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Using Cloud computing as a Model to Design the Service Web

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Abstract: *The purpose of this paper is to provide insights into the Service Web, which is one of the five components of the Logistics Web enabled by the Physical Internet. Specifically, it aims to present potential benefits for using a Service Web and it also highlights challenges and concerns surrounding it. After a brief review of the literature on the Physical Internet and cloud computing, the authors present a conceptual model of the Service Web. A key concept is that what the Service Web represents for the Physical internet is similar to what cloud computing represents for the Digital Internet. Following this thought, it is proposed that cloud computing be used as a model to initiate the development of the Service Web. To demonstrate the proposed conceptual model of Service Web, it is contextualized in the construction industry as an example. Current practices within the construction industry are first highlighted, then an illustration is provided of how construction companies can benefit from the use of Service Web. This paper offers a perspective on the utility and value of the Service Web for companies that will be using the Physical Internet. It is to be useful to researchers and companies interested in the new Physical Internet paradigm and notably on the potential for interconnected open pooling to improve the accessibility and utilization of assets and goods.*

Keywords: *Physical Internet, Service Web, Cloud computing, Construction supply chain*

1 Introduction

In an era where globalization dominates and international competition is fierce, companies feel the pressure to seek new management and organization approaches. The development of the Physical Internet is aligned with addressing the ongoing sloppiness, disorganization and unsatisfactory practices in global logistics as well as the societal concerns of global environmental destruction and global economic burden. In other words, Physical Internet is an answer enabling a significant reduction of these global problems through standard sets of collaborative protocols, modular containers and smart interfaces. The Service Web, as one of the five components of the Logistics Web enabled by the Physical Internet, is a basis for open sharing of goods and assets. It enables communication between owners and users of the goods, as well as professional service providers and professional service seekers, and facilitates the operational process associated with the flow of goods.

One of the most well-known success stories of efficient sharing systems in recent years is ridesharing. Grouping passengers into fewer cars had several advantages for everyone. The drivers can share the fuel costs; the passengers can travel spending the least and at the same time, as the fuel consumption in passenger vehicles is reduced, economical and environmental benefits can be gained.

Another well-known sharing system is the cooperative apartments. In the low cost “co-op”, each room is rented to one person and the common areas are shared. The new trends are luxury apartment sharing and the owners sub renting their apartments when they are away. Instead of booking a room in a hotel, the whole apartment or a room in a luxury apartment can be rented.

If seats in cars and rooms in apartments are getting shared, there are so many other idle resources out there that may also be used collaboratively. Instead of having resources sitting idle in their warehouses or storage yards, companies owning these resources can make them available for other companies that cannot afford spending a fortune in purchasing, leasing or hiring these resources or for those companies that need to exploit these resources occasionally or once in a while on a short-term basis. This is called resources sharing. Resources sharing can be smart sharing. Aside from its obvious purchasing cost savings benefits, it has the potentiality to save money on maintenance, to favor effective and efficient collaboration among the involved parties, to maximize production while meeting deadlines and to be sustainable. Modern technological advances in connecting users and systems, tracking physical objects and accessing remotely places and resources, make the concept of resource sharing and thus, the Service Web feasible.

Aiming to introduce a general conceptual model for the Service Web, the structure of this paper is as follows: in the next section, an overview of the Service Web and cloud computing is presented. The proposed conceptual model is discussed in details in section three. Section four lists some of the most important benefits and challenges regarding the application of the Service Web in practice. In order to provide a clear vision of the Service Web and its benefits, an application in the case of the construction industry is discussed in section five. Finally we conclude by summarizing our main contribution and by pointing out the future research avenues.

2 Service Web and cloud computing

According to Montreuil et al. (2013), “the Physical Internet (PI, π) is an open global logistics system founded on physical, digital and operational interconnectivity through encapsulation, interfaces and protocols. It is a perpetually evolving system driven by technological, infrastructural and business innovation.” The Physical Internet enables an open Logistics Web that has five key constituents: the Mobility, Distribution, Realization, Supply and Service Webs, as depicted in Figure 1.

As defined in Montreuil et al. (2013), “in general, a web can be defined as a set of interconnected actors and networks. In the PI context, the types of actors and networks can be characterized, leading to define a web as a set of interconnected physical, digital, human, organizational and social agents and networks. A logistics web is defined as a web aiming to serve logistics needs of people, organizations, communities and/or society. A Logistics Web is a logistics web that is both open and global."

While the other components of the Physical Internet have been studied in the literature, little could be found on Service Web. Montreuil et al. (2013) referred to the Service Web as "a web aiming to serve the needs for physical object usage. It is focusing on the accessibility of the services provided by, through, and with physical goods and beings. The Service Web is expected to enable efficient and sustainable collaborative consumption on a worldwide basis." (p.2) In other words, Service Web is about making idle resources available for sharing purposes across the world.

