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Cloud Computing technology in Telecommunication ecosystems and recent ITU-T standardization efforts

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Outline

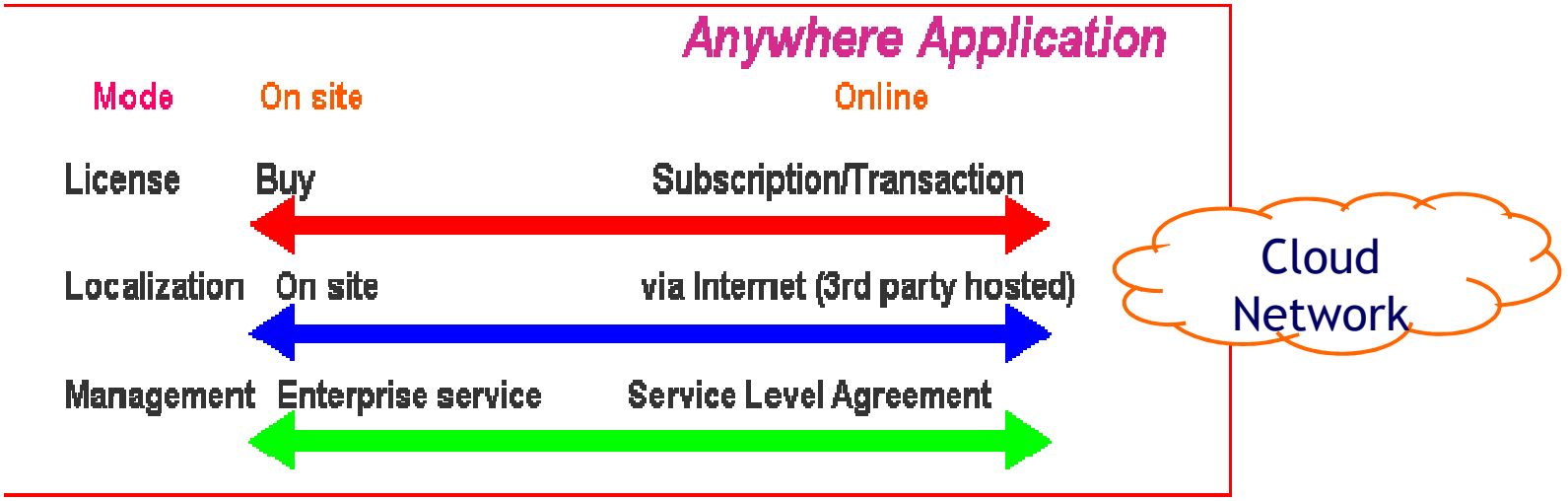
- Basics of Cloud Computing technology
- Telecommunication centric Cloud Ecosystem, cloud services and use cases
- Cloud Computing standardization and ITU-T FG CC
- Other details on ITU-T FG CC technical work (Functional Architecture, Network Infrastructure)

Basics of Cloud Computing technology

The origin of the Cloud Computing paradigm

- **"Cloud": term introduced in 2008 to designate "Online" or "delivery through the network" characteristic of Software as a Service (SaaS) (network schema usually illustrated by a cloud)**
- **" SaaS": new "IT service-centric" concept for accessing a software application (computing task). SaaS can be seen as a software distribution model in which applications are hosted by a service provider and made available to customers over a network, typically the Internet, and where a single instance ("virtual application") of the software runs on the SaaS provider servers, following a multi-tenant 1-to-N architecture, and charged on a per usage basis.**
- **SaaS model has similarity with the Application Service Provider (ASP) model (years 2000) as an evolution of Internet Service Provider (ISP) model.**
- **Key starting points for cloud computing market emergence: recent development of high bit rate access and improvement of the ISPs' network layer availability.**
- **Cloud Computing as an evolution of ASP and some generalization of SaaS online services with extension to platform and infrastructure services.**

From Online "Software as a Service" to Cloud Computing



Cloud Computing as an evolution of the Application Service provider model and some generalization of SaaS online services with extension to platform and infrastructure services

Cloud Computing ≡ Network Computing ≡ Internet Computing

Definitions of « Cloud Computing »

A number of definitions (different focus) …

"A style of computing where massively scalable IT-enabled capabilities are delivered 'as a service' to external customers using Internet technologies"– Gartner

"A standardized IT capability (services, software, or infrastructure) delivered via Internet technologies in a pay-per-use, self-service way" – Forrester

"Scalable, virtualized information services provided on demand over the Internet with multi-tenant capability, service-level agreements (SLAs) and usage-based pricing. The service architecture is shared, virtualized , self-maintained and designed according to an utility-like model " – Yankee

" On-demand network access to shared ITC resources (e.g. infrastructure, network, storage) and/or application services (« elastic computing capacity ») " – other analyst firm

"Cloud computing is an emerging approach to shared infrastructure in which large pools of systems are linked together to provide IT services" – IBM

Definition of ITU-T Focus Group on Cloud Computing (adapted from NIST):

"Cloud computing is a model for enabling service user's 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. Cloud computing enables cloud services."

NOTE - It is considered from a telecommunication prescriptive that users are not buying resources, but cloud services that are enabled by cloud computing environments.

Cloud Computing essential characteristics - 1

ON-DEMAND SELF-SERVICE

An user can unilaterally provision computing capabilities, such as server time, network storage and communication and collaboration services, as needed automatically without requiring human interaction with each service's 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, laptops, and PDAs).

RESOURCE POOLING

The provider's computing resources are pooled to serve multiple users using a multi-tenant model, with different physical and virtual resources dynamically assigned/reassigned according to user 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, network bandwidth and virtual machines.

Cloud Computing essential characteristics - 2

RAPID ELASTICITY

Capabilities can be rapidly and elastically provisioned, in some cases automatically, to quickly scale out, and rapidly released to quickly scale in. To the user, the capabilities available for provisioning often appear to be unlimited and can be purchased in any quantity at any time.

MEASURED SERVICE

Cloud systems automatically control and optimize resource use by leveraging a metering capability 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 user of the utilized service.

Some technologies related to Cloud Computing

GRID COMPUTING	Network of computers utilized together to gain large supercomputing type computing resources (and perform large and complex computing operations).
VIRTUALIZATION	Introduction of a layer between Hardware and Operating System. Users can then access servers or storage without knowing specific server or storage details. The virtualization layer executes user request for computing resources by accessing appropriate resources.
UTILITY COMPUTING	Introduction of a pay-per-use model for using computing services. Various billing models are possible. Billing adaptation to changing computing requirements of an organization with no additional cost.
AUTONOMIC COMPUTING	Self-managing computing. In autonomic computing, computing infrastructure can automatically correct itself in unforeseen situations without human intervention.

The basic 3 Cloud service categories from NIST - 1

APPLICATION
SaaS

Software as a service (SaaS): A category of cloud services where the capability provided to the cloud service user is to use the cloud service provider's applications running on a cloud infrastructure. NOTE: Applications have all the common characteristic to be non real time and may be of different kinds, including IT and business applications, and may be accessible from different user devices. The cloud service user does not manage or control the underlying cloud infrastructure with the possible exception of limited user-specific application configuration settings.

PLATFORM
PaaS

Platform as a service (PaaS): A category of cloud services where the capability provided to the cloud service user is to deploy onto the cloud infrastructure user-created or acquired applications developed using platform tools supported by the cloud service provider. NOTE: platform tools may include programming languages and tools for application development, interface development, database development, storage and testing. The cloud service user does not manage or control the underlying cloud infrastructure, but has control over the deployed applications and possibly application hosting environment configurations.

The basic 3 Cloud service categories from NIST - 2

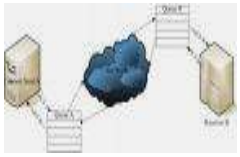
INFRASTRUCTURE
IaaS

Infrastructure as a service (IaaS): A category of cloud services where the capability provided by the cloud service provider to the cloud service user is to provision processing, storage, intra-cloud network connectivity services (e.g. VLAN, firewall, load balancer, application acceleration), and other fundamental computing resources of the cloud infrastructure where the cloud service user is able to deploy and run arbitrary application.
NOTE: The cloud service user does not manage or control the resources of the underlying cloud infrastructure but has control over operating systems, deployed applications, and possibly limited control of select networking components (e.g., host firewalls).

Other two service categories of telecommunication centric cloud ecosystems (ITU-T FG CC)

COMMUNICATIONS
CaaS

Communications as a Service (CaaS): A category of cloud services where the capability provided to the cloud service user is to use real time communication and collaboration services.
NOTE: Communication and collaboration services include voice over IP, instant messaging, video conferencing, for different user devices.



NETWORK
NaaS

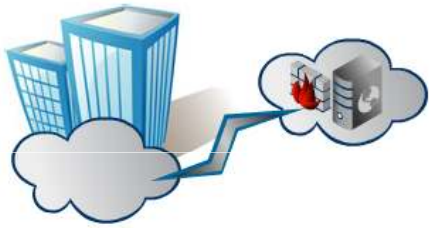
Network as a Service (NaaS): A category of cloud services where the capability provided to the cloud service user is to use transport connectivity services and/or inter-cloud network connectivity services.
NOTE: NaaS services include flexible and extended VPN, Bandwidth on demand etc.

