Supporting Public Service Reform

Cloud Computing Strategy

An Roinn Caiteachais Phoiblí
agus Athchóirithe
Department of Public
Expenditure and Reform

The Programme for Government and the Public Service Reform Plan highlight Information and Communications Technologies (ICT) as key enablers to delivering improved public services. Implementation of the ICT elements of the Programme and the Reform Plan will ensure a strong focus on the customer and that better and more innovative use is made of technology to improve the customer experience.

To progress these, CMOD, working with the Public Service CIO Council, will develop a series of ICT Strategy and Policy documents.

The first of these *eGovernment 2012-2015* was published in April 2012.

This second one entitled *Cloud Computing Strategy* sets out a strategic approach for the public service to engage with Cloud Computing and to undertake a comprehensive programme of Data Centre Consolidation. It positions both as key elements of the public service's ICT Strategy. It details the criteria to be considered by individual public bodies when considering public Cloud offerings, and highlights how a Public Service Community Cloud will be progressively phased in. In this context, it details the ICT activities that will be migrated to the Cloud and the procurement approaches that will be taken. Finally, it highlights the need to consider a new approach to ICT organisation in the public service arising from the implementation of this Strategy over time.

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Foreword

As part of the Programme for Government, we announced that we would promote greater use of Cloud Computing in the public sector, and in the Public Service Reform Plan published in November 2011, we committed to developing a Cloud Computing Strategy for the public service.

"Cloud" marks the next major shift in computing. As it is still evolving, the move to Cloud Computing, in its various guises, will be a multi-year process rather than an event.   "Cloud" has the potential to fundamentally change the nature of ICT and its provision everywhere, not just in the public service. Therefore, our reliance on owned ICT infrastructure and solutions may reduce over time in favour of increased usage of ICT services that are consumed on some form of metered basis.

This paper aims to set out how this change will impact on the use of computing in the public service and it lists the criteria that public bodies will need to use in their consideration of cloud-based solutions. It also sets out how a Public Service Community Cloud is required, explores how that may be provisioned, and highlights opportunities for partnership with the private sector. As part of this, the paper identifies how the current consolidation of computer and data centres in the public service needs to be continued and formalised.

While change in itself can be important to renew and energise, we must remain mindful of the realities of our economic circumstances in setting policies and strategies. In this context, the move to Cloud Computing must be underpinned with solid business cases that provide compelling value-for-money for the State and taxpayers.

Accordingly, I look forward to private sector organisations engaging with my officials and those in senior ICT management positions throughout the public service in the implementation of this Strategy.

This Cloud Computing Strategy *was prepared by CMOD in my Department in conjunction with the Public Service CIO Council. I wish to express my appreciation for their work on this paper.*

Brendan Howlin TD
Minister for Public Expenditure and Reform

Executive Summary

Cloud Computing is a radically new approach to the delivery of ICT services which promises –

- "anywhere" access to shared computing resources;

- "freedom" from capital expenditure on back-end computing equipment and software;

- the ability to provision computing services very quickly and cheaper than traditional models; and

- the ability to pay for such services on some form of metered or per-use basis.

As Cloud Computing is evolving, there are still considerable challenges pertaining to, *inter alia*, security, legalities, jurisdiction, availability and reliability, and pricing models that provide definitive and sustained value. Accordingly, the move to Cloud Computing will take time.

This Strategy is based on extensive engagement, research and trials with the ICT industry over 2 years. Notwithstanding the challenges, this Strategy –

- places Cloud Computing at the heart of our ICT Strategy;

- sets a course for centralising and implementing our common ICT needs as a set of shared services;

- commits to reducing the number of our computer and data centres from potentially hundreds to approximately 10 primary facilities;

- establishes our aim to use external service providers as much as possible in the fulfilment of this approach and to maximise competition in this regard by establishing multi-vendor procurement frameworks;

- details and timelines lists of ICT activities that we will migrate to Cloud Computing and shared services over a number of phases; and

- highlights our need to consider a new ICT organisational structure and new ICT funding and governance arrangements over time.

Finally, it makes it clear that the implementation of the measures set out in this Strategy must provide tangible cost savings before they will be advanced.

1. Background and Introduction

1.1 The purpose of ICT in the public service is to support the effective and efficient delivery of public administration and services. In that context it needs to be –

- fit-for-purpose in terms of functionality, availability and reliability;

- delivered in a way that supports the obligation of the State to protect and secure the data and privacy of its citizens and enterprises; and

- implemented and operated in a way that provides best value-for-money.