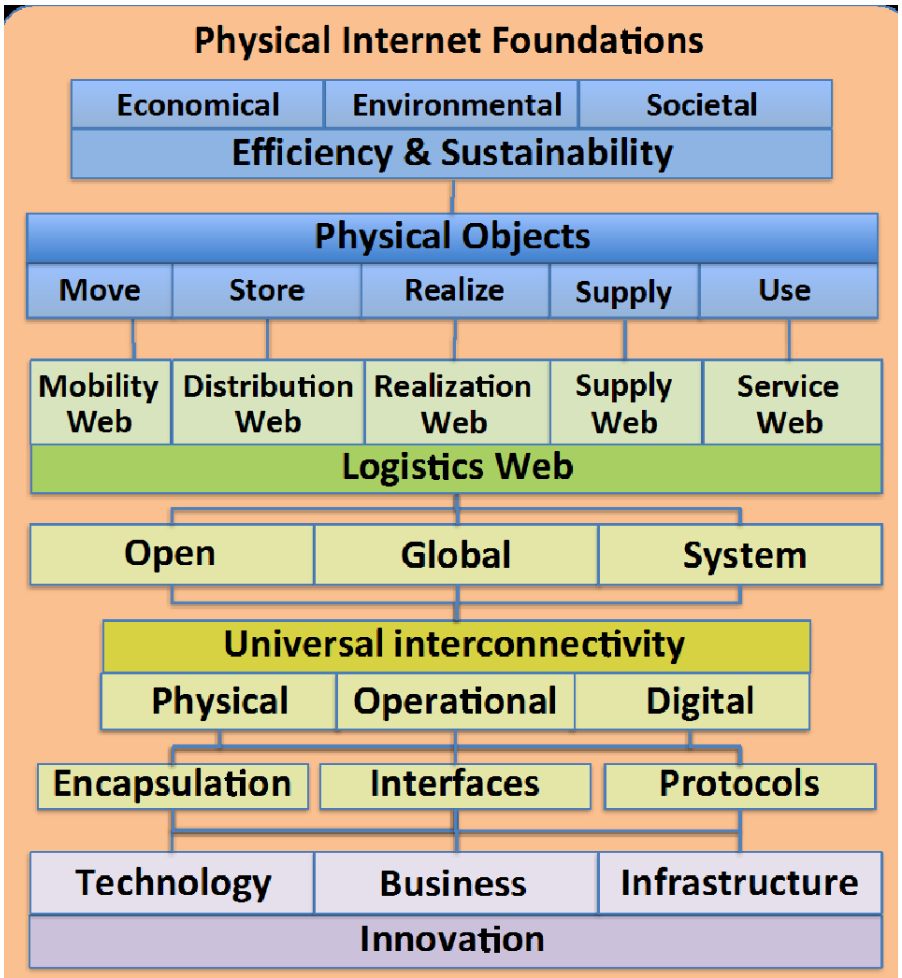

Figure 1. Physical Internet Foundations Framework, Montreuil et al. (2013)

What makes the realization of the Service Web a challenge is how to share the resources and have access to them on a real time basis. The notion of Physical Internet is built on a metaphor of the Digital Internet. How PI is enabling the Logistic Web resembles how the Digital Internet has enabled the World Wide Web. Therefore looking at the Digital Internet enablers and concepts can be of help to define and design the Service Web. In the Digital Internet, the problem of sharing and accessing resources and spaces has been significantly resolved by introducing the "cloud computing" notion and its enabling technologies.

“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.” (Mell & Grance, 2011, p. 2). According to Vaquero et al. (2008), the cloud is a large pool of resources, which can be easily used and accessed.

Following these definitions, we introduce a π-cloud as a large pool of physical objects and human resources that can be shared and accessed through the Service Web. Therefore, before introducing our conceptual model of the Service Web, having a quick look at the characteristics of the Service Web and its π-clouds, based on cloud and cloud computing literature seems to be required.

2.1 Service Web Characteristics

The Service Web has characteristics similar to cloud computing. Users rent the resources from owners and pay them for the rented resources. In other words, owners are given the opportunity to make their idle resources available to those that are in need. This characteristic is called shared resource pooling in cloud computing terminology (Zhang et al., 2010).

Geo-Distribution and ubiquitous network access (Zhang et al., 2010) is another characteristic of the Service Web. Although due to transportation and other related costs, the resources may not be available for rent worldwide, they can be accessible anytime and anywhere within the defined region.