Cloud deployment models from NIST

Private Cloud : cloud infrastructure is dedicated to a specific organization and not shared with other organizations. It may be shared in private way with other entities of the organization (e.g. a group and its affiliates). It may be managed by the organization or a third party. It may exist:

- on-premise
- externally hosted (used by one organization but hosted by a third party)

More expensive and more secure than a public cloud.



Public Cloud : cloud infrastructure is made available to the general public or large industry group, owned by an organization selling cloud service and acccessible via Internet. Customer has no visibility/control over where the cloud infrastructure is hosted. Ressources can be shared among several cloud clients.

Community Cloud : cloud infrastructure is shared among organizations of the same community which has shared concerns (e.g., mission, security requirements, policy). It may be managed by the organizations or a third party, and may exist on premise or off premise.

[**Virtual Private Cloud**: VPN-like Cloud]

Hybrid Cloud : cloud infrastructure is a composition of two or more clouds (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology enabling data and application portability. Examples: critical apps are hosted on a private cloud and the other apps (non critical, development and testing, temporary projects) on a public cloud; cloud bursting for load-balancing between clouds.

Cloud deployment types from ITU-T FG CC

It is assumed that all these cloud deployment types are able to support the different cloud service categories (SaaS, CaaS, PaaS, NaaS, IaaS)

Deployment types versus NIST models	Private IT Cloud Ecosystem	Public/ Community Cloud Ecosystem	Internet/ Telecom Cloud Ecosystem	Hybrid Enterprise Cloud Ecosystem	Hosted Enterprise Cloud Ecosystem	Virtual Network Operator Cloud Ecosystem
Private Cloud	X		X		X	
Public Cloud		X	X		X	X
Community Cloud		X	X			
Hybrid Cloud			X	X	X	

Cloud Computing market evolution: Gartner's forecast

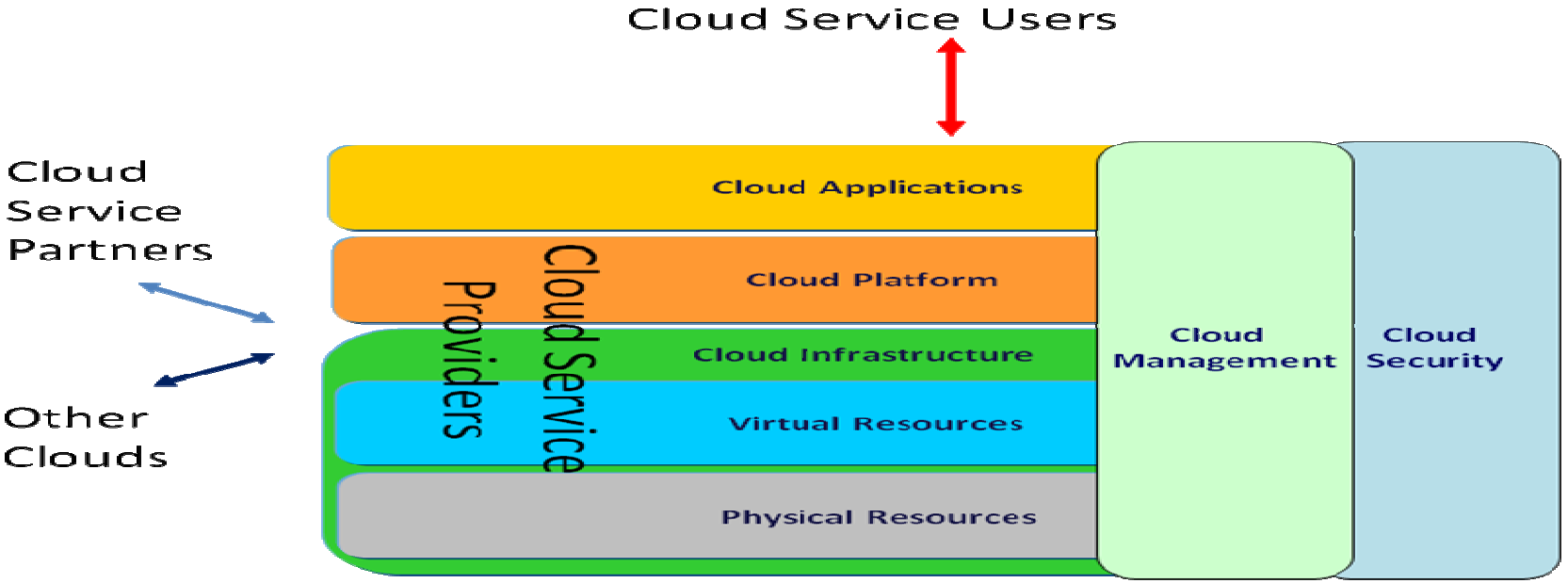
Phase 1 – 2007 to 2011
Time for pioneers and trailblazers.
Usage of cloud computing for "quick-hit, tactical opportunities where time to market and developer productivity outweigh long-term technical viability".
Focus on end user data and opportunities associated with social networks.

Phase 2 - 2010 to 2013
Time when the market becomes overcrowded, with a plethora of services, resulting in consolidation and exit of weaker players.
During this period, cloud computing will appeal to a broader range of companies, resulting in a more mainstream user base. By 2013, cloud computing will be the preferred choice for "architecturally simple" application development projects among global 2000 companies.

Phase 3 - 2012 to 2015
Market dominated by large vendors using a mix of proprietary technologies and cloud APIs.
Large players will build gateways and increase interoperability among clouds.
Growing concern over vendor lock-in and industry-wide push for an open source cloud software stack as an alternative to proprietary approaches. Cloud services will reach mainstream critical mass and commoditization. Priority on innovation, service stability and advanced cost management.

Telecommunication centric Cloud Ecosystem, cloud services and use cases

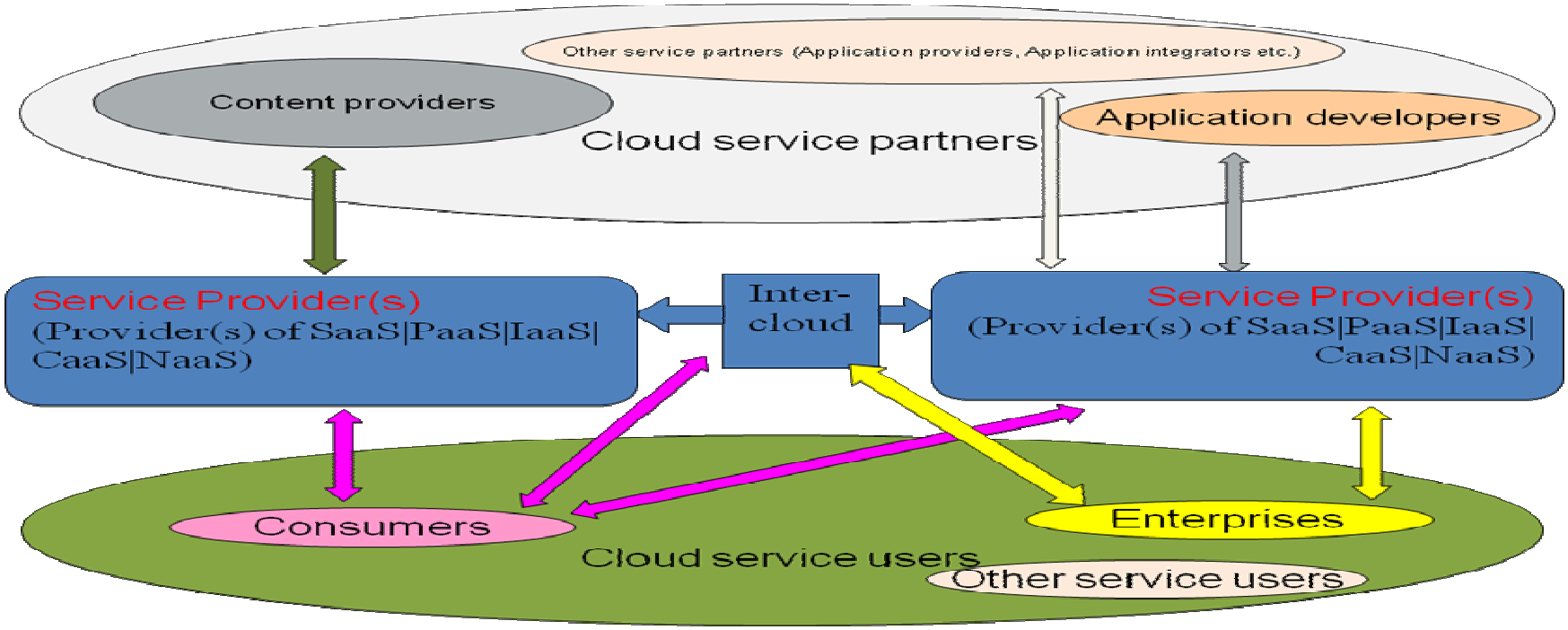
Cloud Ecosystem (from ITU-T FG CC) - 1



Conceptual diagram of the main technical components of a Cloud ecosystem

- **Cloud service user**: A user who consumes delivered cloud services.
- **Cloud service provider:** A provider who maintains delivered cloud services.
- **Cloud service partner**: *An entity who provides support to cloud service provider's service offer building.*

