ICT cloud-based platform and mobility services available, universal and safe for all users

D3.5.1 Smart Mobility Services and cooperative and sensor-based mobility applications in a cloud-computing environment

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Contents

List of Figures

List of Tables

List of Abbreviations

<Abbreviation>	<Explanation>
App	Software application
CRM	Customer Relationsip Management
DCaaS	Data Computing as a Service
Dev tool	Development tool
DSaaS	Data Storage as a Service
Exr	Execution resource
IaaS	Infrastructure as a Service
NIST	National Institute of Standards and Technology of U.S. Department of Commerce
PaaS	Platform as a Service
QoS	Quality of Service
SaaS	Software as a Service
VLAN	Virtual Local Area Network
Vm	Virtual machine
VPN	Virtual Private Network

Executive Summary

Various interpretations and definitions of "cloud computing" and / or "clouds" exist. The two most recognized interpretations of this concept are those given by NIST (National Institute of Standards and Technology of U.S. Department of Commerce) and by the European Commission Expert Group.

According to NIST [1] "Cloud computing is a model for enabling 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".

Instead the European Commission Expert Group definition [2] of cloud computing is: "a cloud is an elastic execution environment of resources involving multiple stakeholders and providing a metered service at multiple granularities for a specified level of quality (of service). To be more specific a cloud is a platform or infrastructure that enables execution of code (services, applications, etc.), in a managed and elastic fashion, whereas "managed" means that reliability according to pre-defined quality parameters is automatically ensured and "elastic" implies that the resources are put to use according to actual current requirements observing overarching requirement definition – implicitly, elasticity includes both up- and downward scalability of resources and data, but also load-balancing of data throughput."

MoveUs refers to NIST definition of cloud computing, reported in Table 1, properly integrated with another service model (DCaaS) as described later in this document.

Service Models	Definition [1]
IaaS: Infrastructure as a Service	The capability provided to the consumer 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.
DCaaS: Data Computing as a Service	Same capabilities as IaaS with additional Big Data and real-time processing services, in order to execute data-mining techniques and advanced algorithms.
PaaS: Platform as a Service	The capability provided to the consumer to deploy onto the cloud infrastructure consumer-created applications using programming languages and tools

	supported by the provider (e.g., java, python, .Net).
SaaS: Software as a Service	The capability provided to the consumer to use the provider's applications running on a cloud infrastructure and accessible from various client devices through a client interface such as a Web browser (e.g., web-based email).

Table 1 Cloud Computing Service Models

Clouds may be hosted and employed in different fashions, depending on the use case and on the business model of the provider, as described in Table 2

Service Model	Definition
Private Cloud	The cloud infrastructure is operated solely for an organization. It may be managed by the organization or a third party and may exist on premise or off premise.
Community Cloud	The cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns (e.g. mission, security requirements, policy, and compliance considerations). It may be managed by the organizations or a third party and may exist on premise or off premise.
Public Cloud	The cloud infrastructure is made available to the general public or a large industry group and is owned by an organization selling cloud services.
Hybrid Cloud	The 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 that enables data and application portability (e.g. cloud bursting to balance spikes).

Table 2 Cloud Computing Deployment Types

The MoveUs value chain identified and shared among partners is depicted in the following figure:

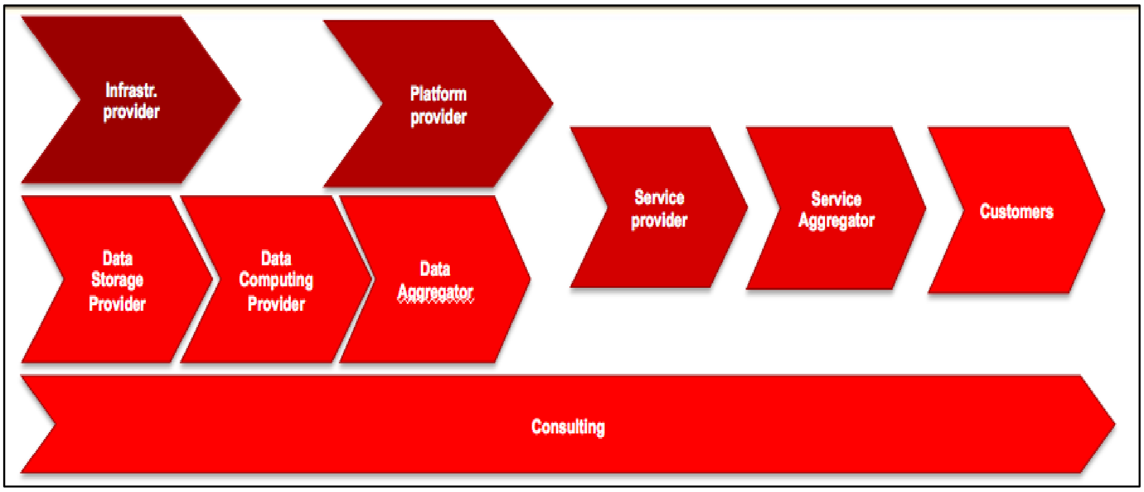

Figure 1 – MoveUs Cloud Computing Value Chain

The document then describes the four MoveUs service models through the concept of business model canvas introduced by Osterwalder in the early 2000s [3]: "A business model describes the rationale of how an organization creates, delivers, and captures value"; the business model canvas is a graphical representation of the business model and describes through nine basic building blocks the logic of how a company intends to make money. The nine blocks cover the four main areas of a business: customers, offer, infrastructure and financial viability.

The business model is like a blueprint for a strategy to be implemented through organizational structures, processes, and systems.

The main outcomes of the canvass exercise are described in Table 3.

Service Models	Main Outcomes
IaaS: Infrastructure as a Service	This business model requires higher investment and fixed cost compared to the other service models.
DCaaS: Data Computing as a Service	It is similar to the IaaS business model providing both storage capability and computing resources. **The DCaaS differs from the IaaS in improving these capabilities** in order to cover Big Data and real-time processing services and to execute data-mining techniques and advanced algorithms.
PaaS: Platform as a Service	It shows very low fixed cost due to absence of investment in infrastructure resources. In this model **the key aspects are the tool developments** to allow the customers to build applications and the training and support.
SaaS: Software as a Service	It focuses more on understanding market needs, developing applications and sales. This is reflected in

	the cost structure where there are fixed costs (as marketing), variable cost (e.g. platform cost) and semi-variable costs (research & development, where development are more variable expenses). **This model differs from the others also in terms of revenue stream, where a significant part comes from advertising.**

Table 3 Cloud Computing Service Models Canvas: main outcomes

A city can become a "Smart City" in transportation if tackles one or more of the four main challenges related to intelligent mobility: **congestion reduction, environmental impact reduction of transportation, safety improvement and journey predictability**; each city can respond to these challenges in different ways according to its needs; there is not a unique solution that "fits all" but various services and mobility applications are combined to finally obtain a "Smart Mobility".

These services have been bundled by main vendors into the so called Smart Transportation Services, generally composed of:

- Traffic Management Systems
- Integrated Supervision Systems
- Parking Management & Guidance Systems
- Ticketing Management Systems
- Passengers Information Systems

The main vendors offering Smart Transportation Services are: Accenture, Affiliated Computer Services, Alstom, Cisco, Cubic, GE Transportation, Ibm, Indra, Kapsch, Siemens, etc.

They can deploy a Smart System in multiple ways, covering the needs of a wide range of cities:

- for larger cities, services can be deployed as **on-premise solution** to give transportation authority managers complete flexibility over its configuration and operation;
- for medium-size cities or for regional transportation authorities, services can be deployed as a **shared service** so that many jurisdictions can collaborate on traffic management across a broad metropolitan area;
- for smaller cities or cities with modest transportation departments, the offer **cloud**-**enabled capabilities** (in form of **Paas**/**SaaS**) can free a city from the time and expenses of deploying the on-premise solution.

1 Introduction

This Deliverable D3.5.1 is the fifth deliverable expected for **WP3 – Analysis, Specification and Design of the MoveUs Architecture and City Services.**

The **objectives of WP3** are:

- To define the data models and ontologies relevant for MoveUs operation.
- To define the high-level architecture for the MoveUs Cloud-based platform and its functional specifications in detail.
- To provide detailed specifications and design for the set of services to be provided in MoveUs pilots.
- To identify the data security and privacy issues to be taken into account in the MoveUs architecture and include them in the definition of the platform and services.
- Develop innovative business models determining the users' willingness to pay for the uptake of MoveUs services

To achieve these objectives, **WP3 is divided in five tasks**, as follows:

- **T3.1**: Data models, object models and ontology definition of the user and the road
- **T3.2**: Specification and architecture design of the MoveUs cloud-based platform
- **T3.3**: Specification and design of the MoveUs city services
- **T3.4**: Data Security & Privacy
- **T3.5**: Cloud-Computing Business Models for Smart Mobility

This Deliverable describes the first outcomes of the Task 3.5 as follows:

Task and Key Objectives	Reference
Cloud Computing Definitions	Chapter 2
Cloud Computing Service Models: definitions and examples	Chapter 3
Cloud Computing Deployment types: definitions and examples	Chapter 4
MoveUs Cloud Computing value chain: description of the value chain chosen by MoveUs	Chapter 5
MoveUs Cloud Computing Business Models Canvas based on the methodology "Business Model Generation"	Chapter 6
Cloud Computing in Smart mobility services and cooperative and sensor-based mobility applications: definitions and offering	Chapter 7

Table 4 Reference Chapters

2 Cloud Computing Definitions

Various interpretations and definitions of "cloud computing" and / or "clouds" exist. The two most recognized interpretations of this concept are those given by NIST (National Institute of Standards and Technology of U.S. Department of Commerce) and by the European Commission Expert Group.

