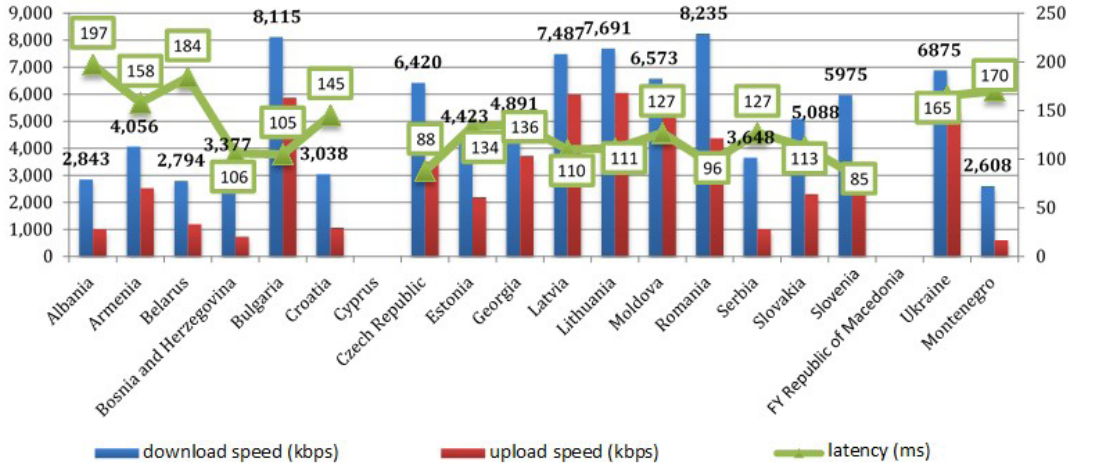
Europe

Figure 25A: Reported speeds and latencies on fixed networks



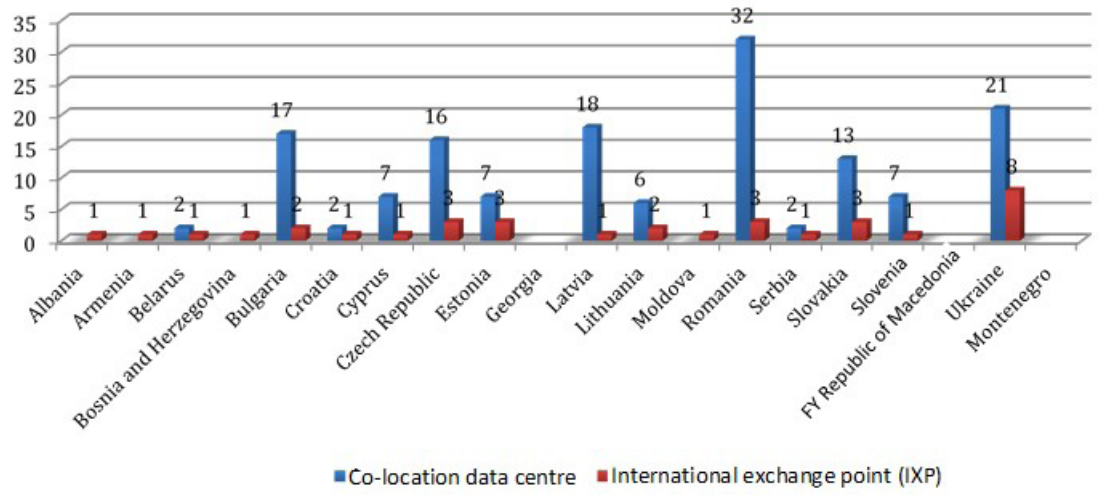
The speed and latency indicators for fixed networks in the countries of Europe are favourable to development of the Cloud market for all services.