Cloud Ecosystem (from ITU-T FG CC) - 2



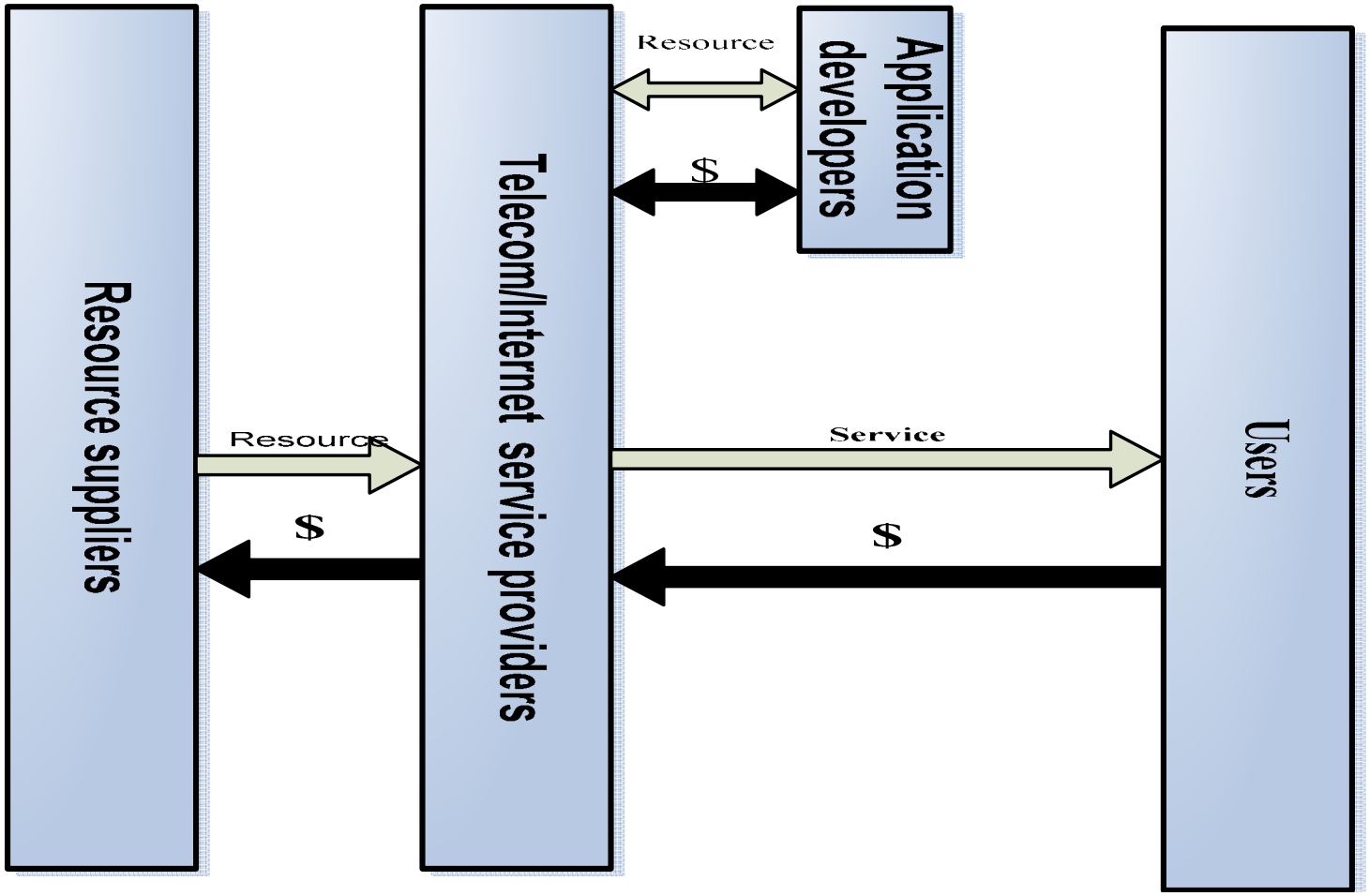
Key business roles in a Cloud Ecosystem

- **Top business roles:** Cloud service user, Cloud service provider, Cloud service partner, Inter-cloud
- **Distinct sub-roles of the Cloud service provider role:**
- Provider of cloud applications
- Provider of cloud platform
- Provider of cloud infrastructure
- **"Actor" is different from "role":** e.g. an actor playing the role of Cloud service provider may offer cloud services of one or more of the cloud service categories (covering one or more cloud provider 's sub-roles)

Actors of a Cloud Ecosystem

Business roles versus Actors	Application CSP	Platform CSP	Infrastructure CSP	Cloud Service Partners	Cloud Service Users	Inter-cloud
Telecom SP	X	X	X	X	(X)	X
Internet SP	X	X	X	(X)	(X)	X
3rd Party Provider	(X)	(X)	(X)	X	(X)	
User					X	

Business value chain in a cloud ecosystem



Example of value chain between actors of a cloud ecosystem

Telecom Service Providers and Cloud Computing

Cloud Computing is an opportunity for Telcos to counter drop of traditional revenues and decreasing mediation role

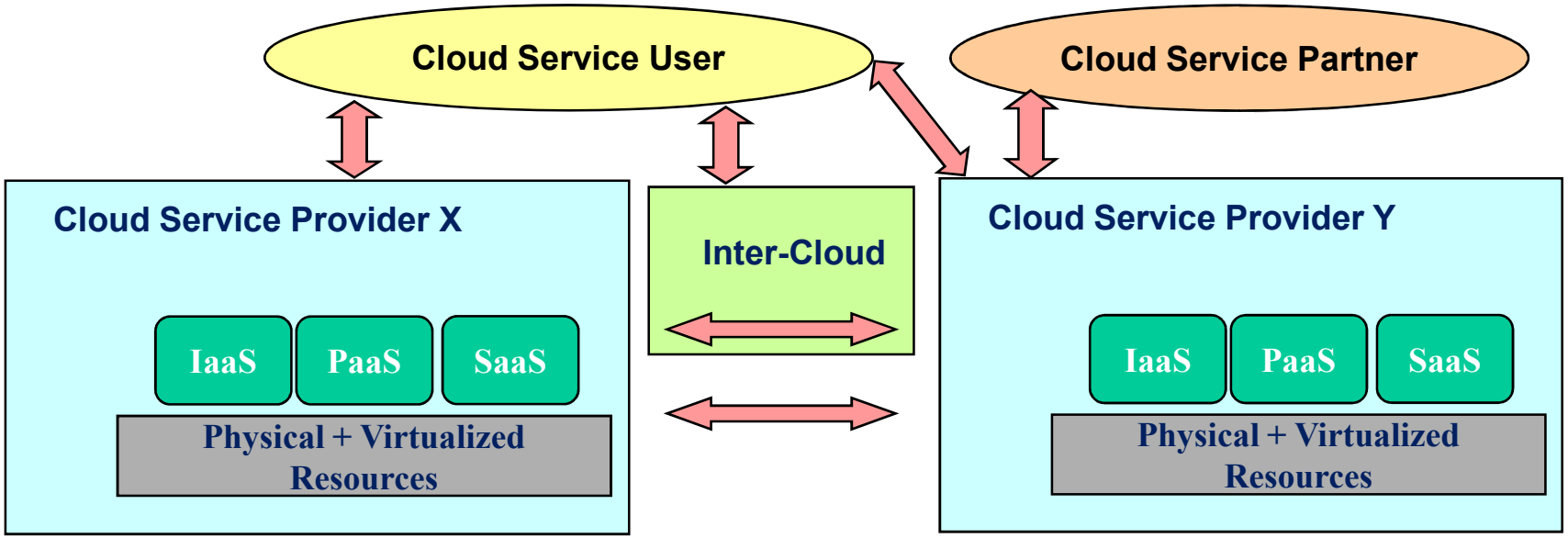
- to reduce growth opportunities of Web giants and major IT companies
- to influence developments in cloud ecosystems
- to act as federators among private, public and hybrid clouds

Telcos' positioning: build on their network assets

- traditional expertise in reliable and scalable operations, and strong end-to-end SLAs
- ongoing global intelligent network transformation ***with integration of SDP*** into ***highly secure and high performance architectures***
- component- based service architectures (NGN, SDP) can adapt smoothly to the cloud environment
- **telecom component manufacturers are moving into the cloud domain (and have actually to move to be part of the game)**

Forrester: ***Cloud services are the future of computing***
Yankee: ***Network (as development and deployment platform for services) is the future of business computing infrastructure***

Inter-cloud (from ITU-T FG CC)



- **Inter-cloud computing** allows on-demand reassignment of cloud resources including compute, storage and network, and transfer of workload through interworking of multi-national and multi-operator cloud systems.