1.2 As with other public administrations and large enterprises worldwide, public bodies in Ireland have traditionally procured or developed their own ICT infrastructures and solutions and most of them have developed their own ICT functions to manage and operate these.

1.3 A range of measures and circumstances are now coming together that provide an opportunity for reconsidering how ICT should be procured, delivered and governed in the public service, *viz.*

- the current economic circumstances mean that public bodies must operate with considerably reduced financial and human resources;

- this in turn is compelling public bodies to concentrate their efforts on their core business and to consider alternative approaches for non-core activities[1];

- front-end interfaces and devices are becoming more consumer-oriented, more mobile and more intuitive to operate, resulting in an increased expectation and demand for complex services in ever-reducing timescales;

- at the same time, back-end ICT infrastructures and systems are increasing in their sophistication and complexity, with commensurate increases in the skill levels required to develop, maintain and operate them;

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[1] ICT or elements of it can fall into both categories. Public bodies with mission-critical operations that are wholly dependent on complex ICT systems treat ICT as a core activity, whereas others view it as an enabler that can be sourced in multiple ways.

- the combination of a moratorium on recruitment and a general shortage of people with the requisite ICT skills makes it difficult for public bodies to attract and employ sufficient quantities of ICT personnel[2];

- the Government has articulated its commitment to rationalising core processes that are duplicated by establishing shared back office operations or shared services for a range of disciplines including ICT;

- a number of public bodies have already entered formal shared ICT service arrangements and have deployed or redeployed staff accordingly;

- quite a number of public bodies are co-locating or consolidating their backend ICT infrastructure or elements of it in other public service data centres (mainly those operated and managed by the Department of Agriculture, Food and Marine and the Office of the Revenue Commissioners) to reduce hosting costs and to share the costs of power, cooling and basic management; and

- Cloud Computing now gives public bodies the opportunity to consider the consumption of ICT services on some form of metered basis as an alternative to traditional provisioning models.

1.4   As part of its aim to make Ireland a leader in Cloud Computing, the Government has said that it will promote greater use of Cloud Computing in the public sector. In this context, both CMOD[3] and HEAnet[4] have been engaged in research and trials with a number of companies dealing primarily with computing power, storage and infrastructural services such as email. These have demonstrated that, while Cloud Computing certainly provides opportunities for efficiencies and cost savings, it isn't yet evolved to the degree required by the public service in terms of security, reliability, service levels, standards, jurisdictional, legal and contractual arrangements, technical interoperability, licensing, dynamic and real-time availability, availability of requisite skills, and commercial models.

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[2]   Notwithstanding this difficulty, and regardless of the models of ICT delivery that emerge, the public service has and will have a continuous need for ICT personnel. It is the nature of such personnel that may change over time.

[3]   CMOD (Centre for Management and Organisation Development) is a division of the Department of Public Expenditure and Reform. It has a public service-wide brief with responsibility for researching, developing and implementing policies in the areas of telecommunications, technology, shared ICT services, and eGovernment. CMOD also operates as the sanctioning authority for ICT expenditure in the Irish public service. It chairs the Public Service CIO Council and represents Ireland at EU level in relation to public service ICT, eGovernment and CIO working groups and fora.

[4]   HEAnet is Ireland's National Education and Research Network, providing advanced Internet and associated ICT and e-Infrastructure services to Educational and Research organisations throughout Ireland – see www.heanet.ie

1.5   This seems in keeping with the findings and opinions of numerous industry analysts and commentators, and seems to reflect the multi-year approaches being taken by other public administrations worldwide including the UK, USA, Canada, Australia, Netherlands, Austria and various Scandanavian countries. Consequently, an incremental approach to the adoption of Cloud Computing seems most likely.

1.6   It is in this context of considerable organisational, financial, and technological change and uncertainty that this *Cloud Computing Strategy for the Public Service* has been developed by CMOD in conjunction with the Public Service CIO Council[5].   CMOD and the CIO Council will continue to monitor developments in these areas through engagement with industry, dialogue with peers throughout the EU, and the trialling of models and applications as they become available.

1.7   It is clear that public administrations in other EU Member States, and indeed further afield, are also considering how best to implement private or community clouds for themselves given the nature of their data holdings. Engagement with the Irish public service in the implementation of the approaches set out in this Strategy may give companies an opportunity to develop responses in this regard, and to develop expertise in this specific market area at relatively low cost and low risk.