The Service web is service-oriented as each owner offers its resources according to the service level agreement. The resources can be obtained and released on the fly. Therefore, it prevents huge fixed costs of owning the resources, which gives Service Web dynamic resource provisioning characteristics. Users and owners can manage use of the resources according to their needs. The companies can get more agile as they are able to respond more quickly to rapid changes in the environment using Service Web.

In Service Web, the users of the idle resources are to be subjected to a utility-based pricing system. Multi-tenancy (Zhang et al., 2010) is another characteristic of Service Web which can only be applied to human resources for example. Indeed it allows different users to benefit from the services provided by the same human resource.

2.2 Π-Cloud Deployment Types

In the cloud computing literature, four cloud deployment models have been identified (Mell & Grance, 2011). These deployment models are also applicable to π-clouds in the Service Web context.

Public: providers of service web use these types of clouds to offer their services to the public. In other words these clouds are open for public use.

Private: these clouds are also referred to as internal clouds. They are specifically designed to be used by single organization.

Hybrid: these clouds are a mixture of public and private clouds. They also have the advantage of addressing the limitations of each type of clouds by expanding their capacities or capabilities

Community: these clouds are suitable for a group of organizations that share common concerns among which security, privacy and compliance. A group of companies that use community clouds share the space available on these clouds as well as the costs related to the use of the clouds. An example of group of organizations using community clouds can be a group of construction companies.

The three basic types of cloud computing are known as Infrastructure as a Service (IaaS), Software as a Service (SaaS) and Platform as a Service (PaaS) (Genez et al. 2012). Based on these basic services, several other services have also been introduced, such as Identity as a Service (IDaaS), database as a service (DbaaS), etc. In this paper we introduce physical object as a Service (PoaS) and Human Resource as a Service (HaaS); Service web is therefore, combination of the PoaaS and HaaS.

We define π clouds within the Service Web as providers of the physical objects. Following the cloud computing terminology we try to define the conceptual model and architecture of the π clouds.

3 The conceptual model of the Supply Web

Using the cloud computing terminology and concepts, π-clouds provide a pool of stored and shared resources which includes human and physical resources. Figure.2 provides the schematic view of a π-cloud. Standard protocols are required to link different layers within each cloud (Data, Physical objects, Human resource, etc.) and allow them to communicate.

Different elements of the Service Web are as follows:

Cloud providers: the cloud can be created using the company`s own infrastructures or using the available resources on the cloud.

Manufacturer: Equipment and machinery producer, suppliers of durable material can offer facilities (e.g. storage space), services (e.g. repair and maintenance), or physical objects for rent.

Owners: those companies, organizations or individuals having idle resources and willing to make their resources available over the cloud to be shared and used by other members of the cloud.

Resources: including human and physical object resources.

Storage space provider: they may be members of the cloud by providing storage space for the physical objects, parking space, etc. These companies are part of the Distribution Web and each time the storing service is required, Service Web will get connected to the Distribution Web.

Transportation companies: they are responsible for moving the objects; basically they are part of Mobility Web. Whenever the resource needs to be moved, the link between Mobility Web and the Service Web will get activated.

Users: those are companies, organizations or individuals borrowing equipment, physical objects or human resources for the leasing period.