According to NIST "Cloud computing is a model for enabling 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 [1]

This cloud model promotes availability and is composed of five essential characteristics [1]:

- *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'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, 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 datacentre). Examples of resources include storage, processing, memory, and network bandwidth.
- *Rapid elasticity.* Capabilities can be rapidly and elastically provisioned, 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 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.

Instead the European Commission Expert Group definition of cloud computing is: "a cloud is an elastic execution environment of resources involving multiple stakeholders and providing a metered service at multiple granularities for a specified level of quality (of service). To be more specific a cloud is a platform or infrastructure that enables execution of code (services, applications, etc.), in a managed and elastic fashion, whereas "managed" means that reliability according to pre-defined quality parameters is automatically ensured and "elastic" implies that the resources are put to use according to actual current requirements observing overarching requirement definition – implicitly, elasticity includes both up- and downward scalability of resources and data, but also load-balancing of data throughput." [2]

As stated in D2.1 Current Infraestructures, mobility requirements and information sources par. 2.3.3 MoveUs refers to NIST definition, properly integrated as described later in this document, as the reference interpretation of Cloud Computing, given the greater consensus in the literature as the most comprehensive, referred and widely accepted definition.

3 Cloud Computing Service Models

3.1 Introduction

In this chapter the three basic service models according to NIST and the European Commission Expert Group are defined with some examples:

- **Cloud Software as a Service (SaaS)**
- **Cloud Platform as a Service (PaaS)**
- **Cloud Infrastructure as a Service (IaaS)**

3.2 Cloud Software as a Service (SaaS)

The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure and accessible from various client devices through a client interface such as a Web browser (e.g., web-based email). The consumer does not manage or control the underlying cloud infrastructure, network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings. Examples of this service model are Google Docs office suit or CRM software of salesforce.com.

NIST [4] describes also the dynamics of an interaction between clients of a typical consumer and the SaaS cloud service through a simplified model:

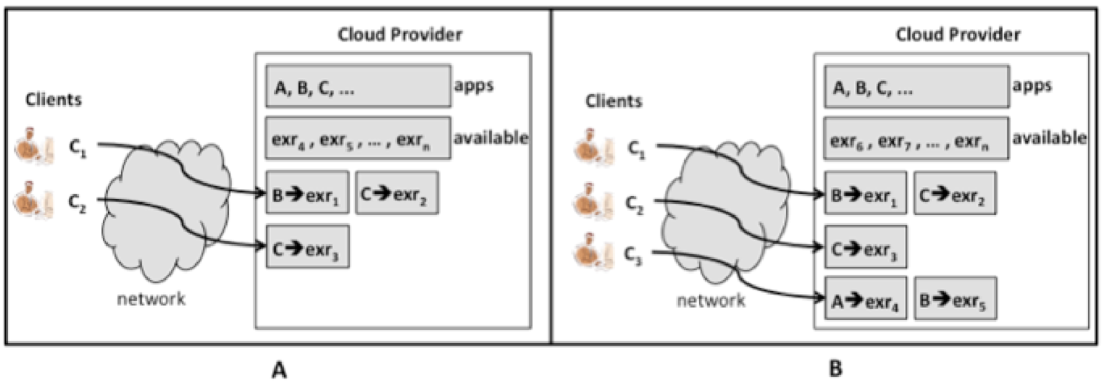

Figure 2 - SaaS Consumer/Provider Interaction Dynamics

The cloud provider possesses an inventory of software applications ("apps" in the figure) that it is offering to clients for use over the network. In addition, the cloud provider possesses (or can rent) application execution resources (labelled "exr" in the figure). In Figure 2.A, client C1 is currently using two applications, B and C. To execute the apps for client C1, the cloud provider has allocated two execution resources, exr1 and exr2, with exr1 supplying the processing power and other resources to run the B application (denoted by B→exr1 in the figure), and exr2 supplying the processing power and other resources to run the C application (denoted by C→exr2 in the figure). An execution resource might be, e.g., a physical computer, a virtual machine, or a running server program that can service client requests, start a virtual machine, or even rent computing cycles and storage from another organization. Similarly, client C2, is using one application, C, which is supported by execution resource exr3. Note that the same application (C in this case) can be rented out to multiple clients at the same time, as long as the cloud provider can marshal the execution resources to support the application. As shown in Figure 2.B, when an additional client requests applications from the cloud, the cloud provider allocates extra execution resources to support the requested applications.

3.3 Cloud Platform as a Service (PaaS)

The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created applications using programming languages and tools supported by the provider (e.g., java, python, .Net). The consumer does not manage or control the underlying cloud infrastructure, network, servers, operating systems, or storage, but the consumer has control over the deployed applications and possibly application hosting environment configurations. Example: Google App Engine.

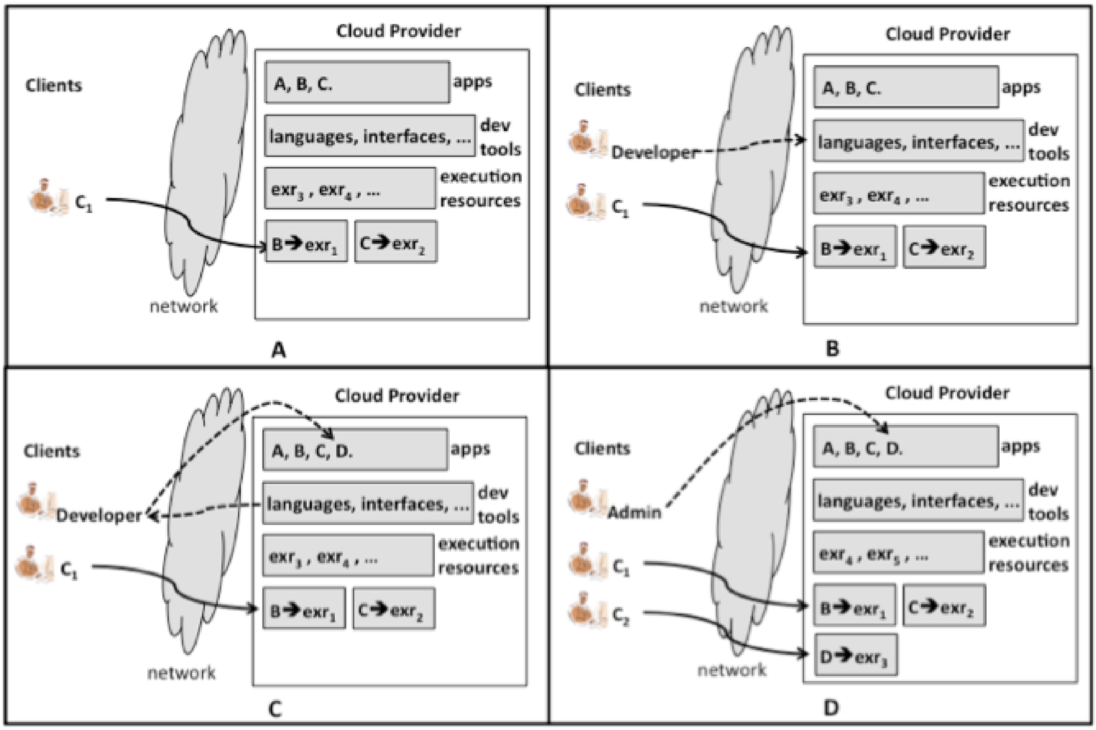

Figure 3 - PaaS Consumer/Provider Interaction Dynamics

D3.5.1 Smart Mobility Services and cooperative and sensor-based mobility applications in a cloud-computing environment

Figure 3 provides a simplified (four-step) view of the interaction dynamics of a PaaS cloud described by the NIST [4]. Figure 3A shows a PaaS cloud running two applications on behalf of a client, C1. In Figure 3A, the PaaS provider has a current inventory of three applications deployed ("apps"). The cloud provider also maintains a set of development tools ("dev tools" in the figure), and a set of execution environments ("exr" in the figure). Figure 3A also depicts two active applications, B→exr1 and C→exr2 indicating that applications B and C are using separate execution resources (just as they would in a SaaS environment).

In Figure 3B, a new developer client accesses the development tools of the provider. The development tools may include programming languages, compilers, interfaces, testing tools, and mechanisms to deploy an application once it's finished.

Figure 3C illustrates the developer's use of tools. The developer may download tools and use them locally in the developer's infrastructure, or the developer may merely access tools in the provider's infrastructure. In either case, the output of the developer's actions is a new application, D, as shown in the figure, that is deployed into the provider's infrastructure.