Figure 26A: Reported speeds and latencies on mobile networks



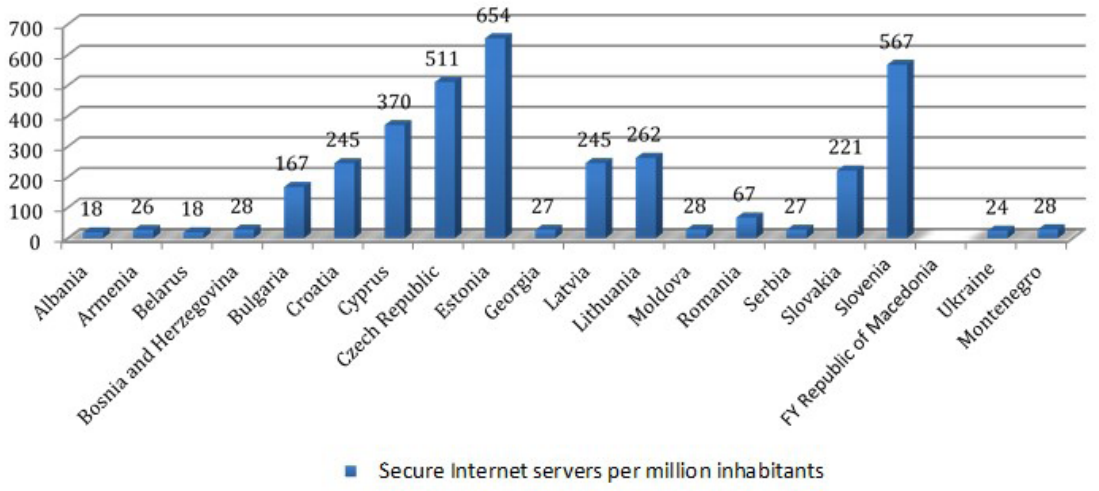
- Mobile network speeds and latency in most of the countries are favorable to development of the Cloud market for basic and intermediate services.
- The Czech Republic, Romania and Slovenia have speeds and latency that are favorable to advanced Cloud services.

Figure 27A: Existence of data centers and exchange points



All of the countries have at least one exchange point. Romania has the highest number of data centres.

Figure 28A: Secure Internet servers per million inhabitants



Apart from The Former Yugoslav Republic of Macedonia, all of the countries have several secure Internet servers per million inhabitants, with the highest numbers in Estonia, Slovenia and the Czech Republic.

Trends

- In almost all the developing countries of Europe, the speed and latency indicators for fixed networks are highly favorable to development of the Cloud computing market for basic, intermediate and advanced services.
- Improvement of the latency on mobile networks will enable the development of advanced Cloud services.

Annex 2: Documents received for consideration by Question 3/1

All documents received for consideration by Question 3/1 are listed below.

QUESTION 3/1

Reports

Web	Received	Source	Title
1/REP/23	2017-03-01	Rapporteur for Question 3/1	Report of the Rapporteur Group meeting on Question 3/1 (Geneva, Tuesday, 28 March 2017, 14:30-15:45 hours)
RGQ/ REP/21	2017-01-13	Rapporteur for Question 3/1	Report for the Rapporteur Group meeting on Question 3/1 (Geneva, Thursday, 12 January 2017, 14:30- 17:30 hours)
1/REP/23	2016-09-20	Rapporteur for Question 3/1	Report of the Rapporteur Group meeting on Question 3/1 (Geneva, Tuesday, 20 September 2016, 14:30- 16:00 hours)
RGQ/ REP/12	2016-04-17	Rapporteur for Question 3/1	Report of the Rapporteur Group meeting on Question 3/1 (Geneva, Friday, 8 April 2016, 09:00- 12:00 and 14:30- 17:30 hours)
1/REP/13	2015-09-15	Rapporteur for Question 3/1	Report of the Rapporteur Group Meeting on Question 3/1 (Geneva, Tuesday 15 September 2015, 14:30- 15:45 hours)
RGQ/REP/3	2015-04-17	Rapporteur for Question 3/1	Report of the Rapporteur Group Meeting on Question 3/1 (Geneva, Tuesday 16 September 2014, 11:15- 12:30 hours)
1/REP/3	2014-09-16	Rapporteur for Question 3/1	Report of the Rapporteur Group Meeting on Question 3/1 (Geneva, Tuesday 16 September 2014, 11:15- 12:30 hours)

