# Smart City Logistics on Cloud Computing Model

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# Smart City logistics on cloud computing model

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**Abstract**

City developing in the sustainable manner – economically, ecologically and socially – is the most competitive when it meets citizens' demands. It becomes the most attractive place for life and work for residents. At the same time, building an inviting place that meets the needs of city residents is a difficult task for local governments. Firstly to identify, and secondly to fulfil the citizens' continuously changing needs. One of the easiest methods to help understand the residents' needs can be crowdsourcing usage. However the most challenging area of responsibility is to manage traffic by the city logistics infrastructure designed to eliminate congestion problems within existing city spatial and, at the same time, to flexibly reply on transport changing demands. The answer to those challenges facilitating future Smart City logistics development is interoperable IT system usage based on cloud computing model. Similarly, cloud computing, by its design and characteristics, is particularly interesting for the public sector aiming to reduce costs and improve flexibility in operations. The cloud computing model gives unique opportunity to design city logistics infrastructure in the way that it is easily adaptive to changing transport demands. The main objective of the article is to present Smart City logistics on the cloud computing model (Cloud Smart City logistics) as the concept of citizens' demand-driven flexible logistics infrastructure performance for the sustainable city of the future which is available for any city government interested in sustainable development.


Peer-review under responsibility of the scientific committee of Green Cities 2014

*Keywords:* Smart City; logistics; cloud computing

*"The 19th century was a century of empires, the 20th century was a century of nation states. The 21st century will be a century of cities."*

– Wellington E. Webb, former Mayor of Denver, Colorado

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## 1. Smart City

Cities are based on a number of different systems (infrastructures, networks and environments) central to their operation and development: people, business, transport, communication, water and energy (Figure 1). The effectiveness and efficiency of these systems determines how a city works and how successful it is at delivering its goals (Dirks & Keeling, 2009). At the same time, cities have limited resources and they must take account of the interconnected challenges and the interrelated systems they influence. In a particular single case, it is always a "trade-off" problem in choosing the most important system to concentrate at the moment. At the same time, presented systems are connected and influencing each other. Therefore, they require from city administration, the ability to predict the holistic impact of decision effects taken in a single area of the chosen system. They also require intelligent management in different layers of cities' activities.

Since it is expected that city administration will manage available resources in the sustainable manner, the measurable effects should be visible in the area of social, ecological and economic growth of the city. Simultaneously, fulfilling the "mixture" of available spatial and road network capacity or management limitations (e.g. there are no practical cargo public transport systems available for freight, so cities' administration have to rely on trucks and vans for urban distribution supported in most of the cases by logistics providers from the private sector).

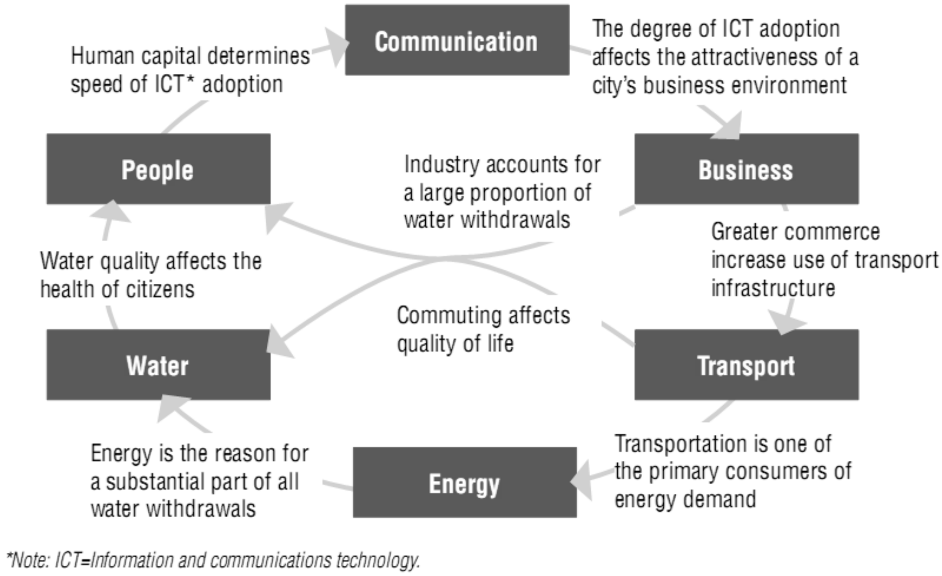


Figure 1 Sample of interrelationships between core city systems.