In Figure 3D, an administrator is shown configuring the new application that has been made available, and a new client, C2, is shown using the new application.

Figure 3 provides a simplified view of how a PaaS cloud operates, however it illustrates key aspects of PaaS clouds: PaaS clouds are platforms for which software may be developed, onto which software may be deployed, and on which software may operate for its entire life cycle.

3.4 Cloud 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, deployed applications, and possibly select networking components (e.g., firewalls, load balancers). Example: Amazon EC2, Windows Azure.

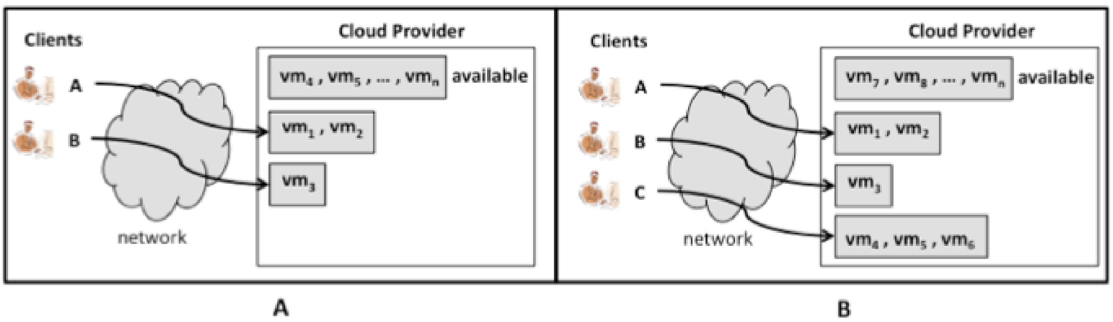

Figure 4 - IaaS Consumer/Provider Interaction Dynamics

Figure 4 presents a simplified view of the interactions within an IaaS cloud described by the NIST [4]. Figure 4A depicts clients interacting with an IaaS cloud over a network. The provider has a number of available virtual machines (vm's) that it can allocate to clients. In the figure, client A has access to vm1 and vm2, and client B has access to vm3. The provider retains vm4 through vmn, where it is presumed that n is larger than the number of vms any client is expected to request.

Figure 4B shows the situation just after a new client, C, has requested and received access to three more vms. At this point, client C has access to vm4, vm5 and vm6, and the provider now retains only vm7 through vmn. Figure 4 is admittedly an extreme simplification of how an IaaS cloud really works, but it is still sufficient to illustrate a number of technical issues that must be addressed for an IaaS cloud to function. Further, figure 4 only illustrates virtual machine allocation (by a provider) and interaction (by a consumer). Although it would be possible to build an IaaS cloud that provides only simple virtual machines that reset to default values when released, such a cloud would have limited functionality. Practical IaaS cloud systems also provide persistent data storage and stable network connectivity. They must also track resources that have economic cost, and bill those costs to consumers.

3.5 Comments on Service Models

The table below contains some comments on the Cloud Computing Service Models from the point of view of MoveUs services.

Service Models	Comments
IaaS: Infrastructure as a Service	Two partners of the MoveUs Consortium have developed a cloud infrastructure; it is likely that MoveUs services will use these platforms.
PaaS: Platform as a Service	This could be the model for some MoveUs services which could be considered "ancillary" to the main MoveUs city services; for example registrations, privacy management, integration of external datasets, etc.
SaaS: Software as a Service	This could be the model for the MoveUs services other than that based on PaaS.

Table 5 The Cloud Computing Service Models from the point of view of MoveUs services

4 Cloud Computing Deployment Types

4.1 Introduction

Similar to Platform/Infrastructure/Software as a Service, clouds may be hosted and employed in different fashions, depending on the use case and on the business model of the provider. So far, there has been a tendency of clouds to evolve private, internal solutions (private clouds) that manage the local infrastructure and the amount of requests e.g. to ensure availability of highly requested data.

This is due to the fact that data centres initiating cloud capabilities made use of these features for internal purposes before considering selling the capabilities publicly (public clouds). Only now that the providers have gained confidence in publication and exposition of cloud features do the first hybrid solutions emerge. This movement from private via public to combined solutions is often considered a "natural" evolution of such systems, though there is no reason for providers to not start up with hybrid solutions, once the necessary technologies have reached a mature enough position

According to NIST [1] and the European Commission Expert Group [2] there are 4 deployment types:

Private Cloud	The cloud infrastructure is operated solely for an organization. It may be managed by the organization or a third party and may exist on premise or off premise
Community Cloud	The cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be managed by the organizations or a third party and may exist on premise or off premise.
Public Cloud	The cloud infrastructure is made available to the general public or a large industry group and is owned by an organization selling cloud services.
Hybrid Cloud	The 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 that enables data and application portability (e.g., cloud bursting to balance spikes).

Figure 5 - Cloud Deployment Types

The private and community deployment types, however, according to NIST, admit two variants that should be discussed separately because they affect the security perimeter: on-site and outsourced.

More on security issues will be discussed in Task 3.4 Data Security & Privacy.

4.2 The Private Cloud Scenario

NIST [4] represents a simple view of an on-site private cloud in figure 6 and an outsourced private cloud in figure 7. As shown in figure 6, the security perimeter extends around both the consumer's on-site resources and the private cloud's resources. The private cloud may be centralized at a single consumer site or may be distributed over several consumer sites. The security perimeter will exist only if the consumer implements it. If implemented, the security perimeter will not guarantee control over the private cloud's resources, but its existence gives an opportunity for a consumer to exercise control over resources entrusted to the on-site private cloud.

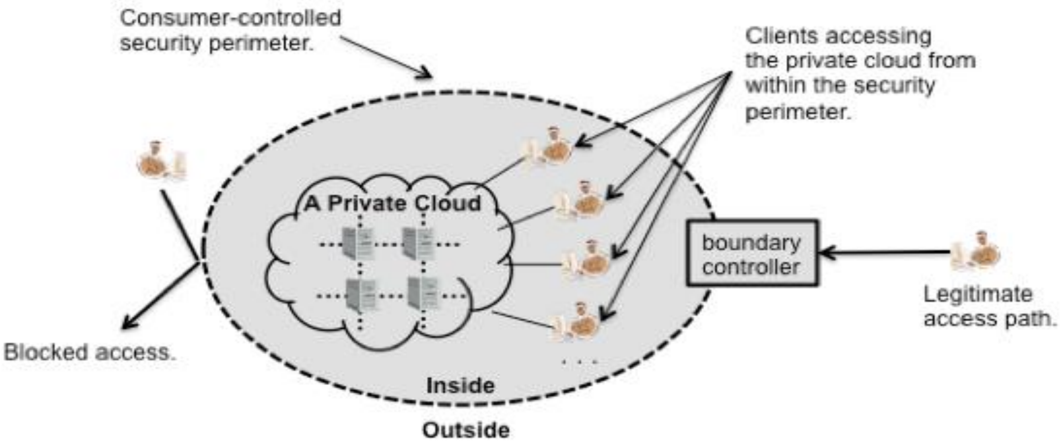

Figure 6 - On-Site Private Cloud

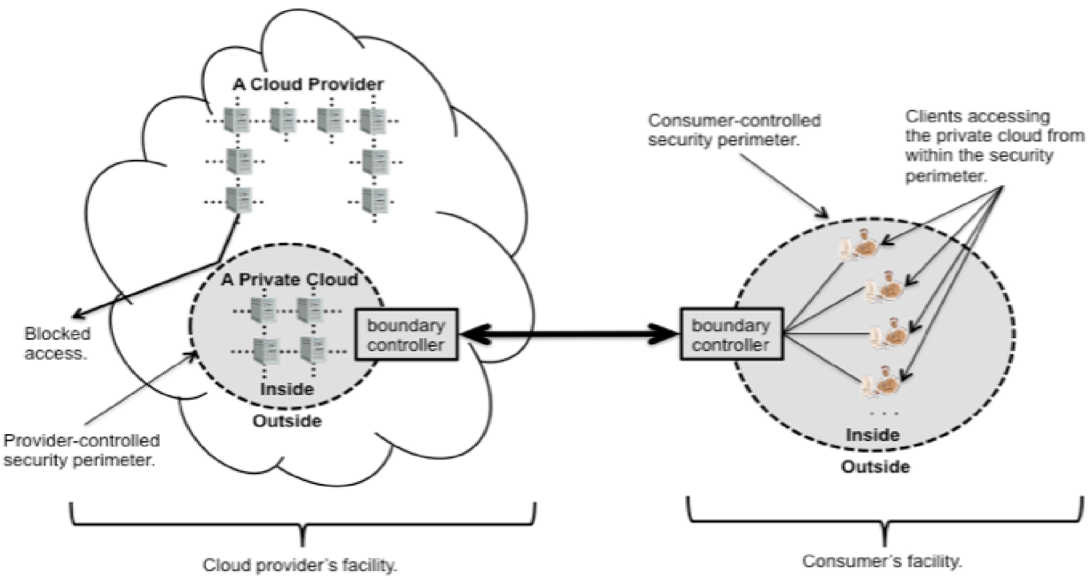

Figure 7 – Outsourced Private Cloud

Figure 7 depicts an outsourced private cloud. As shown in the figure, an outsourced private cloud has two security perimeters, one implemented by a cloud consumer (on the right) and one implemented by a provider (but perhaps configured by the consumer). The two security perimeters are joined by a protected communications link. As is apparent from the figure, the security of data and processing conducted in the outsourced private cloud depends on the strength and availability of both security perimeters and of the protected communication link. The provider thus accepts a responsibility to enforce the provider-implemented security perimeter and to prevent mingling of private cloud resources with other cloud resources that are outside the provider-controlled security perimeter. The suitability of various mechanisms for achieving an appropriate strength of separation between private cloud resources and other cloud resources depends on the consumer's security requirements. A number of possible mechanisms could be used with various trade-offs between separation strength and cost/convenience (e.g., Virtual Local Area Network (VLAN), VPN, separate network segments or clusters). This scenario, however, should, not merely employ separation mechanisms that are identical to the normal mechanisms (e.g., hardware virtualization, VLANs) that separate customers in a public cloud. If those mechanisms alone were used, this scenario would essentially become the public cloud scenario.