Question 3/1 contributions for Rapporteur Group and Study Group meetings

Web	Received	Source	Title
1/470 Annex	2017-03-17	BDT Focal Point for Question 1/1	GSR-17 provisional programme focusing on living in a world of digital opportunities
1/450	2017-03-10	China (People's Republic of)	Participants are invited to consider this document and it is requested to include the relevant results in the Final Report for Question 3/1
1/439	2017-01-12	Rapporteur for Question 3/1	Report of the Rapporteur Group meeting on Question 3/1, Geneva, 12 January 2017
1/424	2017-02-14	China (People's Republic of)	The advantages of applying cloud computing on smart city and case analysis
1/414 [OR]	2017-02-10	Rapporteur for Question 3/1	Final Report for Question 3/1
1/408	2017-02-08	Bhutan (Kingdom of)	Migrating to the cloud – Bhutan's experience

(continued)

Web	Received	Source	Title
RGQ/272 [OR]	2016-11-14	Rapporteur for Question 3/1	Draft Final Report for Question 3/1
1/370 +Ann.1	2016-09-07	Singapore (Republic of)	Promoting cloud computing adoption in Singapore
1/355	2016-09-07	China (People's Republic of)	An overview of the development of China's e-Government cloud platform
1/342	2016-08-05	Rapporteur for Question 3/1	Etat des lieux des réseaux TIC et de l'énergie
1/341 [OR]	2016-08-05	Rapporteurs for Question 3/1	Draft report on Question 3/1
1/308 +Ann.1	2016-08-04	BDT Focal Point for Question 6/1	GSR 2016 Discussion Papers and Best Practice Guidelines
1/281	2016-07-28	China (People's Republic of)	Advantages of applying cloud computing technology to smart tourism and promotion measures
1/243	2016-04-08	Rapporteur for Question 3/1	Report of the Rapporteur Group Meeting on Question 3/1, Geneva, 8 April 2016
RGQ/232 +Ann.1-3	2016-03-22	BDT Focal Point for Question 3/1	Compilation of results on cloud-related topics based on responses to the 2015 ITU annual telecoms regulatory survey
RGQ/217	2016-03-22	Korea (Republic of)	Cloud Computing Development Act in Republic of Korea
RGQ/205	2016-03-21	BDT Focal Point for Question 3/1	Study on the use of cloud computing technology in education in Arab Countries
RGQ/194	2016-03-11	Democratic Republic of the Congo	Etat des indicateurs de l'informatique en nuage dans les pays en développement: Cas des pays de l'Europe
RGQ/193	2016-03-11	Democratic Republic of the Congo	Etat des indicateurs de l'informatique en nuage dans les pays en développement: Cas des pays de la région d'Amérique
RGQ/192	2016-03-11	Democratic Republic of the Congo	Etat des indicateurs de l'informatique en nuage dans les pays en développement: Cas des pays de l'Amérique Centrale
RGQ/191	2016-03-11	Democratic Republic of the Congo	Etat de lieu des indicateurs de l'informatique en nuage dans les pays en développement: cas des pays de l'Amérique Latine
RGQ/190	2016-03-11	Democratic Republic of the Congo	Cette contribution présente un état de lieu des indicateurs favorables au développement du marché du cloud dans quelques pays en développement de l'Asie-Pacifique

(continued)