Smart City can be then defined when, "investment in human and social capital and traditional (transportation) and modern (ICT-based) infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory government" (Komninos, 2002). The other definition identifies key domains of Smart Cities, such as: smart economy, smart mobility, smart environment, smart living, smart people, and smart governance (Center of Regional Science, 2007). As well, Smart Cities can be understood as places generating a particular form of spatial intelligence and innovation, based on sensors, embedded devices, large data sets, and real-time information and response. Pervasive information and communication technology means that there is a much greater scope for leveraging technology for the benefit of cities (Dirks & Keeling, 2009):

- instrumentation, or digitization, of a city's system means that the workings of that system are turned into data points and the system is made measurable,

- interconnection means that different parts of a core system can be joined and "speak" to each other, turning data into information, and
- intelligence refers to the ability to use the information created, model patterns of behavior or likely outcomes and translate them into real knowledge, allowing informed actions.

At the same time, collective intelligence and social media have been major drivers of the spatial intelligence of cities and they can be used by a crowdsourcing tool to examine the demand for transport. The other way to measure traffic and plan transportation (and others, like commercial) activities within the urban spatial area is analyzing the density of mobile usage within different areas of the city. Future internet technologies with instrumentation and interconnection of mobile devices and sensors can collect and analyze urban data in real time, improve the ability to forecast and manage urban flows. Then, it is worth considering the technology drivers of embedded spatial intelligence, the new e-services that can be created in cities and the governance of innovation ecosystems within smart environments embedded in the urban space (Komninos, 2013).

As mentioned, the Smart City concept is multi-dimensional. In most of the cases it is a future scenario (what to achieve), even more it is an urban development strategy (how to achieve it). It can focus on how technologies enhance the lives of citizens or other stakeholders, but should not be interpreted as drawing the Smart City technology scenario. Rather, the Smart City is how citizens are shaping the city in using this technology, and how citizens are enabled to do so by getting the support of cities government. The Smart City can then be understood also by how people are empowered, through using technology for the contribution to urban change and realizing their ambitions by living in a specific, chosen place. "Cities have the capacity of providing something for everybody, only because, and only when, they are created by everybody" (Jacobs, 1992).

The Smart City is able to provide the conditions and resources for change. Urban areas can then be understood as an innovative ecosystem with specific demand and supply needs of different s of citizens or other stakeholders. In the ideal model, the Smart City is the engine of transformation, a generator of solutions for wicked problems - it is how the city is able to behave smarter for sustainable growth.

## 2. City logistics

According to the Council of Supply Chain Management Professionals, logistics management is that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverses flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet the customers' requirements (cscmp.org/about-us/supply-chain-management-definitions).

The main objective of logistics is to co-ordinate the most important activities like: freight transport, storage, inventory management, materials handling and all the related information processing in a way that meets customer requirements at optimum cost. In the past this cost has been defined in purely monetary terms. As concern for the environment rises, companies pay more attention to the "external costs" of logistics associated mainly with climate change, air pollution, noise, vibration and accidents (www.greenlogistics.org/).

Urban freight transport involves shippers, freight carriers, administrators and residents (consumers) – a configuration made all the more complex by the often times varying visions among these stakeholders with different goals and interests. Simultaneously, freight carriers are expected to provide higher levels of service with lower costs (e.g. Just-in-Time or short-time deliveries requirements). Since freight is the most influencing logistics' activity on environment quality, logistics and supply chain management often concentrates on its optimization (mainly in the fields of time and cost and mostly it is driven by the level of customer service provided). To address these complicated and difficult problems, numerous city logistics schemes have been proposed and implemented including: cooperative freight transport systems, advanced information systems, Intelligent Transport Systems (ITS), urban consolidation centers, regulation of load factors, time windows for entering city center, off-hour delivery, and road pricing. Other available tools helping to solve complex congestion problems in urban spatial are: ITS, Internet of Things (IoT) and/or Corporate Social Responsibility (CSR) implemented by the private sector, all supported by Information and Communication Technology (ICT).