4.3 The Community Cloud Scenario

Figure 8 and 9 represent the on-site community cloud and the outsourced community cloud described by NIST [4]. Figure 8 depicts members that provide cloud services (and possibly consume them also) on the left and those that consume-only on the right. Assuming that each organization implements a security perimeter, the participant organizations are connected via links between the boundaries controllers that allow access through their security perimeters. Optionally, organizations may implement extra security perimeters to isolate the local cloud resources from other local resources.

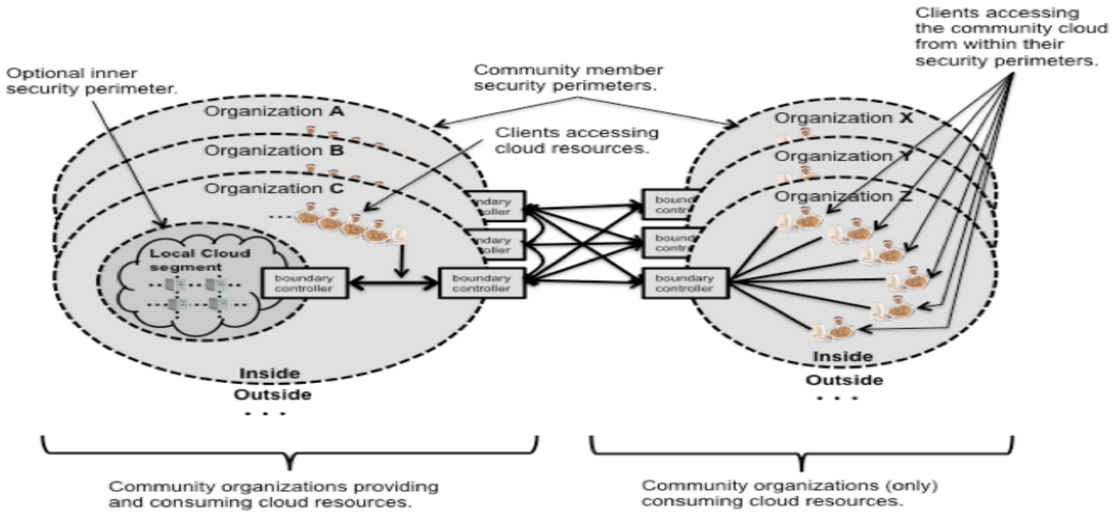

Figure 8 - On-Site Community Cloud

Figure 9 depicts an outsourced community cloud. The community depicted in the figure is made up of a set of participant organizations that consume cloud services. This scenario is very similar to the outsourced private cloud scenario: server-side responsibilities are managed by a cloud provider that implements a security perimeter and that prevents mingling of community cloud resources with other cloud resources that are outside the provider-controlled security perimeter. A significant difference is that the cloud provider may need to enforce a sharing policy among participant organizations in the community cloud.

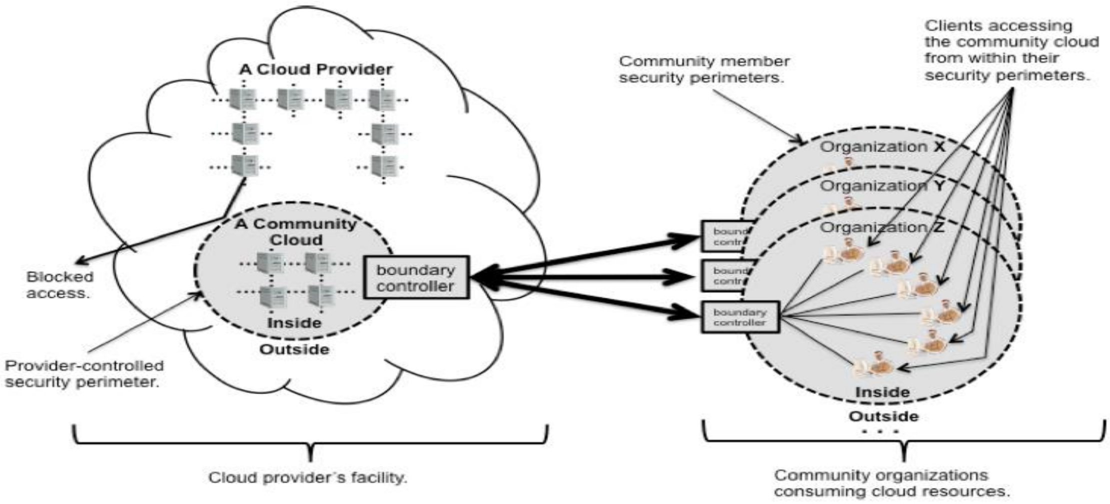

Figure 9 - Outsourced Community Cloud

4.4 The Public Cloud Scenario

Figure 10 depicts a public cloud according to NIST [4]. Figure 10 gives a general view of a cloud and its clients: the cloud's computing resources are depicted as a grid of computer systems where clients access a cloud over network connections. As shown in the figure, new clients may arrive, existing clients may depart, and the number of clients using a cloud at any one time is variable. Similarly, a cloud maintains a pool of hardware resources that it manages to maximize services and minimize costs. To maintain highly available services despite expected component failures and service life expirations, a cloud incorporates new hardware components as needed and retires old or failing components.

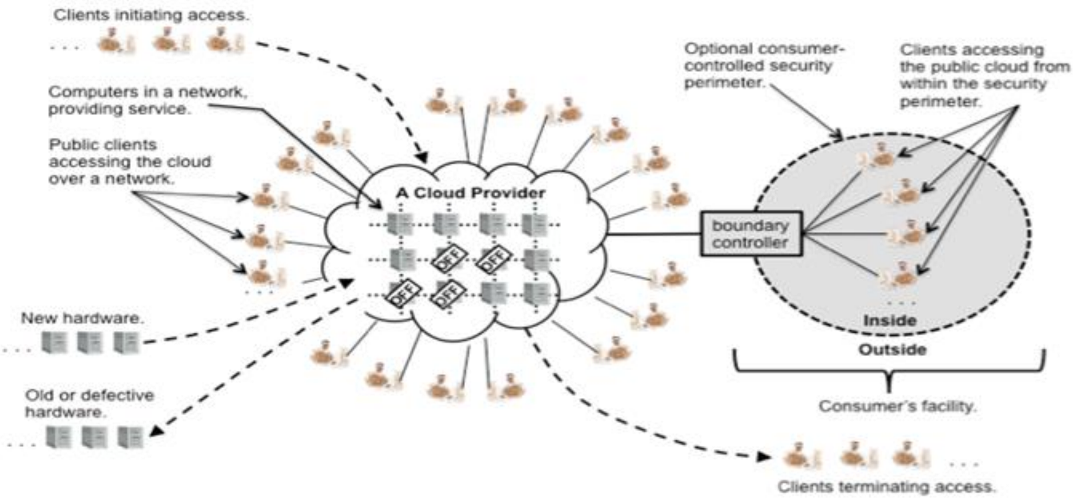

Figure 10 – Public Cloud

4.5 The Hybrid Cloud Scenario

A hybrid cloud is composed of two or more private, community, or public clouds. As presented in Figure 11 [4], both the private and the community deployment models have two significant variations: on-site and outsourced. The variations are significant because they have different performance, reliability, and security properties, among others. A hybrid cloud, consequently, is a composition of clouds where each constituent cloud is one of the five variants.