1.8   The purpose of ICT in the public service, as set out at Paragraph 1.1, has not changed. Accordingly, the implementation of the measures set out in this Strategy is contingent on this purpose being demonstrably fulfilled and verifiable cost reductions being achieved.   In this context, private sector providers are invited to consider how they can engage with this vision to generate a new approach to the provision of ICT infrastructures and solutions in the public service and how they can provide tangible value in this context.

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[5]   A Public Service Chief Information Officer (CIO) Council, comprising senior ICT Directors from across the public service, was established in 2011. Its purpose is to work with CMOD in the on-going development of ICT and eGovernment policies. It is referred to as the "CIO Council" hereafter.

2. Strategic Approach

Definition

2.1 The Irish Public Service accepts the definition of Cloud Computing and its various models and deployments provided by the US Government's National Institute of Standards and Technology (NIST)[6].

Principles

2.2 The Irish Public Service accepts that Cloud Computing is a major shift in the provision of ICT infrastructure, systems and services. It is acknowledged that it has the potential to fundamentally change the nature of ICT delivery over time, and to provide benefits in terms of efficiencies, cost effectiveness, speed to market, the leveraging of new opportunities, fulfilling elements of the green agenda, improving mobility and access, and deploying resources on core activities. As a consequence, it is anticipated that Cloud Computing will be a key part of the strategic future of ICT in the public service, eventually becoming the default and primary delivery mode.

2.3 Accordingly, as a general principle, and once the appropriate guidance for evaluation and assessment is in place (see Paragraph 2.7 below), public bodies should seek Cloud-based provision as an option for consideration when procuring ICT solutions.

2.4 In this context, this Strategy proposes that –
- the use of "private clouds" will be limited to those that receive sanction based on a solid business case and specific, unique requirements;
- offerings of "public cloud" based provision of solutions need to be subjected to an appropriate application of the criteria set out at Annex II by the public body concerned; and
- the public service will seek to develop a Public Service Community Cloud to negate the necessity for private clouds and to provide another Cloud option where the public cloud is deemed not suitable.

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[6] See http://www.nist.gov/itl/csd/cloud-102511.cfm (repeated at Annex I of this document).

Public Cloud

2.5 While public clouds may be considered by a public body for any requirement, it seems most likely that initial deployments would be most appropriate for –

a). any public-facing and non-sensitive activity, *viz.*

  o open data initiatives,

  o public information repositories,

  o public collaboration or surveying facilities,

  o analytics involving non-sensitive or non-confidential data,

  o the front-end elements of online services or apps that do not store sensitive data,

  o simulation testing of the availability, robustness and functionality of online services;

b). developing, piloting and testing new applications or solutions where deep integration with back-end data of a sensitive or confidential nature is not required; and

c). trialling new approaches that would ordinarily require a considerable capital investment or risk.

2.6 CMOD, working with the CIO Council, will seek to develop procurement frameworks that would be available to all public bodies, for public cloud solutions that may have general applicability across some or all of the public service.

2.7 Under the auspices of the CIO Council, guidance for public bodies will be developed to –

• provide detail on the specific assessment criteria set out at Annex II;

• explain how this criteria needs to be applied against each opportunity to determine whether the public cloud can be considered; and

• describe how actual procurement exercises for public cloud offerings need to be evaluated and compared with each other.

Public Service Community Cloud

2.8   The Irish public service needs to develop its own Community Cloud for those circumstances where public cloud offerings are deemed unsuitable.

2.9   Phase I of a Public Service Community Cloud will seek to evaluate and provision Infrastructure as a Service (IaaS) as follows –

a).   Availability only through connectivity with Government Networks[7].

b).   It will be coupled with the continuing programme of data and computer centre rationalisation (see Pargraphs 2.14 – 2.16 below). In this context, it is anticipated that this IaaS will be provided from computer/data centres owned and managed by public bodies. However, the use of commercial data centres may be considered subject to a satisfactory evaluation of risk, adequate protections and remedies being provided for contractually, and demonstrable value for money. CMOD and the CIO Council will continue to explore this option with industry[8].

c).   A public procurement exercise will be conducted to establish a framework of multiple IaaS providers – ideally offering a variety of platforms. While the infrastructure may reside in Government-owned facilities on Government Networks (subject to [b] above), the infrastructure would remain the property of the providers, and would be operated, maintained and managed by those providers. They would provide public bodies with a standardised catalogue of offerings and services and with the required provisioning tools or services.

d).   In general, all new infrastructure requirements of public bodies, such as compute and storage and associated services, would be satisfied through this framework. Each public body would choose its infrastructure provider through mini-competitions within the framework. Public bodies would pay for such infrastructure services on some form of metered basis. Actual charging models and thresholds would be agreed as part of the framework establishment.