Taking above determinants into consideration and analyzing global trends (influencing both – private and public sector activities), the sustainable logistics activities are the main areas of interest of the future Smart City. That should be analyzed within the aspects of society (safety, health, access, equity), environment/ecology (climate change, air quality, noise, lad use, biodiversity, waste) and economy (growth, efficiency, employment, competitiveness, choice). The sustainable logistics dimensions are presented on Figure 2. (www.greenlogistics.org).

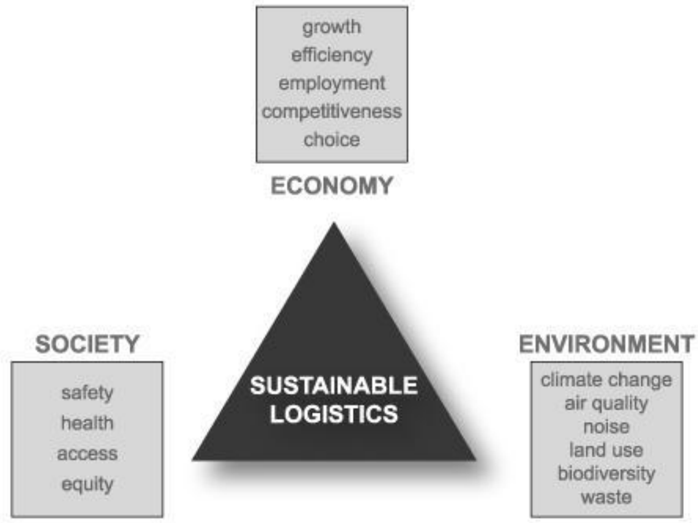


Figure 2 Sustainable logistics dimensions.

City logistics can be then defined as, the process of totally optimizing urban logistics activities by considering the social, environmental, economic, financial and energy impacts of urban freight movement and/or, “the process for totally optimizing the logistics and transport activities by private companies with the support of advanced information systems in urban areas considering the traffic environment, its congestion, safety and energy savings within the framework of a market economy”. It considers three aspects: mobility (smooth and reliable traffic flow including freight traffic), sustainability (environmentally friendly, reducing greenhouse gas emissions and decreasing the impact on the local environment) and livability (e.g. growing importance of elderly residents’ specific needs) (Taniguchi, 2012).

There is a wide range of literature emphasizing the negative impacts of freight transportation on the environment, air quality, safety and quality of life in cities caused in most of the cases by congestion. At European level, the European Union recognized the need to reduce these externalities (European Commission, 2001). Due to this fact, logistics activities and management practices were developed in urban space and are the subject of worldwide analysis. The examples of digital urban renewal initiatives using ICT tools in different categories of cities management layers are shown in Table 1. (Green, 2011).

The other project, which was addressed towards the problems of the inefficient and ineffective management of urban freight distribution, a critical component of the overall urban transport system and primary source of pollution, was called SUGAR and promoted basic actions for the exchange, discussion and transfer of policy experience, knowledge and good practices through policy and planning levers in the field of urban freight management. The SUGAR partnership brought together 17 institutions from 10 countries working on enhancing capabilities in terms of infrastructures and the design of urban mobility (SUGAR, 2011).

Table 1. Digital urban renewal initiative categories

| CATEGORY | DESCRIIPTION | EXAMPLE |
|---|---|---|
| Citizen services | Using ICT to make existing processes involving interaction on between the municipality and citizens better, cheaper, or both. | Guldborgsund's video-enabled satellite offices |
| Regional/economic development | ICT-oriented economic development or regeneration. Aimed at attracting digital industries or residents that make real estate decisions based on the availability of broadband. | Barcelona's 22@district |
| Community | Using ICT and "crowdsourcing" to increase community cohesion or influence and improve the political system. Typically started by civil sector organizations of social enterprises. | Harringay Oneline, Ecomodo, StreetBank, EveryBlock, Tyze.com |
| Law enforcement | Using ICT to improve law enforcement and/or crime prevention through surveillance or improved communication of operatives. | Drancy's CCTV network Birmingham Shotspotter gunshot location system |
| Resource management | The use of ICT to improve the functioning of citywide system to use energy and other resources more efficiently, | Adaptive traffic lights Singapore's water distribution system, Amsterdam's EcoMap |
| Behavioral change | Using ICT to facilitate behavioral change by providing information or tools that make the desired behavior easier or more attractive. | The Digital Environment Energy Management System (DEHEMS), Liftshare wallkit, WhopCar, Seoul Personal Travel Assistent |
| Health | The use of ICT to promote or deliver healthcare and control illness or disease. | HelthMap Global Disease Alert Map |