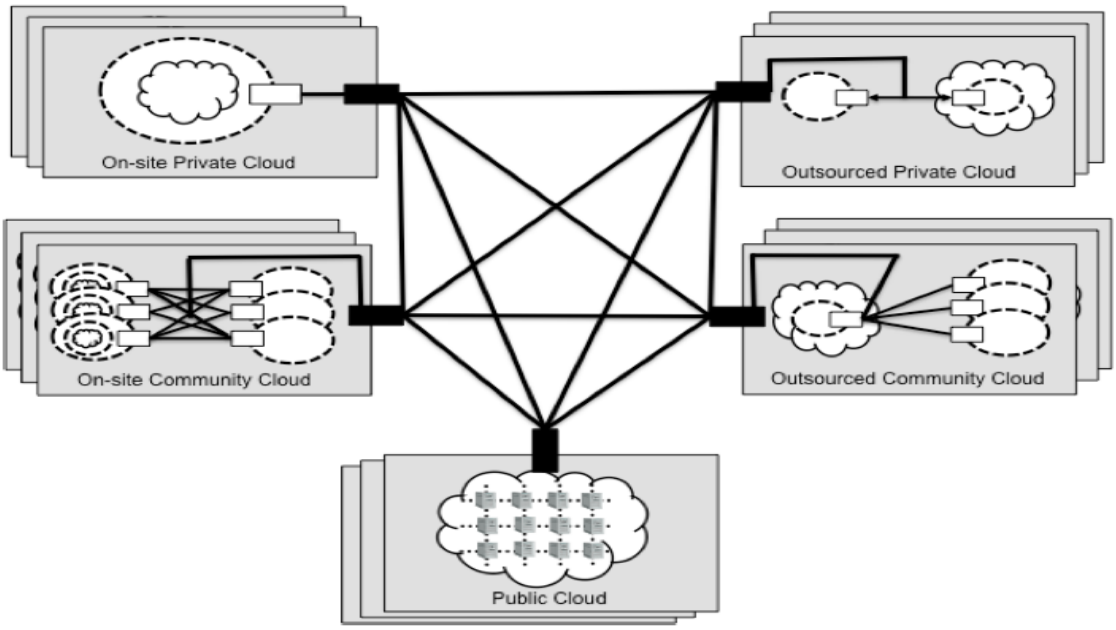

Figure 11 – Hybrid Cloud

4.6 Comments on Deployment Types

MoveUs services will integrate into a private or community cloud data coming from various sources, most of them public and resident on public clouds.

At the moment of issuing this deliverable, it is not yet clear which deployment type will best fit the MoveUs Services.

5 MoveUs Cloud Computing Value Chain

Numerous cloud computing value chains are described in literature; the most suitable for MoveUs is that presented in "Financial Aspects of Cloud Computing" [5].

The value chain was adapted, presented, discussed, modified and approved at the MoveUs meeting of 24-25 February 2014 held in Genova.

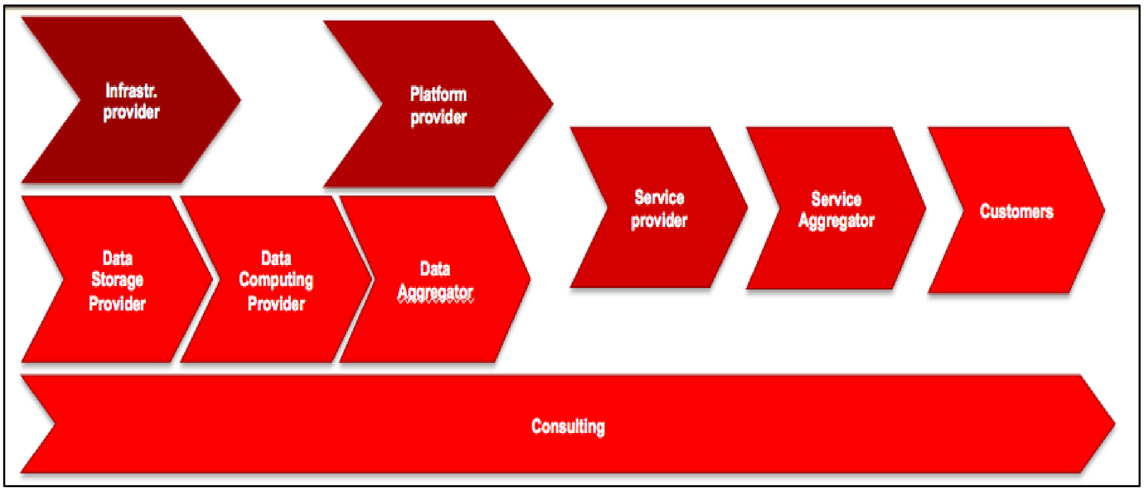

Figure 12 – Moveus Cloud Computing Value Chain

In addition to the three main service models described by NIST (IaaS, Paas, SaaS) the value chain above includes also:

- *Data Storage as a Service* (DSaaS): the delivery of virtualized storage and data services on demand over a network, based on a request for a given service level that hides limits to scalability, is either self-provisioned or provision less, and is billed based on consumption. [6]
- *Data Computing as a Service* (DCaaS): cover Big Data and real-time processing services, in order to execute data-mining techniques and advanced algorithms. This new model is proposed by MoveUs group to cover some new services came up recently in comparison to the rest (e.g. AWS Elastic MapReduce, Microsoft Azure HD Insights, Google Compute Engine, and Rackspace Cloud Big Data Platform; Big compute services (real-time processing, HPC): in Azure [7], in AWS [8])

Cisco IBSG [9] analysed the wide range of roles cloud providers play in the end-to-end cloud value chain. The figure 13 shows how PaaS providers, for instance, can deliver services to end users and SaaS providers alike. The diagram also illustrates how PaaS providers can either be customers of IaaS providers or run their own IT infrastructures. Taking this complexity into account, it helps generate more insights about the role of cloud computing in the IT value chain.

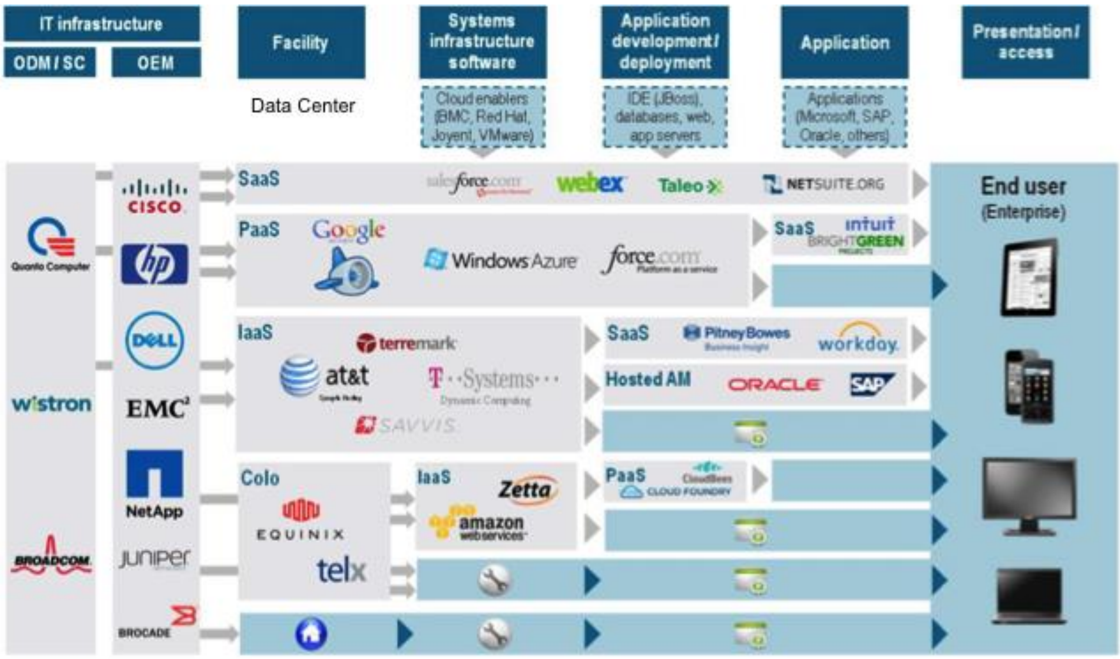

Figure 13 - Cloud Computing Value Chain, Cisco[9]

6 MoveUs Cloud Computing Business Model Canvas

6.1 Introduction

Cloud service models can be better explained through the concept of business model canvas introduced by Osterwalder in the early 2000s. "A business model describes the rationale of how an organization creates, delivers, and captures value" [3].

The business model canvas is a graphical representation of a business model and describes through nine basic building blocks the logic of how a company intends to make money. The nine blocks cover the four main areas of a business: customers, offer, infrastructure and financial viability. The business model is like a blueprint for a strategy to be implemented through organizational structures, processes, and systems.

The nine building blocks are:

- **Customer Segment:** the different groups of people or organizations an enterprise aims to reach and serve
- **Value Proposition:** the bundle of products and services that create value for a specific customer segment
- **Channels:** how a company communicates with and reaches its customer segments to deliver a value proposition
- **Customer Relationships:** the types of relationships a company establishes with specific customer segments
- **Revenue Streams:** the cash a company generates from each customer segment (costs must be subtracted from revenues to create earnings)
- **Key Resources:** the most important assets required to make a business model work
- **Key Activities:** the most important things a company must do to make its business model work
- **Key Partnerships:** the network of suppliers and partners that make the business model work
- **Cost Structure:** the most important costs incurred to operate a business model.