Web	Received	Source	Title
RGQ/189	2016-03-11	Democratic Republic of the Congo	Etat de lieu des indicateurs de l'informatique en nuage dans les pays en développement: Cas des pays du Moyen Orient et Asie Centrale
RGQ/187	2016-03-11	Democratic Republic of the Congo	Etat de lieu de l'exploitation de l'informatique en nuage dans les pays en développement: cas des pays Africains
RGQ/160 (Rev.1)	2016-02-19	Rapporteurs for Question 3/1	Draft provisional report on Question 3/1
RGQ/158	2016-02-18	Burkina Faso	Deployment of cloud infrastructure for the administration of companies and citizens in Burkina Faso
1/198	2015-08-21	Zimbabwe (Republic of)	To use of not to use cloud computing?: The question for the developing world
1/110	2015-05-08	Rapporteur for Question 3/1	Work plan for Question 3/1 and proposed outline of the Question 3/1 report
1/103	2015-05-07	Rapporteur for Question 3/1	Report of the Rapporteur Group Meeting on Question 3/1, Geneva, 17 April 2015
RGQ/110 +Ann.1	2015-04-17	ISO	ISO/JTC1 liaison report on ISO Cloud Standards Work
RGQ/69	2015-03-04	Burkina Faso	Technique contractuelle et perspectives réglementaires en matière de cloud computing
RGQ/64	2015-02-28	Rapporteur for Question 3/1	Unleashing the power of cloud computing
RGQ/51	2015-02-26	India (Republic of)	Essential features of the access networks used for the cloud computing
RGQ/45	2015-02-26	Brazil (Federative Republic of)	Adoption of ITU-T Y.3500 and ITU-T Y.3502 for regulation and consumer information purposes
RGQ/42	2015-02-26	India (Republic of)	Successful utilisation of cloud computing for effective implementation of e-Governance projects
RGQ/37	2015-02-25	Cameroon (Republic of)	Access to cloud computing: challenges and opportunities for developing countries
RGQ/9	2014-12-15	Rapporteur for Question 3/1	Draft work plan for Question 3/1
1/68	2014-09-09	Microsoft Corporation	Proposal for initial work plan for Question 3/1
1/43 +Ann.1	2014-07-31	BDT Focal Point for Question 3/1, Telecommunication Standardization Bureau	Overview of ITU's work in the area of Cloud Computing

Contributions for QAll for Rapporteur Group and Study Group meetings

Web	Received	Source	Title
1/371	2016-09-07	Telecommunication Development Bureau	Update on innovation activities to ITU-D Study Groups
1/332	2016-08-05	General Secretariat	WSIS Stocktaking 2014-2016 Regional Reports of ICT Projects and Activities
1/331	2016-08-05	General Secretariat	WSIS Prizes 2016-2017
1/330	2016-08-05	General Secretariat	WSIS Stocktaking 2016-2017
1/310	2016-08-04	General Secretariat	WSIS Action Line Roadmaps C2, C5 and C6
1/309	2016-08-04	General Secretariat	ITU's Contribution to the Implementation of the WSIS Outcomes 2016
1/307	2016-08-04	General Secretariat	WSIS Forum 2016 and SDG Matrix
1/306	2016-08-04	General Secretariat	WSIS Action Lines Supporting Implementation of the SDGs
1/305	2016-08-04	General Secretariat	WSIS Forum 2016: High Level Track Outcomes and Executive Brief
1/304	2016-08-04	General Secretariat	WSIS Forum 2016 Outcome Document- Forum Track
1/303	2016-08-04	General Secretariat	WSIS Forum 2017 – Open Consultation Process
1/253 Rev.1	2016-05-31	Chairman, ITU-D Study Group 1	Compendium of Draft Outlines for expected outputs to be produced by ITU-D Study Group 1 Questions and Resolution 9 (September 2016)
RGQ/204	2016-03-18	BDT Focal Point for Question 8/1 and Resolution 9	Outcomes of RA-15,WRC-15 and CPM19-1 related to ITU-D
RGQ/152	2016-02-18	Kazakhstan (Republic of)	Contribution from Kazakhstan to Questions 1/1, 2/1, 3/1, 4/1, 5/1, 6/1, 7/1, 8/1 and 5/2
1/232 +Ann.1	2015-09-13	Chairman, ITU-D Study Group 1	Work plan for ITU-D Study Group 1 (September 2015)
1/231 (Rev.1)	2015-09-04	Chairman, ITU-D Study Group 1	Compendium of Draft Outlines for Expected Outputs to be Produced by ITU-D Study Group 1 Questions and Resolution 9 (September 2015)
1/229 (Rev.1)	2015-09-02	Argentine Republic	Draft new Resolution: "Telecommunication/ICT accessibility for persons with disabilities and persons with specific needs"
1/228 (Rev.1)	2015-09-02	Argentine Republic	Modification of the Resolution ITU-R 61 "Contribution in implementing the outcomes of the World Summit on the Information Society"

(continued)