- **Inter-cloud computing can be implemented in different manners:**
  - internal inter-cloud computing capability (i.e. inter-cloud peering)
  - inter-cloud service broker capability – external to cloud platform [e.g. virtual network operator with limited physical cloud resources]
    - **Service broker functions: intermediation/negotiation, aggregation/integration**
  - cloud federation capability (i.e. inter-cloud federation) : mutually trusted clouds logically join together by integrating their resources. [e.g. cloud service provider dynamically outsources resources to other provider in response to demand variations.]

Cloud Services (XaaS)

- **Cloud Service:** A service that is delivered and consumed on demand at any time, through any access network and using any connected devices using cloud computing technologies.

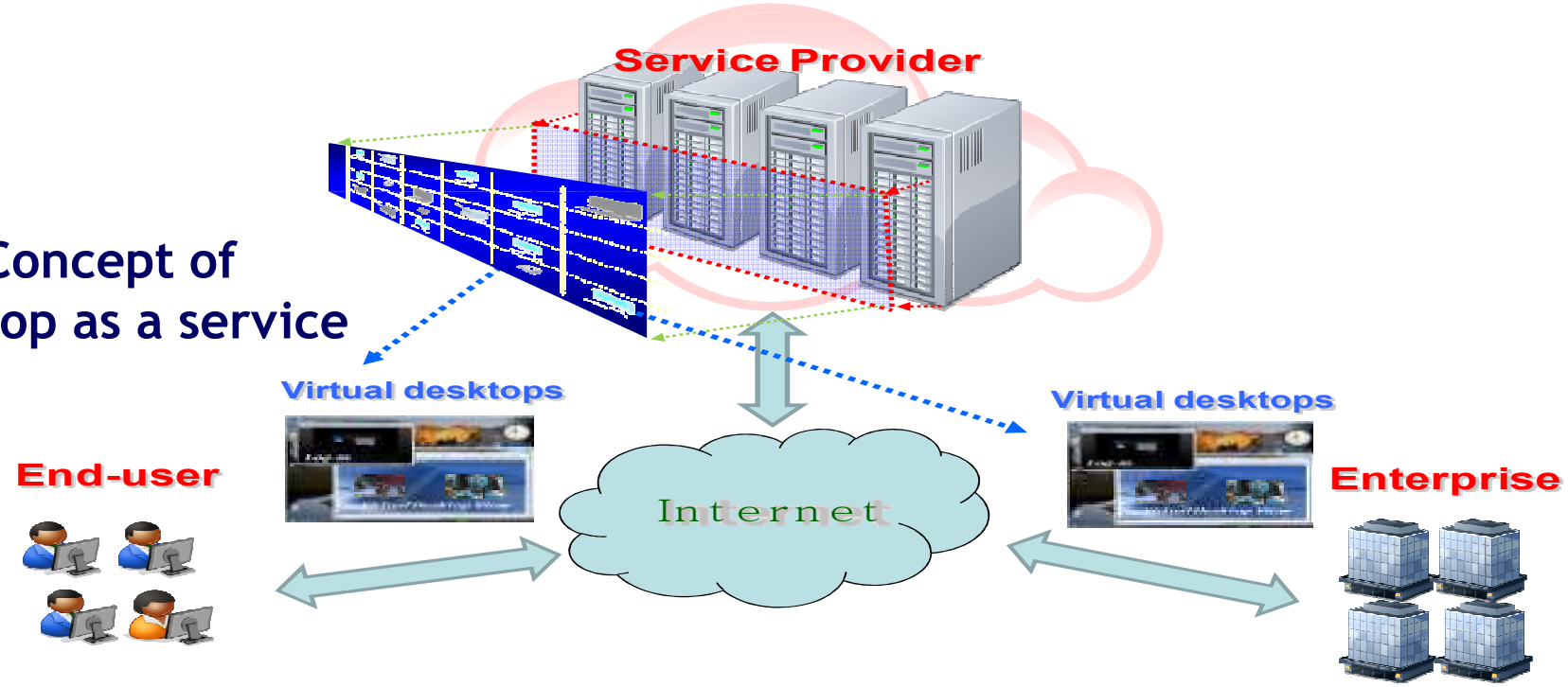
- A plethora of terms used for specific XaaS offerings
  - e.g. Database-aaS, Storage-aaS, Security-aaS, Integration-aaS, Content-aaS, BPM/Process-aaS etc.

- Some relevant cloud services identified by the ITU-T FG CC [table below]

	SaaS	PaaS	IaaS	NaaS	CaaS
Desktop as a Service			X		
Service Delivery Platform as a Service	X	X			
Cloud Communication center	X				X
(Flexible and extended) VPN				X	
Bandwidth on demand				X	

Relevant services/use cases: Desktop as a Service - 1

Concept of
Desktop as a service



Cloud service users use virtualized desktops from a cloud service provider in the form of outsourcing.

A remote central server retains the virtualized desktops, instead of running and maintaining desktop products in local storage of remote client, and all used applications and data are kept and run centrally.

Based on application streaming and virtualization technology, service users can access operating system and applications through a completely hosted system.

Relevant services/use cases: Desktop as a service - 2

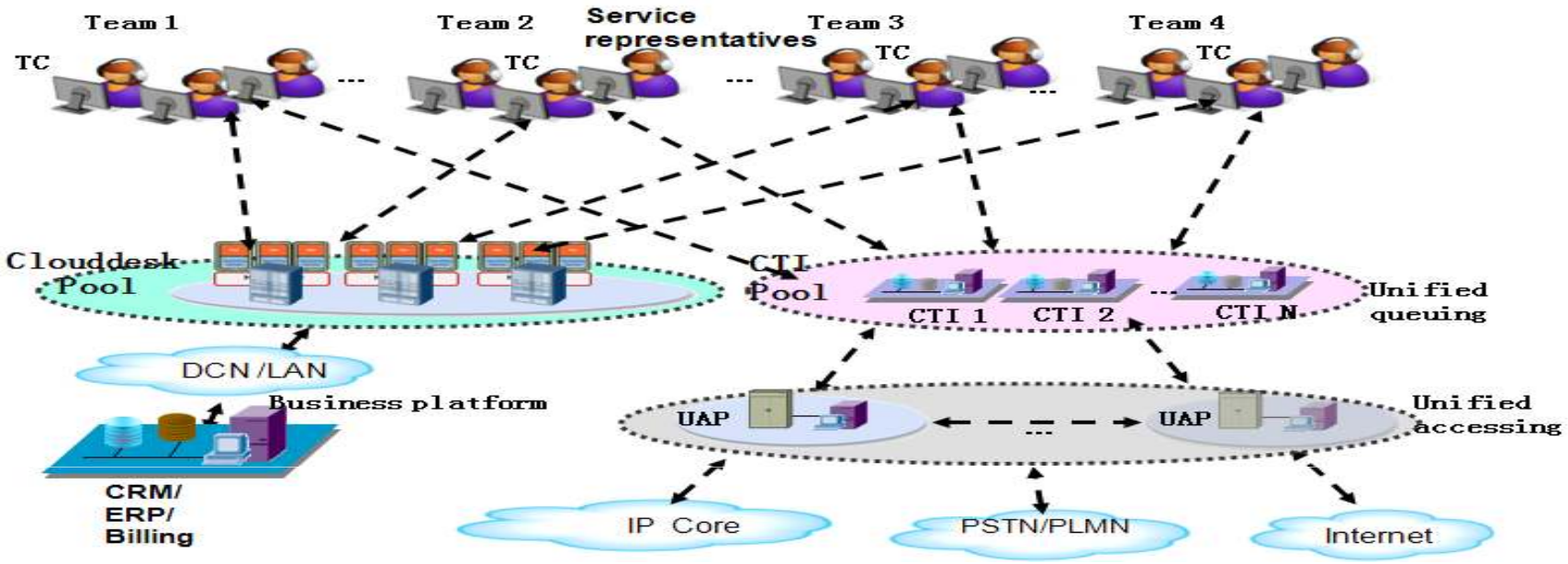
DaaS benefits

- Management and security enhancement
- Reduced TCO (Total cost of ownership)
- Rich client experience preservation
- Separation of service provider and user responsibilities

DaaS technical characteristics

- Presentation virtualization: separation of application's user interface from application logic and presentation of user interface in a location different from that of the application logic processing.
- Desktop Virtualization separation of the personal computer desktop environment from the physical machine using a client-server computing model. The client may use a different hardware architecture and operating system than those used by the projected desktop environment.
- Virtual Desktop Infrastructure (VDI): a server computing model enabling desktop virtualization, encompassing the hardware and software systems required to support the virtualized environment.