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[7]   See http://ictprocurement.gov.ie/government-networks/ for a definition and explanation of Government Networks. The core of this network and the interconnections between the primary nodes will require upgrading to facilitate this move to Cloud Computing – this work is underway. Any additional security and audit requirements will be assessed during Phase I.
[8]   A number of cloud providers in the USA are now offering Government-segmented Clouds from their data centres which are being subjected to particular security standards.

2.10 Phase II of a Public Service Community Cloud/s will seek to deploy a range of key infrastructural solutions on a centralised multi-tenanted basis, such as, firewalling, web/content filtering, anti-spam, and anti-virus solutions.

2.11 Whereas Phase I of a Public Service Community Cloud will ensure a gradual movement away from owned computing infrastructure to the IaaS solutions, Phase III will seek to develop pilots, proofs of concepts, and live implementations on top of those IaaS platforms, including Platform as a Service (PaaS) solutions. Examples could include –

a). a range of common services/platforms such as –

   o websites and portals – both in terms of development and hosting,

   o caching for websites,

   o database services,

   o dynamic DR (disaster recovery) based on multi-site provision; and

b). key infrastructure platforms such as –

   o directory and federated authentication services,

   o virtual desktop infrastructure (VDI), and

   o email.

2.12 Phase IV of a Public Service Community Cloud will seek to expand the IaaS environment with Software as a Service (SaaS) solutions such as –

• analytics with sensitive information;

• collaboration/content sharing technologies;

• document management; and

• case management.

However, it is acknowledged that some of these may take considerably longer than the proposals at Phase III because of the specific nature of customisations typically implemented in individual organisations.

2.13 Phase V of a Public Service Community Cloud will involve the migration of existing legacy and mission-critical systems from traditional platforms. As it is usual to migrate such systems when requiring redevelopment, it seems inevitable that this Phase will take considerable time.

Data/Computer Centre Rationalisation

2.14 Over the last 18-24 months, numerous public bodies have successfully moved elements of their back-end infrastructure and systems to data centres belonging to other public bodies – primarily those of the Office of the Revenue Commissioners and the Department of Agriculture, Food and Marine. This consolidation effort will now be formalised as follows –

- criteria will be developed to identify appropriate data/computer centres/facilities for inclusion in a framework of both fixed and container-based facilities – this framework will incorporate regional distribution for business continuity and DR purposes and is likely to number less than 10;

- the levels and qualities of services to be provided as standard and as value-added in these facilities will be established and catalogued;

- the staffing levels and skills required to operate these facilities and environments and how those should be sourced will be identified;

- principles for the funding (including if necessary, cost-sharing models) of these facilities will be defined; and

- the appropriate governance structures will be designed and established.

2.15 The concentration will be on the consolidation of sites, rather than the consolidation of equipment. The latter will be dealt with over time with the advancement of the Public Service Community Cloud as detailed at Paragraphs 2.8 – 2.13 above. While this consolidation programme may not result in any significant reduction in equipment, it will remove a great deal of attendant costs in servicing multiple sites with power, cooling, light, networking, maintenance services, and staff supports.

2.16 Once these policies have been adopted, and a sufficient level of operation has been established, Government approval will be sought to mandate public bodies to use the selected data centre facilities for all new developments and to migrate existing environments within a defined timeframe.

3. Outlook

3.1 The combination of the approach to Public Service Community Cloud and Data Centre Rationalisation detailed in this Strategy, will, over time, result in a very considerable aggregation of the ICT infrastructure and service requirements of the Irish public service, and thereby provide the market with the necessary economy of scale to develop viable and cost-effective proposals.

3.2 It is acknowledged that the use of Government-owned facilities for consolidating data centres and for locating Public Service Community Cloud environments would not benefit from the same economies of scale that some Cloud providers may achieve in their own environments when operating at a global scale. However, as Cloud providers are now beginning to segment Cloud infrastructure and services in their own data centres exclusively for Government use, the probability is that it would not be any more expensive for Cloud providers to do similarly in public service owned facilities as it would negate the necessity for them to invest in or enhance facilities, power, cooling, networking, and access control for public service purposes. Accordingly, Cloud providers should factor this into their metering and pricing models for the public service.