## 3. Cloud computing model

Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. It is composed of five essential characteristics (on-demand self-service, broad network access, resource pooling, rapid elasticity, measured service), three service models (Software as a Service – SaaS – the capability provided to the consumer is to use the provider's applications running on a cloud infrastructure and are accessible from various client devices; Platform as a Service – PaaS – the capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created by the provider; 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) and four deployment models (Private cloud - the cloud infrastructure is provisioned for exclusive use by a single organization; community cloud - the cloud infrastructure is provisioned for exclusive use by a specific community of consumers from organizations; public cloud - the cloud infrastructure is provisioned for open use by the general public. It may be owned, managed, and operated by a business, academic, or government organization, or some combination of them. It exists on the premises of the cloud provider; hybrid cloud - the cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities, but are bound together by standardized or proprietary technology) (Mell & Grance, 2011).

The most important factor from the management point of view of cloud computing model are its essential characteristics (Mell & Grance, 2011):

- On-demand self-service. A consumer can unilaterally access computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service provider,
- Broad network access. Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thick or thin 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 a location at a higher

level of abstraction (e.g., country, state, or datacenter). Examples of resources include storage, processing, memory, and network bandwidth,

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

These characteristics imply a broad range of benefits enterprise and other organizations that adopt the cloud computing model. These are (Centre for Economics and Business Research, 2010):

- reduced IT capital expenditures due to hardware abstraction from users,
- reduced spend on IT headcount or more valuable redeployment of staff elsewhere in the IT department or elsewhere in the business,
- rapid access to faster computing capabilities without the need for intervention by the providers of the services being accessed and without having to "wait in line" for IT department assistance,
- improved IT capacity utilisation through pooled resources that serve multiple users, improved business scalability in response to client demands through computing capabilities that can be elastically provisioned, that is, increased when users wish to scale up and real improved business scalability in response to client demands through computing capabilities that can be elastically provisioned (increased when users wish to scale up and released when users wish to scale back down),
- rapid rollout of on demand resources resulting in faster time to market for new goods and services and quicker returns on investment,
- "pay-per-use" model so that users incur only the costs of the computing capabilities that they need and use, and
- lower barriers to entry to markets due to the reduced fixed costs of entry.

Due to its characteristics cloud computing transparently shares among users scalable elastic resources over a limitless network. The most important benefits for respondents of Ovum survey (conducted in 2011) concerning cloud services usage representing multinational corporations are presented in Figure 3. (Molony, 2011).

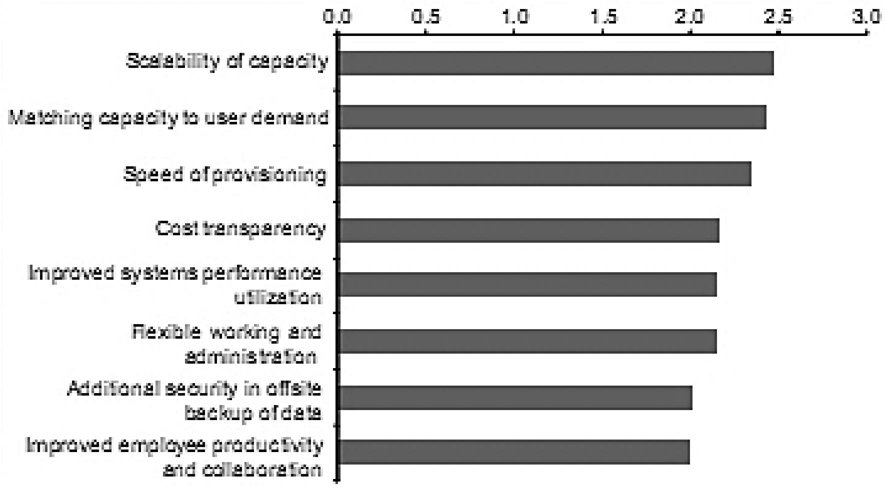


Figure 3 The main benefits from use of cloud services.