Relevant services/use cases: Cloud communication center

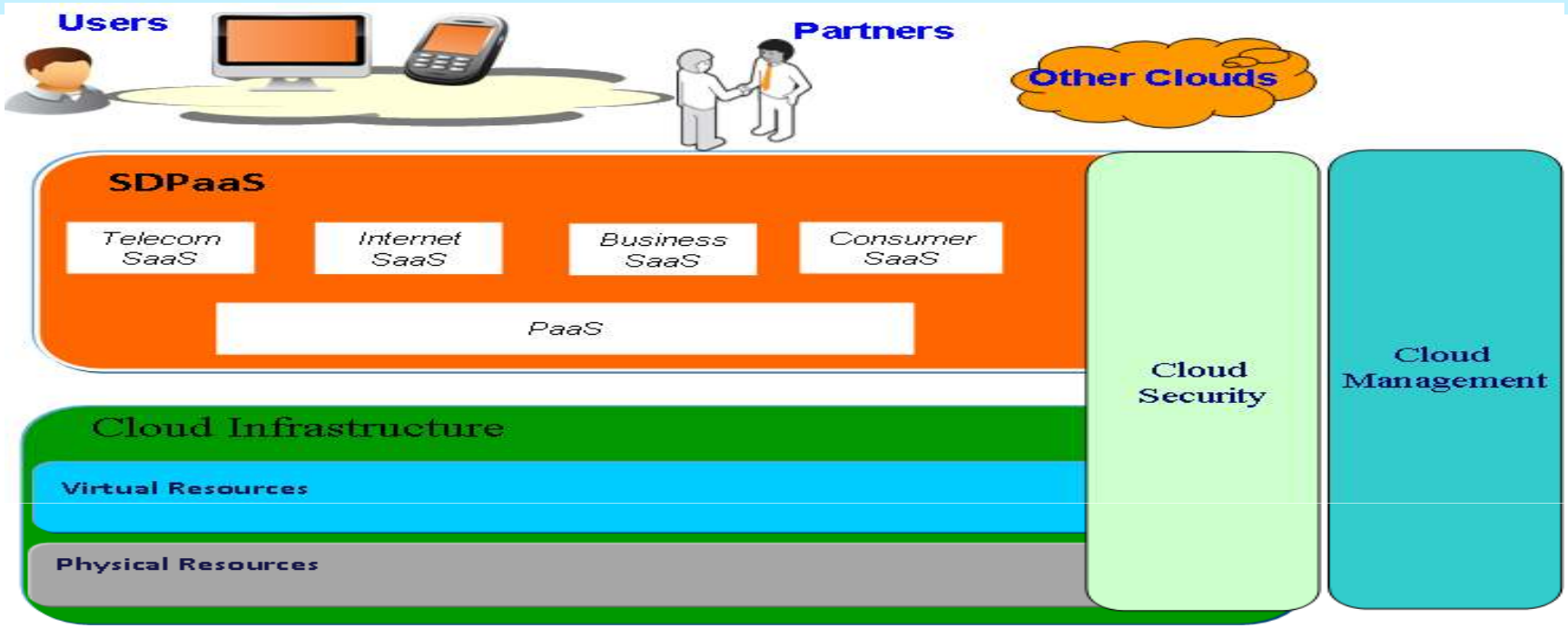


Enabling advanced features for the customer-enterprise interaction using the communication and management capabilities provided by a cloud based telecommunication infrastructure.

Examples of capabilities:

- management of resources in the cloud (e.g. customer, enterprise agent, media storage, content, transport and communication resources);
- sharing of enterprise applications common among different enterprises;
- application charging to enterprises on a per-resource usage basis.

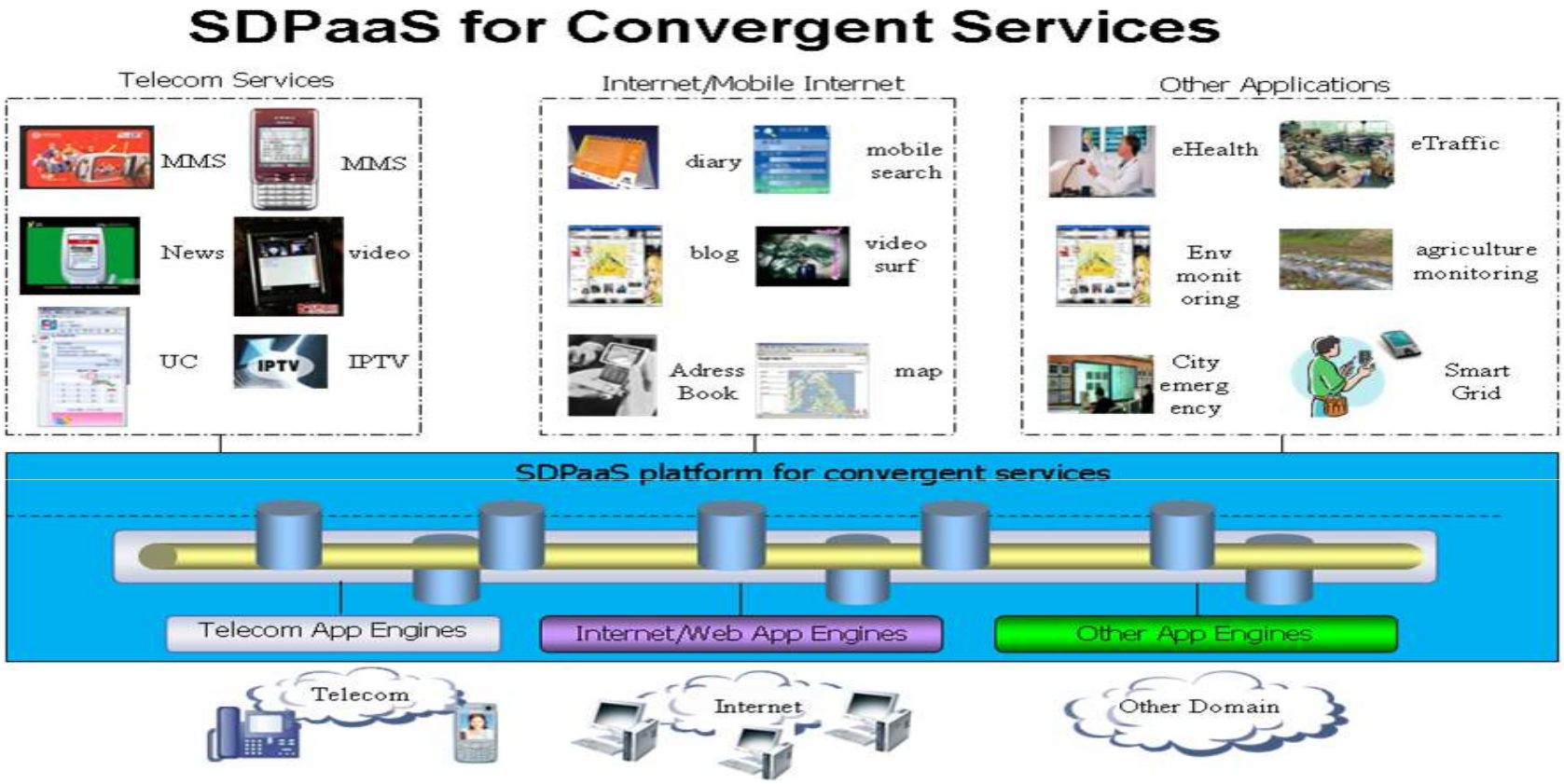
Relevant services/use cases: SDP as a Service - 1



Service Delivery Platform as a Service (SDPaaS): The capability provided to the cloud service user to use Service Delivery Platform (SDP) functionalities and applications provided by a cloud service provider and the capability provided to a cloud service provider to deploy, control and manage SDP functionalities.
NOTE - SDPaaS may be implemented via utilization and intermediation of different basic SaaS and Paas cloud services.

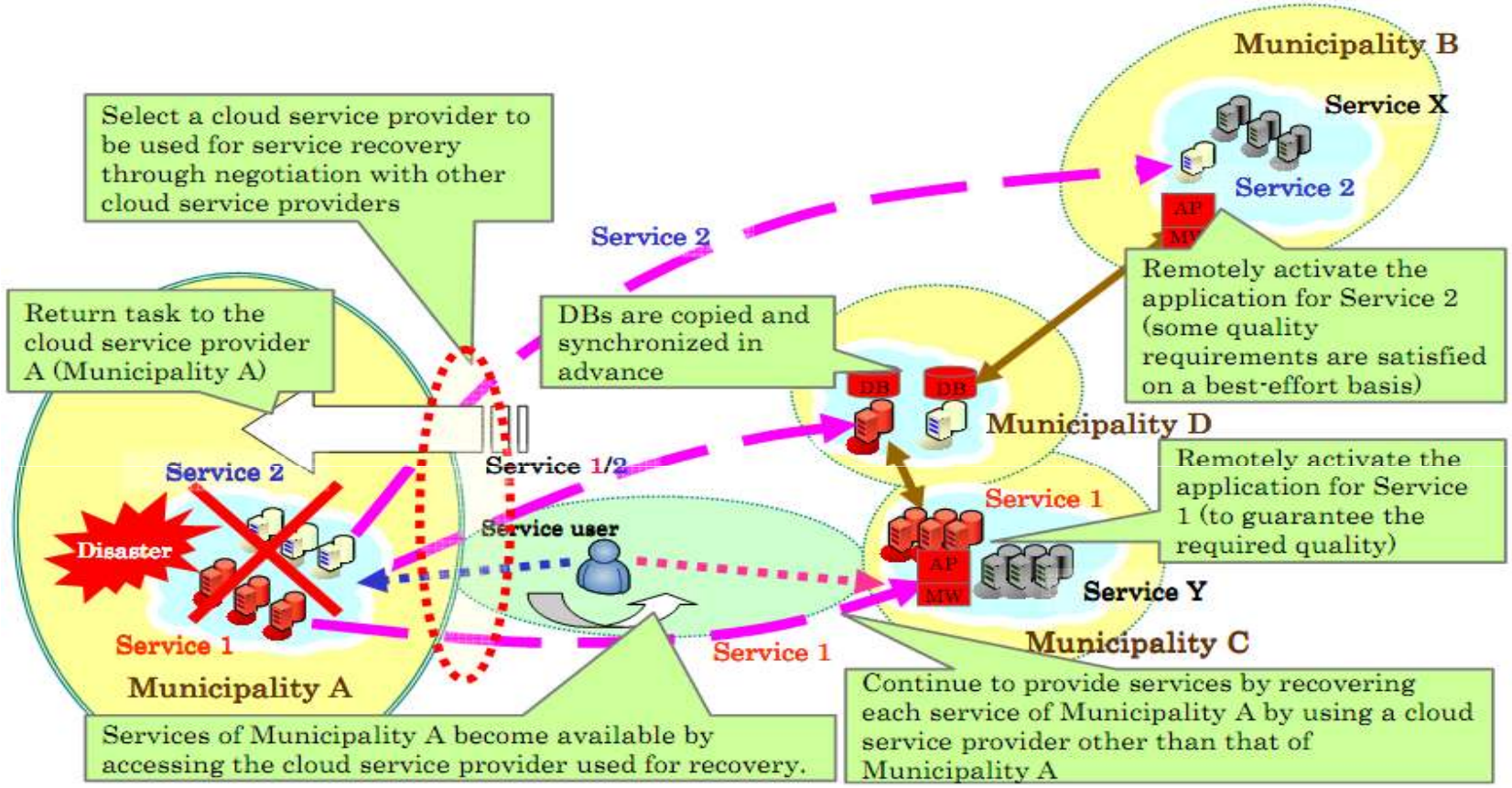
Service Delivery Platform (SDP): System architecture/environment enabling efficient creation, deployment, execution, orchestration and management of one/more service classes.