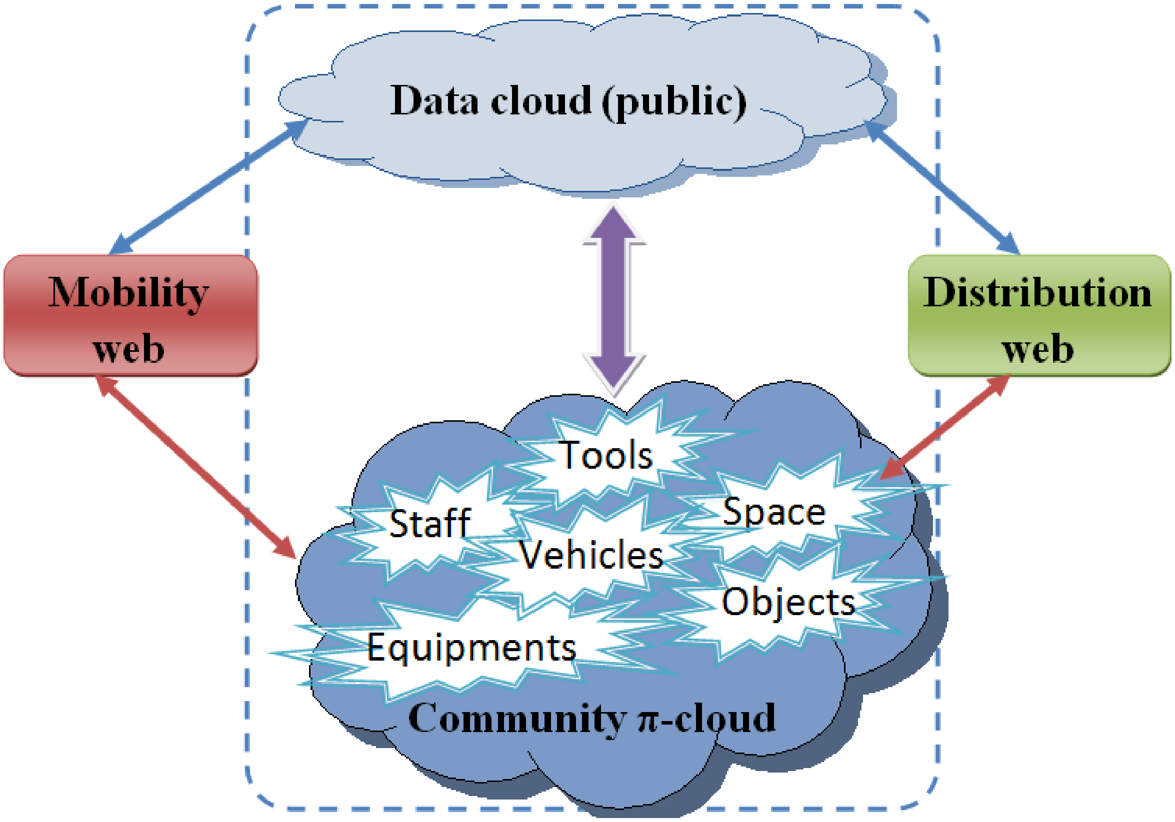

Figure.2. The clouds

We also define four processes within Service Web for sharing and using the resources, namely: Finding, Obtaining, Using and Returning (FOUR):

Finding: Sharing the resource and requesting a resource from the resource pool is linked to the finding process. The owner needs to put the information about the type, characteristics, price and availability of the resource on the public π-cloud. The users will search this public cloud to find the best fitting match. The Abstraction process will take place at this phase, which is a process used to create the resource pools by mapping an address for each resource (Sosinsky, 2010). Using the Service Web, the user is directed to the available resource pool. When the user requests a resource from the pool, the system uses a scheduling algorithm to assign the request. The π-cloud is then searched to find the best fitting match for the request. The fastest delivery time, the working schedule of the product owner, the needs-fitting characteristics of the requested resources, the lowest price and the lowest transportation costs are among the criteria taken into account at this phase. The π-cloud needs to get connected to the Mobility and Distribution Webs to check the moving and storing possibilities to provide the user a list with different options to choose from.

Π-Cloud providers need to make resources available in the air. Based on current locations and the company's profile, the resource will be assigned to a center in the π-cloud. The following factors will normally be taken into consideration: current location of the company, nearby π-hubs and other facilities by searching the Mobility and Distribution Webs, the working schedule of the owner company so that the resources will be returned to the owner on time.

When the user initiates searching the data cloud, the query is sent to the server. The pool of addresses is searched and the geographically closest options are offered. Verification and Virtualization of the pool take place at the same time to have access to the most update information. Virtualization is a process of managing the resources. It is dynamic and changes the address assigned to each resource dynamically in line with the rapid changes in their condition (Sosinsky, 2010).

Obtaining: The obtaining process is handled through the π-cloud. It includes the renting, storing and other related fundamental processes. Hosting, storage, the platform, application services and the tools are all provided by the π-cloud provider. Each resource is equipped with remote controlling or information devices; its exact location is controlled using GPS, RFID and other technologies. Encapsulated in π-containers, the objects move freely through the Mobility Web and get stored / parked in the Distribution Web facilities.

Using: Whenever a user receives the physical object, it evaluates its condition. It compares the object with the specifications and conditions mentioned in the database. All objects are equipped with tracking systems, any misuse of the equipment is recorded and the π-cloud provider is notified. The exact location of objects is always known via the system. The π-cloud provider later evaluates users of the objects based on these records.

Returning: When the lease period is over, the physical objects need to be sent for maintenance and repair as pertinent. The object's condition is checked and the system evaluates the user. We define a reciprocal evaluation system within the returning process. For a human resource, the user evaluates the human resource who also shares his/her experience with the company, as depicted in Figure 3.