3.3 Additionally, it is acknowledged that for some business processes and solutions, there may be genuine opportunities for seeking to mix elements from the public cloud and the Public Service Community Cloud in a Hybrid approach, particularly where such elements are fine-grained and independent.

3.4 With respect to the Public Service Community Cloud, it is accepted that it will not be possible to give the market firm indications of likely volumes or levels of business in specific timeframes. Consequently, while consideration will be given to some level of upfront investment from providers when establishing procurement frameworks, greater consideration will be given to demonstrable technical and scaling capability in a timely fashion.

3.5   The implementation of the approaches set out in this Strategy will automatically generate a new dynamic in how ICT applications and solutions are sought by public bodies. It seems likely that there will be less need for the specification and acquisition of the physical hardware and software environments. Instead public bodies will specify the functionality of solutions required and the environment in which they must be provided. This in turn should result in a new approach by the provider market as greater innovation and collaboration between providers will be required. In this context, it is anticipated that the software industry will need to review and consider how its licensing, support and maintenance (LS&M) models will be impacted by the move to "solution packaging" and "metered use" that the Cloud advocates.

3.6   Additionally, the software industry is invited to work with public bodies to determine how they can migrate their environments and solutions to a Public Service Community Cloud as set out in Phases III, IV and V of this Strategy, while retaining the value of their existing software investments.

3.7   The implementation of the approaches set out in this Strategy, and the dynamic shifts they will generate, will bring about a change in the nature, structure, staffing and operations of individual ICT functions throughout the public service. In this context, it is anticipated that, over time, individual public bodies will require less staff to develop and manage ICT infrastructure and common services. On the other hand, there will be a continuing need for ICT staff for the analysis, development and project management of business-specific solutions. There will also be a new need for staff with knowledge and expertise that is specific to Cloud-based provision of infrastructure, systems and services including –

- specifying, evaluating and selecting Cloud-based solutions;
- negotiating and managing various legal and technical matters relating to provisioning, service levels and qualities, availability management, transitioning, performance management, integration with other Cloud environments, etc.; and
- particular security, territoriality and jurisdictional matters.

4. Implementation

4.1   In summary, this Strategy advocates that –

- Cloud-based provision of ICT solutions and ICT shared services will, over time, become the default approach for the public service;

- CMOD and the CIO Council will develop guidance with respect to the procurement and usage of public cloud offerings and the assessment criteria set out at Annex II;

- public bodies will then begin to include consideration of Public Cloud offerings in their procurement exercises for ICT solutions;

- CMOD will work with public bodies to develop procurement frameworks for public cloud solutions of universal applicability;

- existing work in consolidating data centres will be standardised and formalised and the necessary funding and governance arrangements will be defined and implemented;

- a Public Service Community Cloud will be developed in phases and coupled with the data centre consolidation work underway;

- the exploration, piloting and development of a Public Service Community Cloud should encompass solutions from private sector providers, ideally offering different solutions; and

- these approaches will be mandated as they become established and proven to provide best value for money.

4.2   The CIO Council will establish Working Groups as required to progress each of these individual elements in accordance with the indicative timeline set out at Figure A overleaf.

4.3   Additionally, the CIO Council will assess the impact of this Strategy, particularly those aspects relating to the consolidation of ICT environments and the greater centralisation or sharing of ICT services, on existing ICT organisational structures in the public service. The Council will bring its assessment through the Public Service Reform governance arrangements to ensure full consideration by senior managers of arising business implications.

4.4   It should be noted that, although five phases have been set out for the implementation of the Public Service Community Cloud at Paragraphs 2.9 – 2.13, these need not be advanced sequentially. It is anticipated that there will be considerable parallelism in the implementation of these discrete phases.

4.5   Additionally, the lists of ICT activities provided for Phases II-V of the Public Service Community Cloud (Paragraphs 2.10 – 2.13) are not exhaustive and other services or solutions may, and most likely will, be added as advancements are made and opportunities emerge. CMOD and the CIO Council will maintain an open approach in the determination of targets and the timing of same.

4.6   The development of the European Commission's European Cloud Computing Strategy[9] will be monitored and aligned with where appropriate. In this context, support will also be given to the assessment, and where necessary, amendment of existing EU procurement law to better facilitate the procurement of cloud-based computing resources or solutions, particularly for circumstances such as –

- unpredictable and irregular use requirements;
- seasonal or burst requirements;
- rapid deployments in specific circumstances; and
- technology trials leading to use.

4.7   The CIO Council views this Strategy as a living document which it will keep under review and which it will amend or supplement as Cloud Computing evolves and material information comes to light.