Web	Received	Source	Title
1/200	2015-08-25	Telecommunication Development Bureau	ITU-D Study Groups Innovation Update
1/183	2015-08-07	Telecommunication Development Bureau	1st ITU-D Academia Network Meeting
1/145	2015-07-24	General Secretariat	WSIS Forum 2015: High level policy statements, Outcome document, Reports on WSIS Stocktaking
1/126	2015-07-06	Uganda (Republic of)	Increasing women's participation in ITU Study Groups' work
1/125	2015-06-29	BDT Focal Point for Question 1/1	ITU GSR15 discussion papers and best practice guidelines
1/70	2014-09-18	Chairman, ITU-D Study Group 1	Appointed Rapporteurs and Vice-Rapporteurs of ITU-D Study Group 1 Questions for the 2014-2018 period
1/66	2014-09-04	Telecommunication Development Bureau	List of information documents
1/65	2014-09-03	Australia, Samoa (Independent State of), United Kingdom of Great Britain and Northern Ireland, Vanuatu (Republic of)	Numbering misappropriation
1/64	2014-09-03	Intel Corporation	New question for ITU-D Study Group 1 (2014-2018): Assistance to developing countries for the implementation of ICT programs in education
1/50	2014-08-28	United States of America	Selected recent developments in U.S. spectrum management
1/48	2014-08-23	Nepal (Republic of)	Need for developing detailed table of contents for each Question under both the ITU-D Study Groups at the beginning
1/38 +Ann.1	2014-08-04	Telecommunication Development Bureau	Quality of Service Training Programme (QoSTP)
1/22	2014-06-27	BDT Focal Point for Question 1/1	Status report on Regulatory and Market Environment
1/5 (Rev.1-2)	2014-09-08	Telecommunication Development Bureau	Candidates for Rapporteurs and Vice-Rapporteurs of ITU-D Study Group 1 and 2 study Questions for the 2014-2018 period
1/4	2014-09-01	Telecommunication Development Bureau	List of WTDC Resolutions and ITU-D Recommendations relevant to the work of the ITU-D Study Groups
1/3	2014-08-20	Telecommunication Development Bureau	Resolution 9 (Rev. Dubai, 2014): Participation of countries, particularly developing countries, in spectrum management

(continued)

Web	Received	Source	Title
1/2 +Ann.1	2014-08-20	Telecommunication Development Bureau	Resolution 2 (Rev. Dubai, 2014): Establishment of study groups + Full text of all ITU-D Study Group 1 Questions in Annex 1
1/1	2014-06-11	Telecommunication Development Bureau	Resolution 1 (Rev. Dubai, 2014): Rules of procedure of the ITU Telecommunication Development Sector

Information Documents

Web	Received	Source	Title
1/INF/3	2014-09-02	University of Rwanda College of Science and Technology (Rwanda (Republic of))	Overview on challenges and benefits facing cloud computing used in the e-Government

Liaison Statements

Web	Received	Source	Title
1/433	2017-02-22	ITU-T Study Group 11	Liaison Statement from ITU-T SG11 to ITU-D SG1 Questions 2/1, 3/1, 6/1 on Operational Plan for implementation of WTSA-16 Resolution 95
RGQ/262	2016-10-31	ITU-T Study Group 13	Liaison Statement from the ITU-T SG13 to ITU-D SG1 Question 3/1 on the results of the questionnaires on cloud computing scenarios in developing countries
1/360	2016-09-07	ITU-T Study Group 13	Liaison Statement from ITU-T SG13 to ITU-D SG1 Q3/1 on invitation to update the information in draft Supplement on Cloud Computing Standardization Roadmap
RGQ/126	2015-12-18	ITU-T Study Group 13	Liaison statement from ITU-T SG13 to ITU-D SG1 Q3/1 on the elaboration of questionnaires on the cloud computing scenarios in developing countries
RGQ/125	2015-12-18	ITU-T Study Group 13	Liaison statement from ITU-T SG13 to ITU-D SG1 Q3/1 on invitation to update the information in the cloud computing standards roadmap and remark on the matrix for standardization gap analysis
1/127	2015-07-04	ITU-T Study Group 15	Liaison Statement from ITU-T SG15 to ITU-D SGs on ITU-T SG15 OTNT standardization work plan
1/115	2015-05-18	ITU-T Study Group 13	Liaison Statement from ITU-T SG13 to ITU-D SG1 on Progress on cloud computing work

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