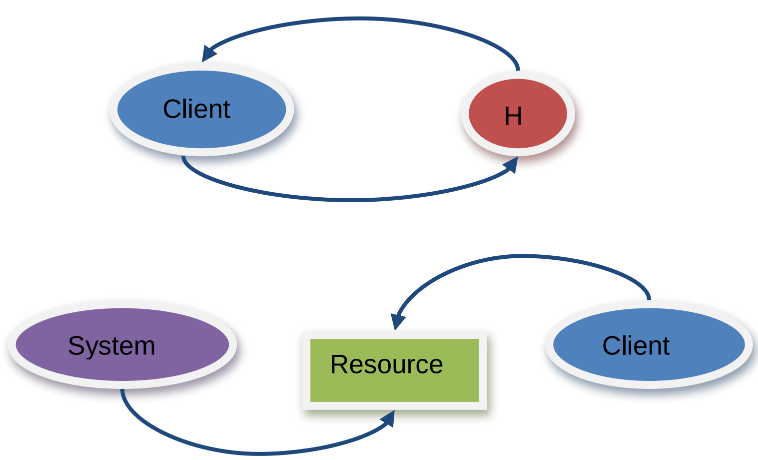

Figure. 3. Evaluation system

After the lease period is over, the user is sending the object back to the π-cloud; the equipment needs to get checked and after checking and maintenance, several options are possible: either it is sent to the storage space, or it is sent to the next user or it may be sent back to the owner to be used for their own work.

The proposed conceptual model for Service Web is synthesized in Figure 4.

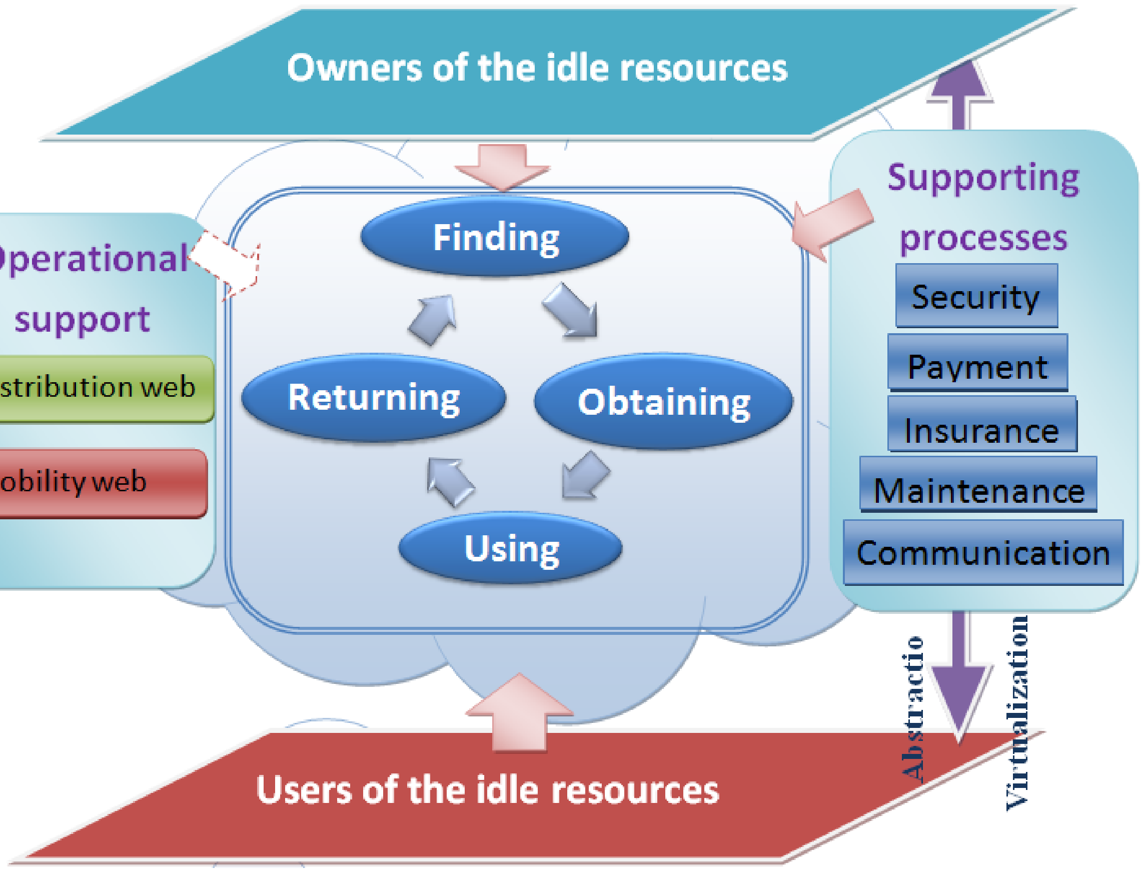

Figure 4. The conceptual model for the Service Web

4 Benefits and challenges of using Service Webs

The Service Web offers great potential to companies, organizations and individuals. Those that own idle resources can make profit out these resources. They can also reduce the costs for maintenance, the costs for storing physical options as well as the costs of hiring human resources. Meanwhile, they can fast track the conditions of their resources.