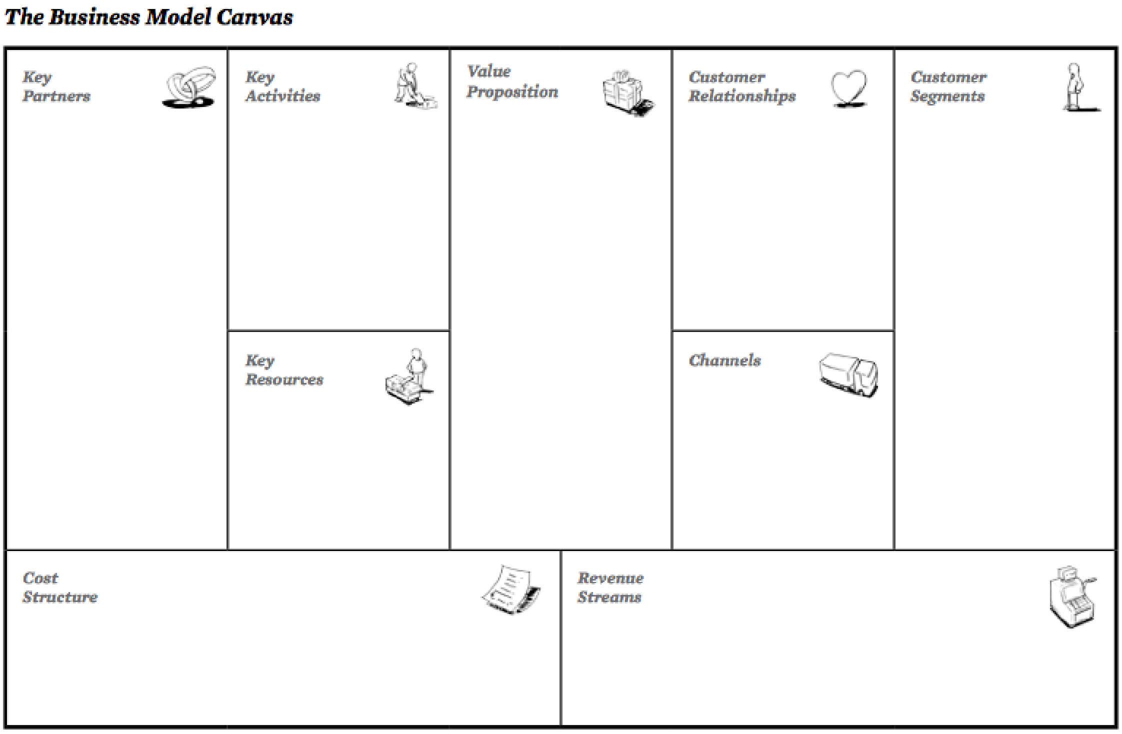

Figure 14 – A generic business model canvas

Figure 14 is the graphic representation of the nine building defined "canvas" by Osterwalder; canvas help to visualize the result of the designing phase a business model.

In the next paragraphs the IaaS, PaaS, SaaS and DCaaS service models are represented with their own business model canvas; the "costs building block" is divided in two parts: fixed on the left and variable on the right to better represent the cost structure.

We have not included DSaaS since we think that it is part of IaaS.

6.2 Infrastructure as a Service (IaaS)

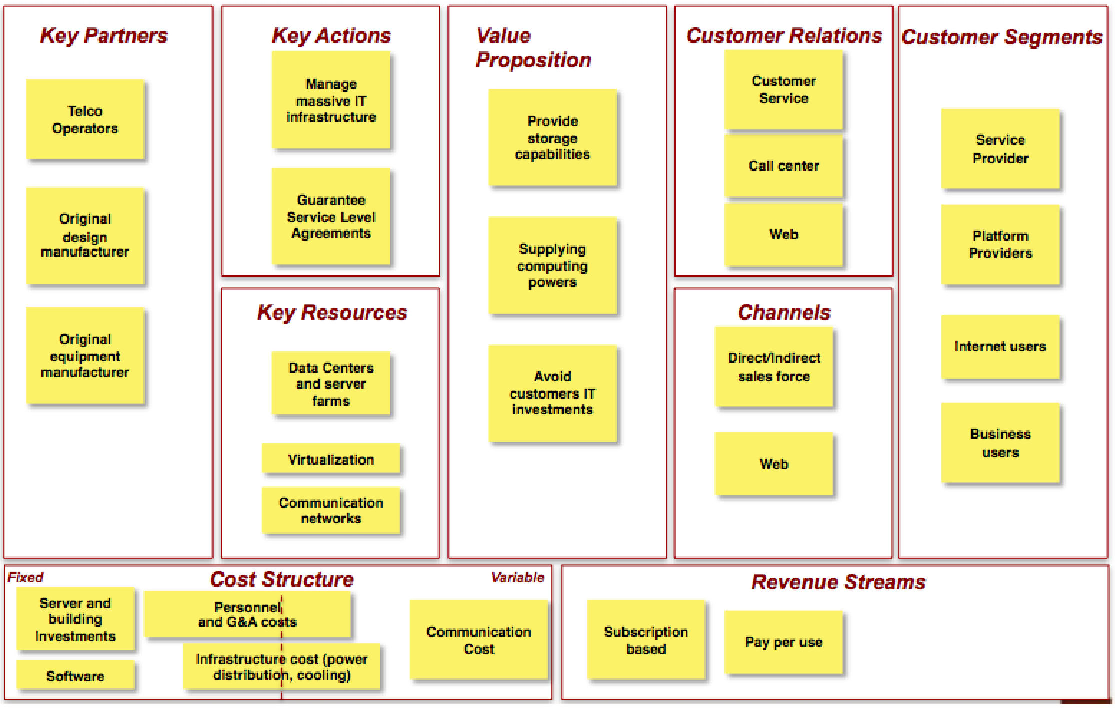

Figure 15 - IaaS business model canvas

Here below some definitions:

- **Customer Segment:**
  - Service providers: Software as a Service provider or Service Aggregator
  - Platform Providers: Platform as a Service Providers
  - Internet users: Consumers through web
  - Business users: Enterprises, research & academic institutions and public authorities
- **Channels:**
  - Direct/Indirect Sales Force: internal sales force and distributors
- **Revenue Streams:**
  - Subscription based: Customer pays a flat fee in order to access the use of a product or to profit from a service
  - Pay per use: Customer pays in proportion of the time or quantity he consumes of a specific service
- **Key Partnerships:**
  - Original design manufacturer: e.g. Quanta Computer, Wistrom, Broadcom
  - Original equipment manufacturer: e.g. Cisco, HP, Dell
- **Cost Structure:**
  - Software: to provide computing power
  - Personnel and G&A costs: direct and indirect personnel
  - Communication Costs: costs from Telco operators

Comment: this business model requires higher investment and fixed cost compared to the others service models. An example is shown in figure 16 here below.

Figure 16 - Example of IaaS (Cisco ISBG)

6.3 Data Computing as a Service (DCaaS)

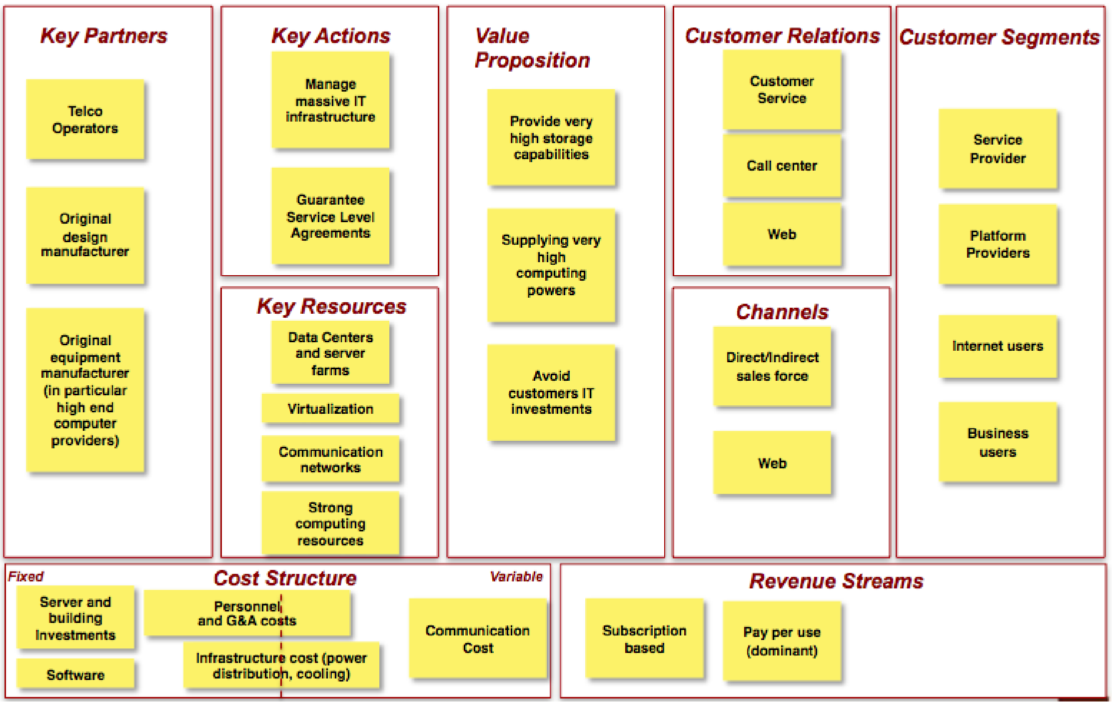

Figure 17 - DCaaS business model canvas

- **Customer Segment:**
  - Service providers: Software as a Service provider or Service Aggregator
  - Platform Providers: Platform as a service Providers
  - Internet users: Consumers through web
  - Business users: Enterprises, research & academic institutions and public authorities
- **Channels:**
  - Direct/Indirect Sales Force: internal sales force and distributors