Relevant services/use cases: SDP as a Service - 2



- Cloud service users invoke SDPaaS services in the cloud through open APIs
- The cloud offers all applications which can be offered by traditional SDPs plus innovative end to end convergent services across multiple domains

An Inter-Cloud use case: guaranteeing availability in the event of a disaster or large-scale failure



- Leasing of other providers' resources to ensure service availability.
- Available resources of other providers autonomously discovered and reserved.
- Network connections among interworking clouds dynamically established and service related data transferred to the leasing cloud.

Cloud Computing standardization and ITU-T FG CC

Cloud Computing: benefits and challenges

Benefits

- CAPEX and OPEX reduction
- Flexible model of usage and pay-per-use
- Hidden complexity and simplicity of provisioning (but may be more complex in some cases than a closed environment)
- Efficiency of standardized services
- Accelerated innovation (PaaS clouds as business ecosystems)
- Scalability of the cloud model

But also challenges

- Service availability and reliability
- Security and privacy (especially for public clouds)
- Performance unpredictability, limits of operating over a network
- SLA management, efficient computing and comm. resource allocation
- Manageability, low customization, user's troubleshooting
- Respect of legal and contractual items (e.g. data physical location), new licensing mechanisms
- Organizational issues (resistances to externalization, in-house IT integration)
- Lack of standards (e.g. for high-level abstract description languages for apps and customer's business requirements, APIs, service portability, service deployment across cloud providers, cloud platforms' interoperability etc.)

Current standardization efforts on Cloud Computing

Numerous SDOs work on cloud computing from different perspectives

ITU-T FG CC work areas	Ecosystem, use cases, Requirements	Functional Reqts & Ref. Architecture	Security, Audit & Privacy	Service & Resource Management	Infrastructure and Network-enabled	Intercloud procedure, interfaces	User Accessibility, Eco- friendly
ITU-T SGs (now SG13, SG17)	(X)	(X)	X	X	(X)	(x)	
ISO/IEC JTC 1	X		X				
NIST	X	X	X				
ETSI	X						
CSA		X	X				
DMTF	X	X	X	X	X		
GICTF	X			X	X	X	
OGF				X			
SNIA				X			
TMF				X			
IETF	X			X	X	X	
OASIS			X	X			
IEEE						X	
ATIS				X		X	
Open Group	X	X		X			
Use Case Group	X	X	X				
ODCA	X		X		X		

ITU-T FG Cloud Computing - 1

Launch in June 2010, end in Dec 2011

Key tasks

- identify potential impacts on standards development and priorities for standards needed to promote and facilitate telecommunication/ICT support for cloud computing
- investigate the need for future study items for fixed and mobile networks in the scope of ITU-T
- analyze which components would benefit most from interoperability and standardization
- familiarize ITU-T and standardization communities with emerging attributes and challenges of telecommunication/ICT support for cloud computing
- analyze the rate of change for cloud computing attributes, functions and features for the purpose of assessing the appropriate timing of standardization of telecommunication/ICT in support of cloud computing
- collaboration with worldwide cloud computing communities (e.g., research institutes, forums, and academia) including other SDOs and consortia

Leadership team

- Chairman: Mr. Victor Kutukov (Russia)
- 6 Vice-chairmen from FT/Orange, KDDI, ZTE, Cisco, Microsoft, ETRI

ITU-T FG Cloud Computing - 2

Working areas

- **WG1: Cloud computing benefits & requirements**
  WA 1-1 Cloud definitions, ecosystem & taxonomies
  WA 1-2 Uses cases, requirements & architecture
  WA 1-3 Cloud security
  WA 1-4 Infrastructure & network enabled cloud
  WA 1-5 Cloud services & resource management, platforms and middleware
  WA 1-6 Cloud computing benefits & first requirements from ICT perspectives

- **WG2: Gap analysis and roadmap on cloud computing standards development in ITU-T**
- WA 2-1 Overview of cloud computing SDOs activities
  WA 2-2 Gap analysis & action plan for development of relevant ITU-T cloud standards

ITU-T FG Cloud Computing - 3

1. Introduction to the Cloud Ecosystem: definitions, taxonomies, use cases, high level requirements and capabilities (75%)
2. Functional Requirements and Reference Architecture (70%)
3. Infrastructure & Network enabled Cloud (80%)
4. Cloud Computing Security (90%)
5. Cloud Computing Benefits from Telecommunication/ICT perspectives (90%)
6. Cloud Resource Management Gap Analysis (initial draft)
7. Overview of SDOs involved in Cloud Computing (not applicable)

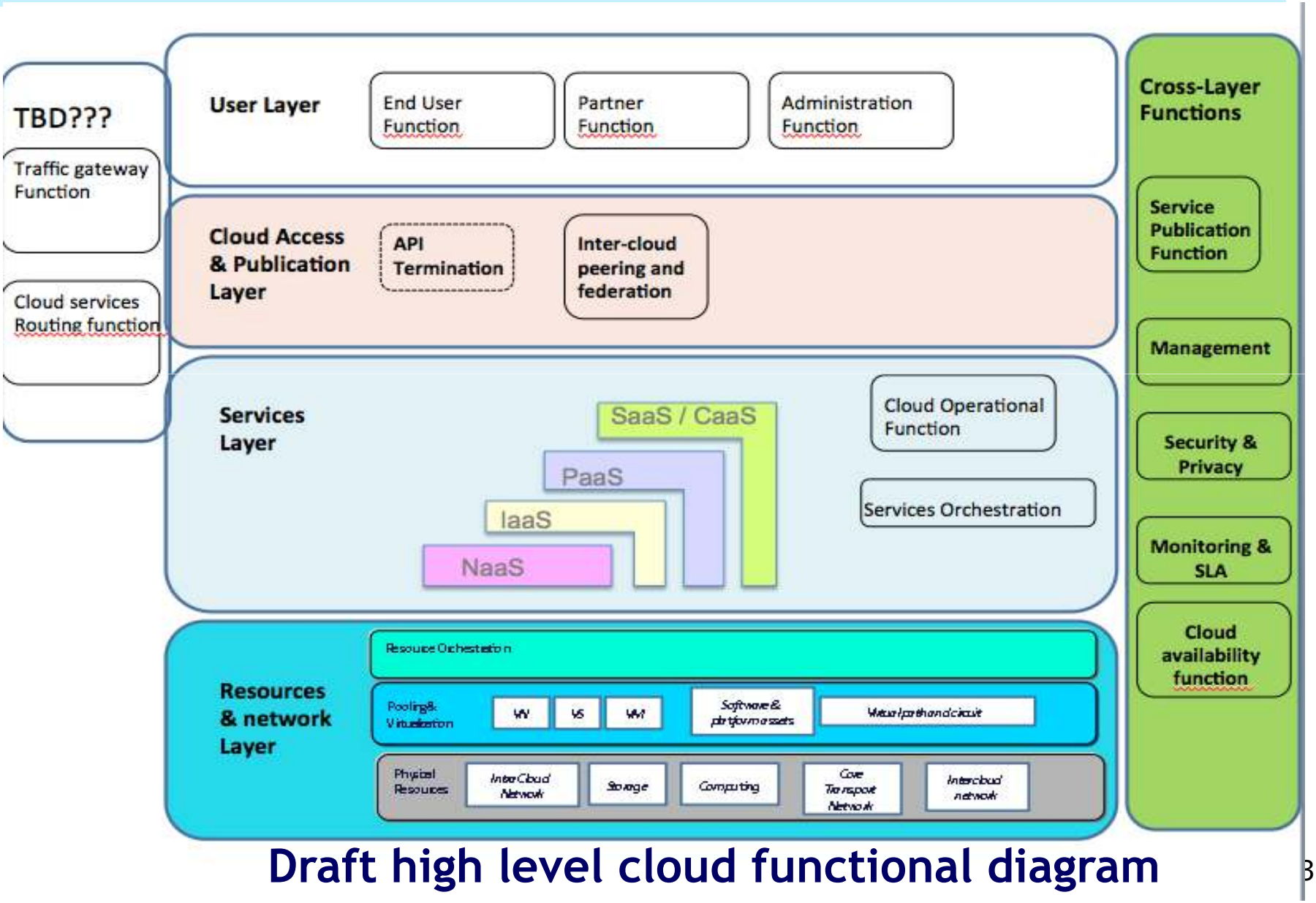
NOTE: (completion %)