Just like those that own idle resources, those who use idle resources can also benefit from the pay-per-use option that the Service Web has to offer them. Pay-per-use can improve information sharing capabilities, decrease supply chain complexity, increase operating effectiveness, enhance constant availability of resources, improve higher flexibility and agility in response to changes, provide many alternatives for acquiring physical objects, open access to rare or expensive resources and allow users to make profit by avoiding huge fixed costs of buying physical objects. Finally, the Service Web offers π-cloud providers the opportunity to make significant profits.

Even though the Service Web can offer numerous benefits for companies, organizations and individuals, it also poses some important challenges that should not be overlooked. One of these challenges is related to the security and confidentiality of the data. Companies, individuals, physical objects and all the other resources are registered on the cloud; the data is accessible by all pertinent users and all transactions are conducted through the cloud. Therefore, the security challenge of the cloud has to be carefully addressed.

Other challenges of the Service Web are technical concerns that have to be addressed and solved by π-cloud providers before offering the service. Π-Cloud providers need to be prepared for issues such as: How huge instruments and equipment can be moved and stored using the Mobility Web and the Distribution Web facilities; how smart, standardized π-containers may be used.

A significant fraction of the resources owners are willing to share them when they are idle under the condition that they will be back to them whenever needed, therefore the π-cloud provider needs to be flexible and robust enough to make both users and owners satisfied with the offered services. How and where maintenance and repair can and should be done? Who is paying for that is another issue that needs to be addressed.

The π-cloud providers also need to be prepared to deal with the cases of lost, stolen or broken objects, or any case of accidents. Who is going to be responsible and how the insurance will be paid, is highly dependent of the exact location of each object. Hence, the π-cloud provider needs to be prepared to provide real time data and on-time service.

5 Exploiting the Service Web: the construction industry as an example

Construction supply chains consist of many companies that work together in order to finalize a project. Depending on its size, especially in medium or large scale, the project can involve hundreds of different companies providing materials, components and a wide range of construction services (Dainty, Briscoe & Millet, 2001). In other words, a medium to large scale construction project requires a diverse group of participants such as contractors, architects, engineers, workers, suppliers, etc. This requirement of a diverse group of participants is due to the high fragmentation of the industry. According to Cheng et al. (2010), the top eight architectural and construction engineering firms control less than 20% of the market share. This represents a small percentage compared to other sectors as, for example, the largest aerospace companies in the same country control more than 60% of all trades in the industry. This phenomenon, according to the same authors, is due to the fact that the construction industry is mostly composed of too many small to medium size companies with different activities.

The economic growth of a nation can be measured through its physical development (roads, bridges, buildings etc). This means that construction industries are at the heart of nations' economic development. It is in this perspective that Ye et al. (2009) mentioned that the construction industry has positive impacts on the European economy in terms of employment and gross product. However, this instrument of economic growth has been facing challenges. These challenges, according to Lam et al. (2008), Toor and Ogunlana (2010) as well as Wang and Huang (2006) have contributed to the complexity of construction projects and of project success definition. In this sense, actors (clients, contractors, construction companies, etc.) involved in the construction industry face numerous challenges among which budget compliance, increase complexity in design, delays in project delivery (Doloi, 2009).

Budget constraints: Considering that resources are generally limited, budgets constitute a major challenge in achieving the objectives of projects. Although all stakeholders agree on the importance of respecting the limits of the project's budget, it is very common that the costs become difficult to control as the project is progressing. For these reasons, it is very important that prior to the implementation phase, data that can impact the budget be identified and reported. Additionally, tools must be put in place to ensure that the financial commitments of the project are met (MCC, 2005; Xue et al., 2007).

Scheduling and Timing constraints: Time constraint is the second major challenge in the process of project implementation. The work must be delivered to a predetermined schedule, which generally corresponds to the date of the client's operations. This forces the project manager to establish its schedule depending on the following factors: availability of resources, availability of sites, access to financing, complexity of the proposed interventions, job scheduling and the construction's seasons and market conditions. Examples of time constraints are unrealistic expectations on the behalf of the general contractor, uncertain lead time regarding the availability of material and equipment and unrealistic program times (MCC, 2005; Xue et al., 2007).

Changes constraints: During the construction process, decisions have to be made. These decisions are usually based on prior experiences of the professionals involved in the project as well as on existing information that is made available to them. However, some internal or external factors may require that minor or significant modifications or adjustments be done on the project. Thus, any of these modifications can affect certain aspects of the work that have already been completed (Sun et al., 2006).