- **Revenue Streams:**
  - Subscription based: Customer pays a flat fee in order to access the use of a product or to profit from a service
  - Pay per use (dominant in this case): Customer pays in proportion of the time or quantity he consumes of a specific service
- **Key Partnerships:**
  - Original design manufacturer: e.g. Quanta Computer, Wistrom, Broadcom
  - Original equipment manufacturer: e.g. Cisco, HP, and Dell. In particular high-end computer providers.
- **Cost Structure:**
  - Software: to provide computing power
  - Personnel and G&A costs: direct and indirect personnel
  - Communication Costs: costs from Telco operators

Comment: Data Computing as a Service business model is similar to the Infrastructure business model providing both storage capability and computing resources. **The DCaaS differs from the IaaS in improving these capabilities in order to cover Big Data and real-time processing services and to execute data-mining techniques and advanced algorithms**.

6.4 Platform as a Service (PaaS)

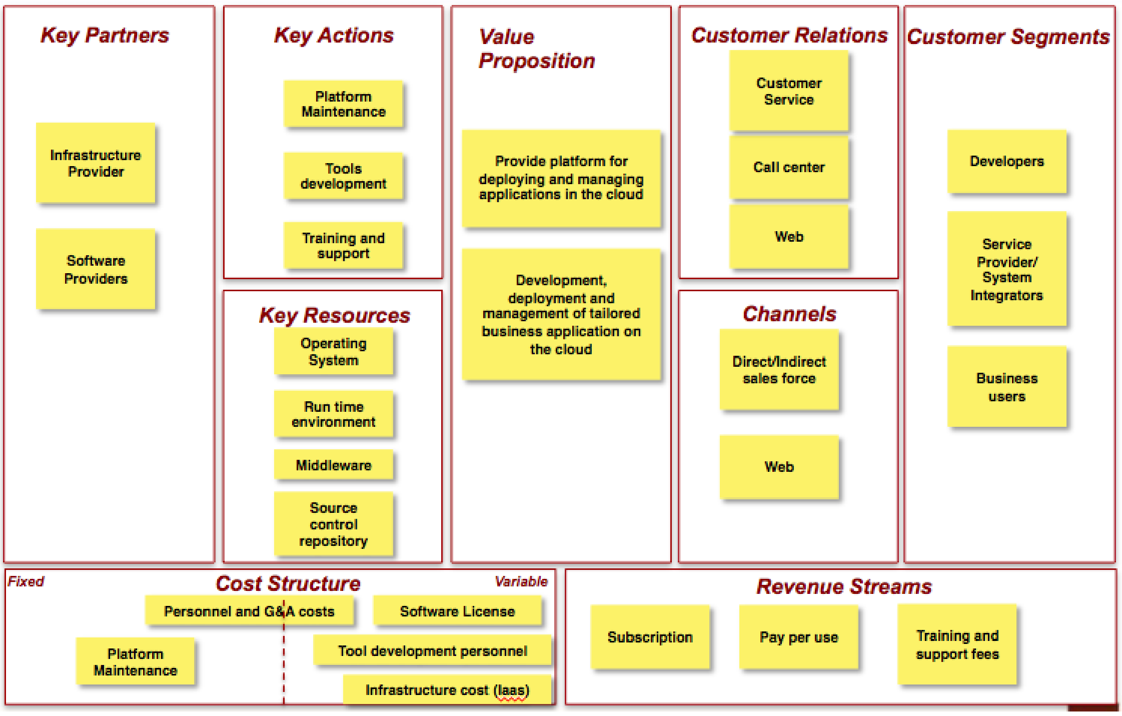

Figure 18 - PaaS business model canvas

- **Customer Segment:**

- Developers: application developers, tester and deployers who design and implement an application's software
- Service provider: Software as a Service provider or Service Aggregator/System integrator
- Business users: Enterprises, research & academic institutions and public authorities

- **Channels:**
  - Direct/Indirect Sales Force: internal sales force and distributors
- **Revenue Streams:**
  - Subscription based: Customer pays a flat fee in order to access the use of a product or to profit from a service
  - Pay per use (dominant in this case): Customer pays in proportion of the time or quantity he consumes of a specific service
  - Training and support fees: fees to support the developers
- **Key Activities:**
  - Tools development: update tools for application development
  - Training and support: service to developers
- **Cost Structure:**
  - Personnel and G&A costs: direct and indirect personnel (without tool development personnel)
  - Infrastructure cost: the infrastructure purchased from IaaS providers
  - Tool development personnel

Comment: Platform as a Service business model, however, shows very low fixed cost due to absence of investment in infrastructure resources. **In this model the key aspects are the tool developments to allow the customers to build applications and the training and support.** An example is shown in figure 19 here below.

Figure 19 - Example of PaaS (Cisco ISBG)

6.5 Software as a Service (SaaS)

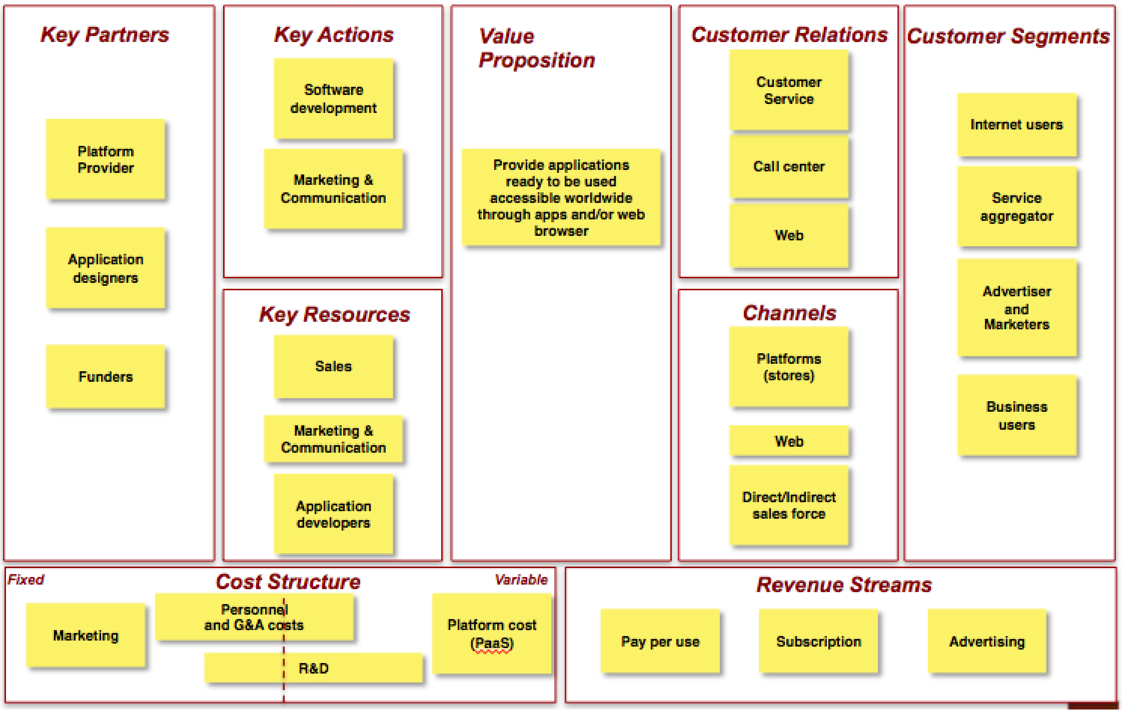

Figure 20 - SaaS business model canvas

- **Customer Segment:**
    - Internet users: Consumers through web or platform
    - Advertiser and Marketers: companies that use the application as an advertising and marketing channel
    - Business users: Enterprises, research & academic institutions and public authorities
- **Channels:**
    - Direct/Indirect Sales Force: internal sales force and distributors
    - Platform (stores): e.g. Apple store, Google Play
- **Revenue Streams:**
    - Subscription based: Customer pays a flat fee in order to access the use of a product or to profit from a service
    - Pay per use (dominant in this case): Customer pays in proportion of the time or quantity he consumes of a specific service
    - Advertising: fees from Advertiser and Marketers
    - Funds: to gain access to investment capital
- **Cost Structure:**
    - R&D: direct personnel to research and development of applications
    - Personnel and G&A costs: direct and indirect personnel (without R&D personnel)
    - Platform cost: the platform to build and run applications
- **Key partners:**
    - Funders: start up owners, apps owners

Comment: the Software as a Service business model focuses more on understanding market needs, developing applications and sales. This is reflected in the cost structure where there are fixed costs (as marketing), variable cost (e.g. platform cost) and semi-variable costs (research & development, where development are more variable expenses). **This model differs from the others also in terms of revenue stream, where a significant part comes from advertising**. An example is shown here below in figure 21.