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[9]   See http://ec.europa.eu/information_society/activities/cloudcomputing/index_en.htm for details.

Figure A
Timeline for Strategy Activities

Activity	Approximate Timeline
Development of Public Cloud Assessment Criteria (Annex II)	Within 1 year
Development of Public Cloud Procurement Guidance	Within 1 year
Development of Evaluation Criteria for Public Cloud offerings	Within 1 year
Initial Procurement Exercise for Public Cloud Based Solution	Within 1 year
Formalisation of Data Centre Selection and Consolidation Criteria	Within 1 year
Consolidation of Data Centres	1 – 5 years
Public Service Community Cloud Phase I	Within 1 year
Public Service Community Cloud Phase II	Within 2 years
Public Service Community Cloud Phase III	1 – 5 years (dependent on the emergence of interoperable and mature solutions, the availability of the resources needed to advance projects, and the need to extract VFM from existing investments)
Public Service Community Cloud Phase IV	1 – 5 years (dependent on the emergence of interoperable and mature solutions, the availability of the resources needed to advance projects, and the need to extract VFM from existing investments)
Public Service Community Cloud Phase V	1 – 10 years (dependent on systems development lifecycle, the investment amortisation/depreciation timeline, and the availability of interoperable and mature solutions)
Implications on ICT organisational structures	Likely to be ongoing over the entire period

Annex I

The NIST Definition of Cloud Computing

Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of five essential characteristics, three service models, and four deployment models.

Essential Characteristics:

On-demand self-service. A consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service provider.

Broad network access. Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, tablets, laptops, and workstations).

Resource pooling. The provider's computing resources are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand. There is a sense of location independence in that the customer generally has no control or knowledge over the exact location of the provided resources but may be able to specify location at a higher level of abstraction (e.g., country, state, or datacenter). Examples of resources include storage, processing, memory, and network bandwidth.

Rapid elasticity. Capabilities can be elastically provisioned and released, in some cases automatically, to scale rapidly outward and inward commensurate with demand. To the consumer, the capabilities available for provisioning often appear to be unlimited and can be appropriated in any quantity at any time.

Measured service. Cloud systems automatically control and optimize resource use by leveraging a metering capability[10] at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts). Resource usage can be monitored, controlled, and reported, providing transparency for both the provider and consumer of the utilized service.

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[10] Typically this is done on a pay-per-use or charge-per-use basis.

Service Models:

Software as a Service (SaaS). The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure[11]. The applications are accessible from various client devices through either a thin client interface, such as a web browser (e.g., web-based email), or a program interface. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings.

Platform as a Service (PaaS). The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider.[12] The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly configuration settings for the application-hosting environment.

Infrastructure as a Service (IaaS). The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, and deployed applications; and possibly limited control of select networking components (e.g., host firewalls).

Deployment Models:

Private cloud. The cloud infrastructure is provisioned for exclusive use by a single organization comprising multiple consumers (e.g., business units). It may be owned, managed, and operated by the organization, a third party, or some combination of them, and it may exist on or off premises.

Community cloud. The cloud infrastructure is provisioned for exclusive use by a specific community of consumers from organizations that have shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It 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.

Public cloud. The cloud infrastructure is provisioned for open use by the general public. It 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 provider.

Hybrid cloud. The cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities, but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load balancing between clouds).

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[11] A cloud infrastructure is the collection of hardware and software that enables the five essential characteristics of cloud computing. The cloud infrastructure can be viewed as containing both a physical layer and an abstraction layer. The physical layer consists of the hardware resources that are necessary to support the cloud services being provided, and typically includes server, storage and network components. The abstraction layer consists of the software deployed across the physical layer, which manifests the essential cloud characteristics. Conceptually the abstraction layer sits above the physical layer.

[12] This capability does not necessarily preclude the use of compatible programming languages, libraries, services, and tools from other sources.

Annex II

Criteria for Public Cloud Consideration

1. Application Design

2. Architecture

3. Business Continuity and Disaster Recovery

4. Commercial and Pricing Model/s

5. Data Location and Retrieval

6. Legal and Regulatory (incl. data protection, governing laws, intellectual property, termination)

7. Performance and Conformance

8. Privacy

9. Reputation

10. Security

11. Security Standards

12. Service Provision (incl. SLAs, transitioning)

13. Staffing and Skills Requirements

14. Technology Lock-In – Migration and Interoperability

15. Technology Standards

16. Value For Money