Communication problems: It is important that effective communication be established among actors involved in the construction process. Lack of transparency, limited communication and poor information are all sources of communication problems (Xue et al., 2007)

Behavioral issues: Misconduct is also part of challenges that the actors of construction projects face. Behavioral issues include: arrogance, lack of recognition for good performance, exclusion of some of the professional from the early involvement phases, narrow minded "win-lose" attitude (based on price) and adversarial relationships among actors (Xue et al., 2007)

Facing all these challenges, efficient exploitation of the resources is a necessity in construction industry. Construction companies need to be rapid, flexible and agile enough in acquiring resources (raw material, machinery, equipments, tools and even human resource) to cope with all uncertainties and pressures from the ever changing work environment. They need to respect the budget and time schedules, cope with the peaks of the work, reduce operating cost, make the best use of their idle resources when they are not involved in any project, reduce the huge cost of ownership and therefore their fixed costs. The Service Web offers the opportunities for the construction companies to overcome the challenges they are facing; it enables them to be more profitable and flexible at the same time.

The Service Web connects the stakeholders in construction industry. The cloud provider offers community π-clouds for the stakeholders. Equipments, tools, warehouses (space), human resource, equipments, machinery, etc. are offered on the π-clouds and can be accessed by all who have registered to use the services (Finding phase on Figure 4).

To offer the service, the cloud provider needs the stakeholder to register by providing, all the exact addresses, and type of service, their specifications and the leasing period using an interface. All the data is saved on a π-cloud and this data cloud can be accessed by the public.

Later, the cloud provider needs to save the project scheduling of each owner on a private cloud in order to schedule the return of the object or the human resource to the owner.

As shown in Figure. 4 using abstraction, each resource is given an exact address and it has to get equipped with tracking and monitoring devices. At this phase all resources are put on the construction π-cloud. Access to this cloud is restricted and each time a match is made between an owner, a user and other parties on the Mobility and Distribution webs, the access will be granted to them. At the same time, the cloud provider performs all the supporting processes in the construction π-cloud. The payment, insurance, maintenance, communication, and security issues are resolved on the cloud and managed by the cloud provider.

The operating process for the construction π-cloud is as follows:

Whenever a match could be found between a user and the owner, service level agreements are prepared and then the provider exploits the Mobility Web and moves the object to the user (obtaining phase on Figure 4). When the resources is obtained by the user, the providor needs to update the information on the public cloud.

While the user exploits the object or uses the services of the human resource, the provider evaluates the user and the user also sends its feedbacks to the provider (mutual evaluation system of users and owners). Any misuse or any case of loss, accident and other special cases will be reported to the cloud provider on real time, so that the provider is able to react timely and prevent any delays in returning the resource to its owner or to the next user (using process on Figure 4). The Service Web allows the users to benefit from the services offered by human resources of other companies without hiring them. These services can be offered on site or using online services. For example, whenever idle at the owner`s site, the workers can be sent to the user`s construction sites, or other services such as accounting, consulting and so on can be offered online, the files, documents, reports and pictures and be sent to the experts, analyzed by them and be sent back to the user.

When the leasing period is over the resource needs to be either stored by searching the Distribution Web or moved to the next user or be back to the owner by searching the Mobility web for the options. Whatever the decision is, the virtualization need to take place and the π-cloud get updated.

Each object it is required to be sent for repairing and maintenance. Where this maintenance has to be conducted, and which party is paying for the repair and regular maintenance depends on the type of the object and it specifications. The provider needs to be prepared with plans for repair and maintenance.

The great opportunities Service Web provides will make it an indispensable part of the business in construction companies in near future, but before its realization it is vital to deliberately ponder the following issues:

The cloud providers need to be prepared and well planned to manage all the data and resources for industries as big as the construction industry. The amount of data shared, required work, coordination of the resources will be unbelievably huge on the Service Web. Especially at the beginning, it is required that the cloud providers offer secure, reliable and robust π-clouds to build trust. Another important issue is the current way of doing business in construction industry. Companies that are winning the bids, making huge profits are mostly those which own resources. One of major way to gain comparative advantage in today's business is to access or own the scares resources faster than the other competitors. By using the Service Web, the resources will be offered to and accessible by any company no matter what their size is. Therefore, it is required that the construction companies define new business models before facing the shocks of doing business in new open global systems.