Other details on ITU-T FG CC technical work (Functional Architecture, Network Infrastructure)

Cloud Functional Reference Architecture: an ongoing work in ITU-T FG CC - 1

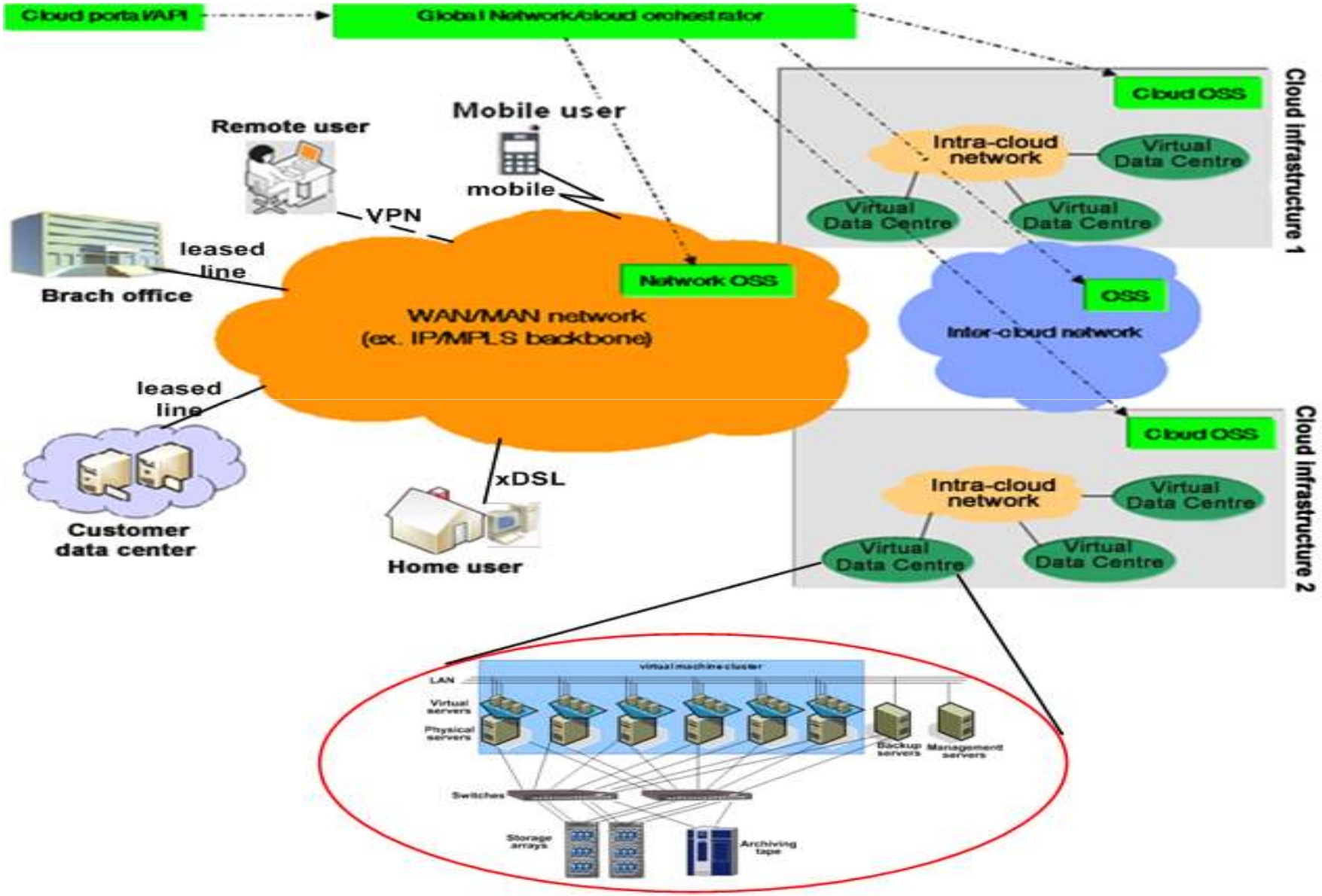
Cloud Layering Framework

Cloud Functional Reference Architecture: an ongoing work in ITU-T FG CC - 2



Draft high level cloud functional diagram

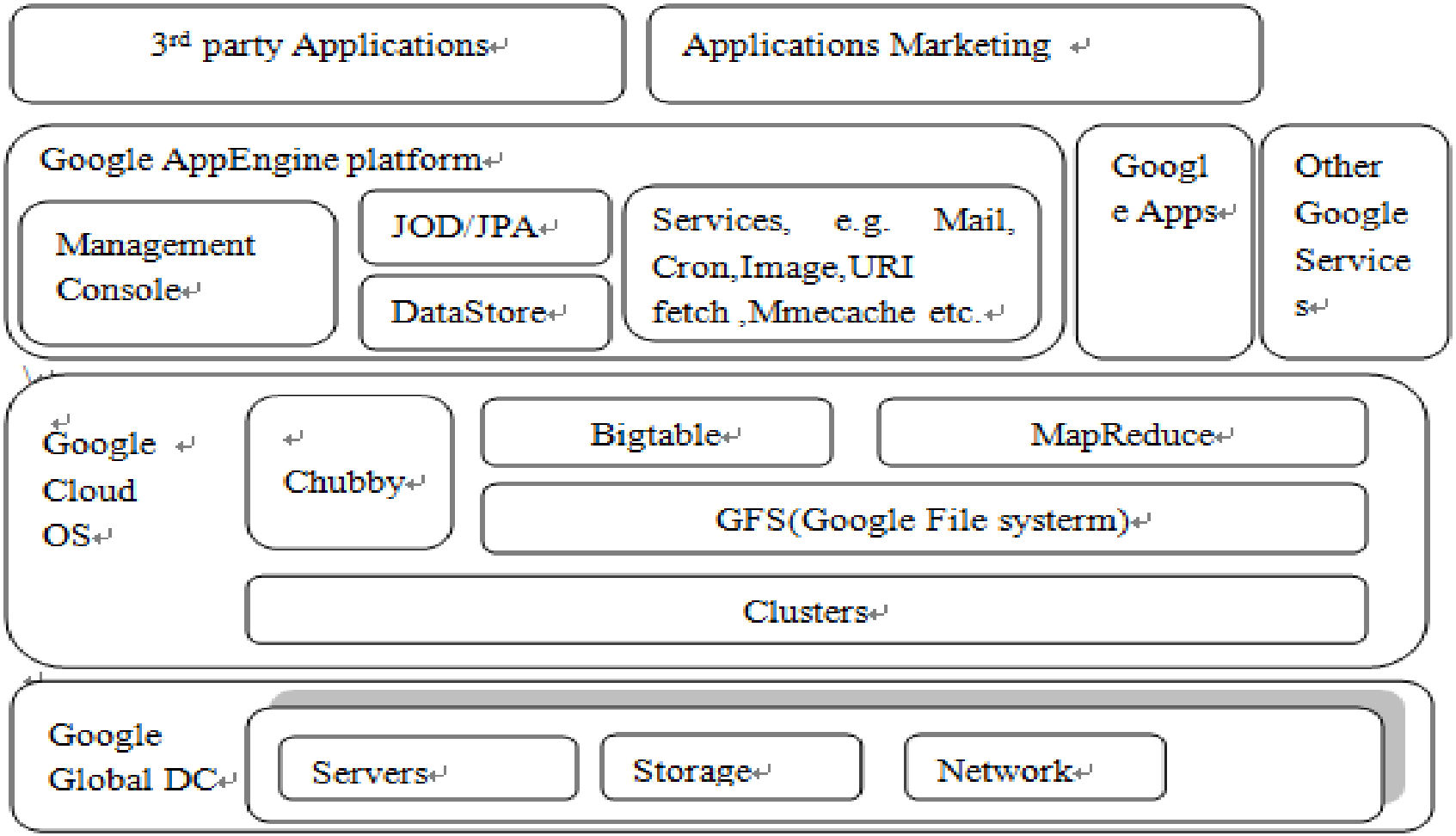
Network infrastructure of a Cloud Ecosystem: network model



Network infrastructure of a Cloud Ecosystem: network components

- **Intra-cloud network:** the network used to connect local cloud infrastructures, such as data center LAN used to connect servers, storage arrays and L4-L7 service devices (firewalls, load balancers, application acceleration devices, IDS/IPS...).
- **Inter-cloud network**: the network used to interconnect distinct cloud infrastructures (owned by same or different cloud providers).
- **Core transport network (WAN/MAN)**: the network used by customers to access and consume cloud services deployed within the cloud service provider's infrastructure.