Figure 21 - Example of SaaS (Cisco ISBG)

6.6 Comments on Business Model Canvas

The main outcomes of the canvas exercise are described in the table below.

Service Models	Main Outcomes
IaaS: Infrastructure as a Service	This business model requires higher investment and fixed cost compared to the others service models.
DCaaS: Data Computing as a Service	It is similar to the IaaS business model providing both storage capability and computing resources. **The DCaaS differs from the IaaS in improving these capabilities** in order to cover Big Data and real-time processing services and to execute data-mining techniques and advanced algorithms.
PaaS: Platform as a Service	It shows very low fixed cost due to absence of investment in infrastructure resources. In this model **the key aspects are the tool developments** to allow the customers to build applications and the training and support.
SaaS: Software as a Service	It focuses more on understanding market needs, developing applications and sales. This is reflected in the cost structure where there are fixed costs (as marketing), variable cost (e.g. platform cost) and semi-variable costs (research & development, where development are more variable expenses). **This model differs from the others also in terms of revenue stream, where a significant part comes from advertising.**

Table 6 Cloud Computing Service Models Canvas: main outcomes

The exercise on canvass is reinforcing the expectation that MoveUs services business model will be a SaaS.

7 Cloud Computing in Smart Mobility Services and cooperative and sensor-based mobility applications

7.1 Smart Mobility Services and cooperative and sensor-based mobility applications

7.1.1 Introduction

The "Smart" concept for the mobility of a city is something that needs to be explained; a city can become smarter if tackles one or more of the four main challenges related to intelligent mobility: **congestion reduction, environmental impact reduction of transportation, safety improvement and journey predictability**.

Each city can respond to these challenges in different ways according to its needs; so you cannot have a unique solution that "fits all" but have the opportunity to combine various services and mobility applications to finally obtain a "Smart Mobility".

In the following paragraph mobility services and applications have been mapped taking examples from literature and from the offer of main solution providers.

7.1.2 Smart Mobility services and sensor-based applications

The table below describes applications based on sensors and Smart Mobility services.

Smart mobility services and applications	Description
Pedestrian crossing safety	Intelligent sensors detect the presence of persons at pedestrians crossings warning approaching drivers and heightening visibility of the crossing
Smart crossing for pedestrians	This service aims to provide the smartest crossing options to the pedestrians, whether using special crossing points or by applying a reaffirmation of a demand. Users subscribed to this service will receive the smartest way (the smartest the crossing the smartest the way) for a predefined route. This service will support the user in its route in order to cross safely in those crossings which use a camera to detect pedestrian crossing (see "Pedestrian crossing safety" above) and that extend the green time

	until it has crossed safely or until a maximum pre-programmed time is exceeded.
Smart routing for pedestrians	This service aims to provide pedestrians with the smartest route between their actual position and a selected destination following the mobility preferences recorded at the registration phase.
Level crossing safety	Intelligent sensors detect the presence of persons and vehicles at level crossings guiding them along designated crossing lanes through illuminated studs (especially at night)
Cycle lanes safety	Intelligent sensors detect the presence of cyclists on cycle lanes guiding them through illuminated studs (especially at night)
Dynamic lane marking	Intelligent sensors detect the presence of vehicles on the road notifying them of changes in lane use, priority and direction of travel according to instruction from traffic operators (especially at night)
Vehicle detection	Intelligent sensors detect the presence of vehicles dynamically regulating road illumination (especially at night) and so reducing the cost of ongoing maintenance
Vehicle detection at road crossings	Same as above at road crossings turning on-off traffic signals and so reducing the cost of ongoing maintenance
Smart prioritization of vehicles	This service gives priority to specific vehicles in crossings controlled by traffic lights from Traffic Control System, so as to optimize the time of travel and the travel efficiency of those modes of transport.
Bicycle detection	Intelligent sensors detect the presence of bicycles enhancing cyclist safety (especially at road junctions)
On-Street and Off-Street parking	Intelligent sensors detect the presence of vehicles at On-Street and Off-Streets parking providing real-time information on occupation for better management of the parking spaces, for effective enforcement and for informing drivers of available parking spaces
Car Park entry/exit	Sensors, based on various technologies (inductive loops, radar, Bluetooth, infrared, video), provide entry and exit counts informing drivers of available parking spaces
Ramp metering	Intelligent sensors and systems measure traffic on slip road and highway to identify suitable time spaces to allow

	waiting traffic to enter into the traffic flow.
Speed detection	Sensors, based on various technologies (inductive loops, radar, infrared, video), measure the speed of vehicles for enforcement and traffic management.
Red light enforcement	Video cameras detect when a vehicle overpasses the stop line on red and take video images for later enforcement
Integration of crowd sourced data	The service is built over the integration of crowd sourced (sensor data) provided by users (citizens, tourists, professional operators) through mobile devices (smartphone, phablet, tablet) with Traffic Control Centers
Traffic counting	Sensors, based on various technologies (inductive loops, radar, Bluetooth, infrared, video), count vehicles in a specific road section
Traffic counting and classification	Same as above including technologies for classifying vehicles (i.e. ANPR) for tolling and enforcement
Traffic Intelligence	Services for data mining, processing, reporting and analysis of key transport data
Traffic Management	Services for managing traffic: they gather data from various sources and control traffic managing traffic light, access permissions and dynamic lanes.
Journey Time Planner	Service for providing drivers with real-time trip information
Public Transport Management	Services for managing PT: they gather data on demand and traffic from various sources and manage offers and schedules accordingly
Smart ticketing	Services enabling the interoperability among different ticketing systems: various transport modes, urban road pricing, highways, car/bike sharing, etc.
Info Mobility	Services for providing information on mobility and point of interests to citizens, tourists and professional operators; they are usually multi-channel: web, mobile phones, totems, monitors, VMS.
Incentive management	Services enabling the creation, issuing, accounting and delivery of incentives to beneficiaries according to pre-defined rules.

Table 7 Applications based on sensors and Smart Mobility services

7.1.3 Smart Transportation Services offering

Most services listed in the previous paragraph have been bundled by main vendors into the so called Smart Transportation Services, generally composed of:

- Traffic Management Systems
- Integrated Supervision Systems
- Parking Management & Guidance Systems
- Ticketing Management Systems
- Passengers Information Systems

The table below shows the references between Smart Mobility Services and sensor based applications > Smart Transportation Services > MoveUs Services

Smart mobility services and applications	Traffic Management Systems	Integrated Supervision Systems	Parking Management & Guidance Systems	Ticketing Management Systems	Passengers Information Systems	MoveUs
Pedestrian crossing safety						
Smart crossing for pedestrians						X
Smart routing for pedestrians						X
Level crossing safety		X				
Cycle lanes safety		X				
Dynamic lane marking						
Vehicle detection	X	X	X			
Vehicle detection at road		X				

crossings						
Smart prioritization of vehicles	X	X				X
Bicycle detection		X				
On-Street and Off-Street parking			X			
Car Park entry/exit			X			
Ramp metering	X	X				
Speed detection		X				
Red light enforcement		X				
Integration of crowd sourced data	X		X			X
Traffic counting	X	X				
Traffic counting and classification	X	X				
Traffic Intelligence	X	X			X	X
Traffic Management	X	X			X	
Journey Time Planner			X		X	X
Public Transport Management	X			X	X	

Smart ticketing				X		
Info Mobility	X				X	
Incentive management						X

Table 8 Smart Mobility Services and sensor based applications > Smart Transportation Services > MoveUs Services.

As shown in table 6, most mobility services are present in commercial offers, while a few of them, still very innovative, are not, and this is the case also for the MoveUs services.

The main vendors offering Smart Transportation Services are:

- Accenture
- Affiliated Computer Services
- Alstom
- Cisco
- Cubic
- GE Transportation
- Ibm
- Indra
- Kapsch
- LG Cns

We have contacted a few of them in order to have an indication on their business models; the synthesis is that they can be deployed in multiple ways, covering the needs of a wide range of cities:

- for larger cities, they can be deployed as **on-premise solution** to give transportation authority managers complete flexibility over its configuration and operation;
- for medium-size cities or for regional transportation authorities, they can be deployed as a **shared service** so that many jurisdictions can collaborate on traffic management across a broad metropolitan area;
- for smaller cities or cities with modest transportation departments, the offer **cloud-enabled capabilities** (in form of **Paas/SaaS**) can free a city from the time and expenses of deploying the on-premise solution.

Vendors would give examples of pricing when the MoveUs consortium will be ready to provide a detailed list of services and expected QoS since they need to customize the solution for each city.

8 Conclusions

This first deliverable of Task 3.5 is a general overview of cloud computing business models while the 3.5.2 will be focused on the various business cases of MoveUs.

As soon as the complete list of service/subservice will be available, a comparison matrix service/subservice vs users will be built, involving also Living Labs, and the most likely cloud computing business model will be identified and deeply described for each scenario, considering also what the main vendors are currently providing.

9 References

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