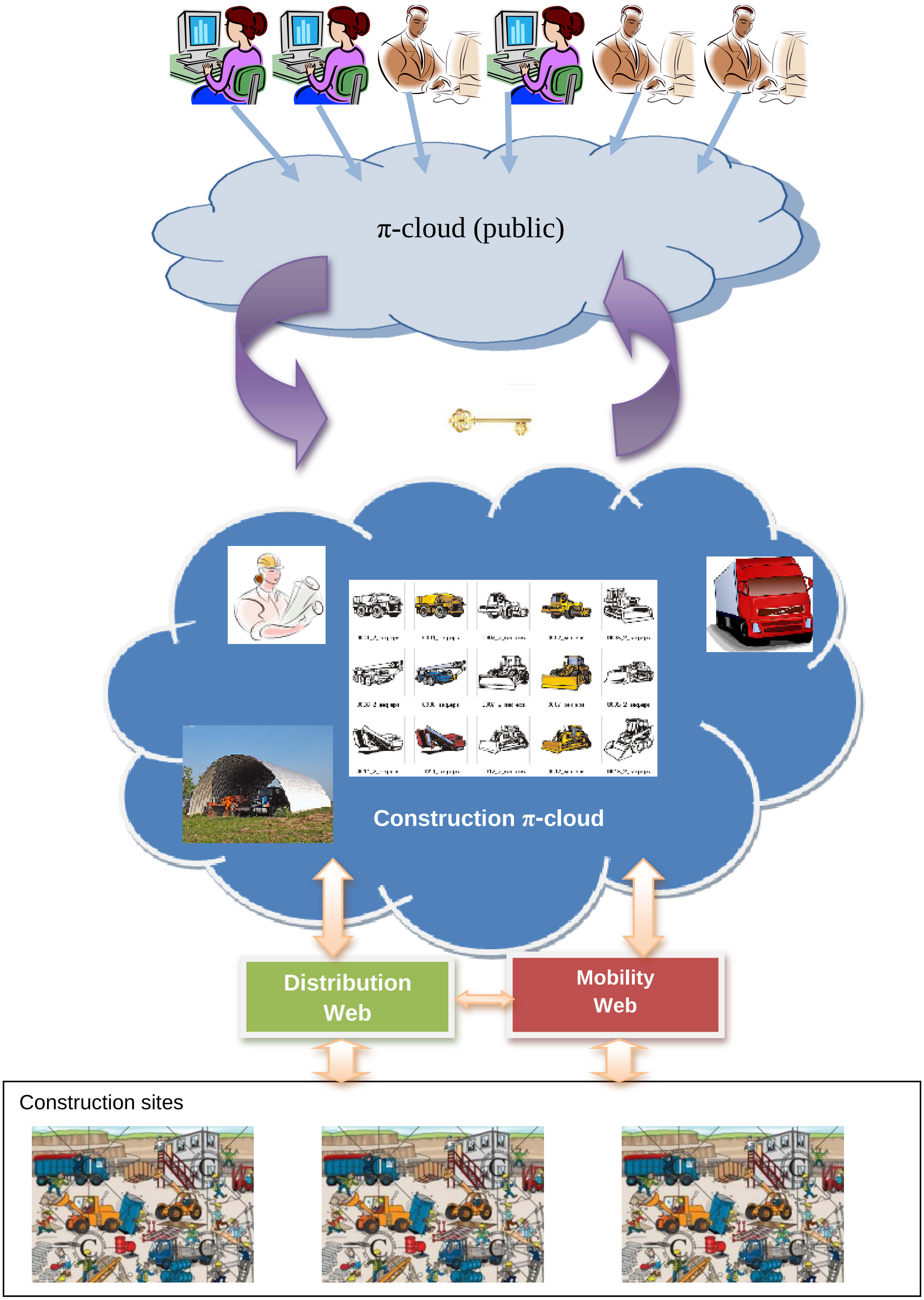

Figure 5 Illustrating π-clouds in the construction industry

6 Conclusion

Companies, organizations and individuals seek new more efficient and sustainable ways to manage their supply chains, to reduce their cost of ownership and to gain competitive advantage by providing timely and cost efficient products and/or services. The technological advances are forcing them to adapt their business models to open global systems. New open global systems bring along opportunities as well as the challenges. Within the paradigm of the Physical Internet, the Service Web is expected to help avoiding high cost of ownership, to respond rapidly to the ever-changing business environment, to gain benefit from the idle resources and to reduce the operational costs.

By identifying and exploiting the similarities between the Service Web and cloud computing, a conceptual model for realization of the Service Web is introduced. The Service web provides the opportunity of making profit from idle resources for the owner of the resources and the opportunity of paying less for accessing the object functionality for the users of the service. The conceptual model of the Service Web and its π-cloud has been introduced, illustratively sketched for the construction industry and its link to the Mobility Web and the Distribution Web enabled by the Physical Internet has been shown.

By introducing the conceptual model exploiting the cloud concepts, this paper attempts to take the first step into realization of Service Web. This work can be expanded upon in order to lead into future research. To evaluate the conceptual model and to realize the Service Web, simulation may be used. Following the new trend in sharing ride and space, the results of exploiting the Service Web and its π-clouds in terms of time and cost savings need to be assessed and disseminated so that companies start to grasp and see in practice the real benefits of open global systems.

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