Reference functional models : market examples from leading Internet providers - 1



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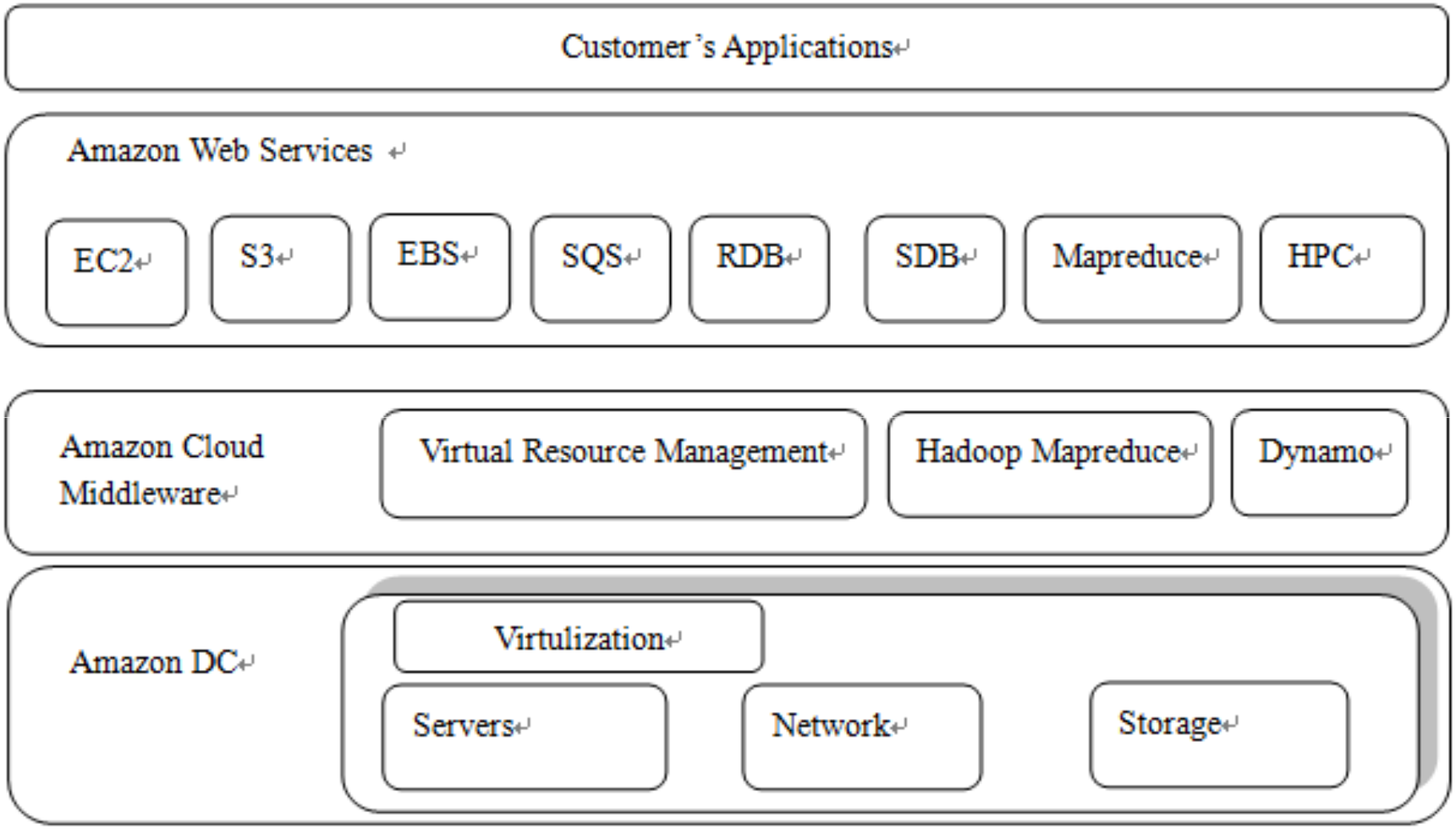
Reference functional models : market examples from leading Internet providers - 2



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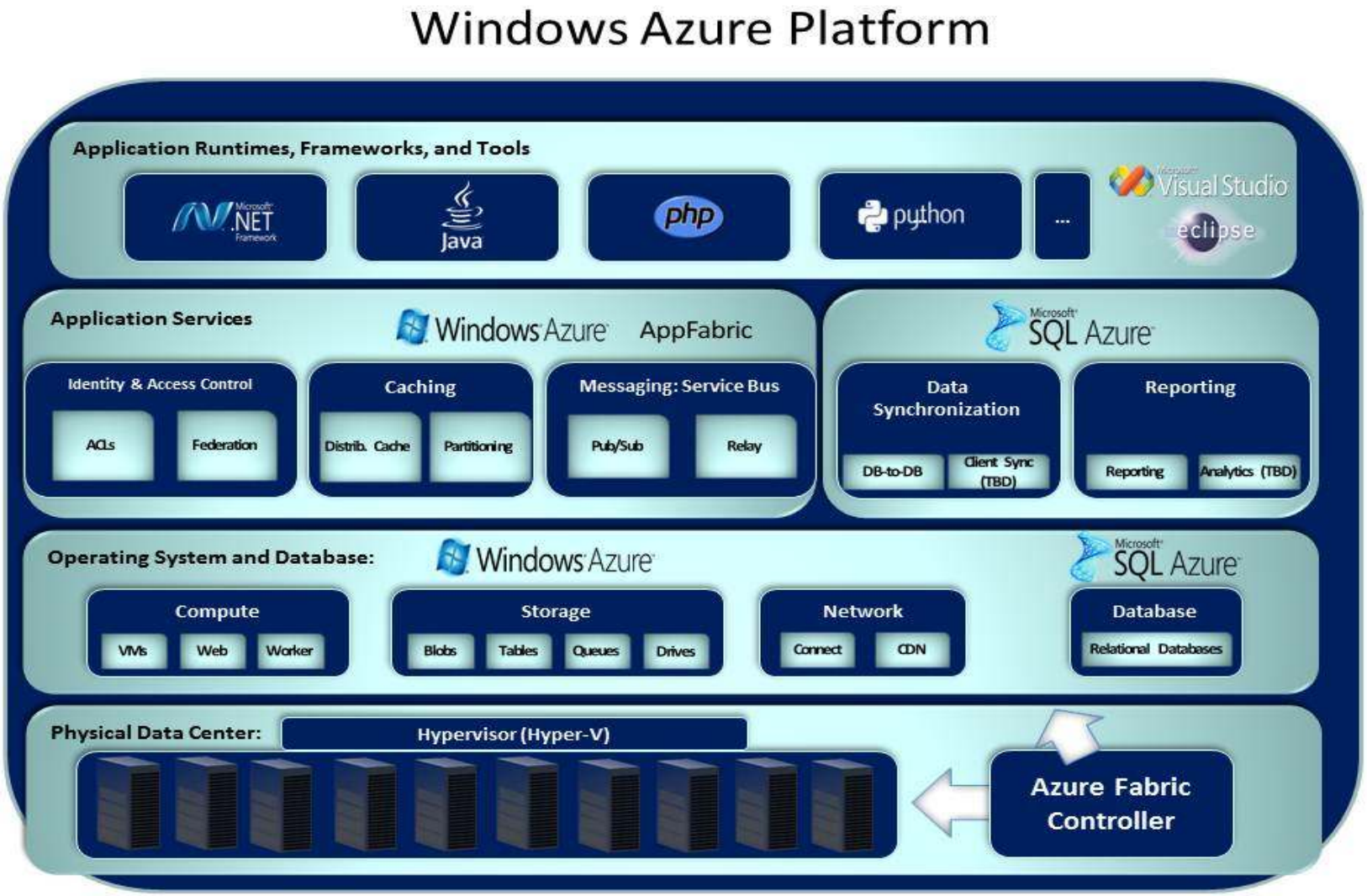
Reference functional models : market examples from leading Internet providers - 3



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Conclusion

- Cloud Computing is an emerging paradigm in Telecommunication infrastructures destined to growing success
- Cloud ecosystems bring opportunities for Telecom providers (but must act quickly to be better positioned in the competition) as well for other existing/new market actors
- Benefits are identified, together with challenges including current lack of standardization
- Numerous SDOs, Forums and Consortia are currently involved in standardization of cloud computing technology for telecommunications from different perspectives
- ITU-T has recognized the strategic importance of such topic and launched in June 2010 the Focus Group on Cloud Computing to accelerate the required standardization roadmap setup

Thank you for your attention

Questions ?