In other – KPMG International and Forbes Insights – survey, close to 430 public-sector government executives from 10 countries were analyzed to learn about their cloud computing strategies and expectations. It is not surprising, that for government respondents, with limited budget resources, the most influential driver for cloud computing implementations was (is) potential cost savings (fig 4). Governments are seeing the potential for achieving cost reduction by migrating to a more virtual operating model through the adoption of cloud as critical. Some are already identifying potential cost savings, such as reduced invested capital by using less IT infrastructure and lower administrative costs by requiring fewer internal staff to perform processes (KPMG, 2012).

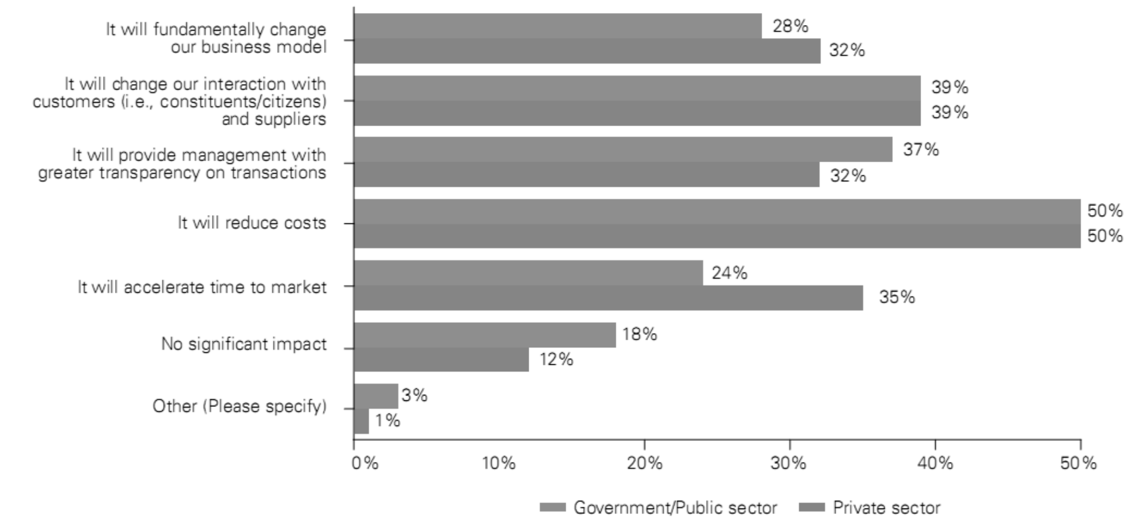


Figure 4 The potential impact of cloud on business model/operations.

Cloud computing technologies result in cost savings to a firms' IT budget which, in turn, increases profitability. There are at least three areas in which firms can make cost savings by cloud computing usage (Centre for Economics and Business Research, 2010):

- IT capital expenditure: by eliminating server and storage costs and replacing these with "pay- per-use" cloud computing capabilities, customers can reduce their net IT capital spend,
- IT labor costs: by outsourcing IT services, customers can reduce their IT headcount and/or redeploy staff into more productive areas of IT departments such as application development, and
- IT power and cooling costs: by eliminating the need to power and cool the server and data centres, firms can save a substantial amount on energy bills.

Capital expenditure cost savings can be associated with the benefits accruing from hardware and software consolidation, as well as a reduction in server and storage costs. For the private cloud computing model, the following capital expenditure cost savings can be potentially available:

- an overall 20% reduction in the costs of external IT services through hardware consolidation and standardized application frameworks,
- an overall 2% reduction in software maintenance costs achieved through software consolidation,
- an overall 18% reduction in server and storage costs through reduced hardware maintenance, and
- an overall 44% reduction in network hardware costs due to server consolidation, reduced facilities and fabric maintenance.

Additionally, the following cost reductions can be achieved by cloud computing model implementation (Centre for Economics and Business Research, 2010):

- 20% reduction in application development costs due to productivity gains in IT services,
- 18% reduction in internal operations, maintenance and support costs.
- Power and cooling cost savings are the result of hardware consolidation, which eliminates the need to power and cool large server and data centers. That can be reached on the following levels:
- 44% of total IT power and cooling costs in a private cloud computing environment,
- 61% of total IT power and cooling costs in a hybrid cloud environment, and
- 79% of total IT power and cooling costs in a public cloud environment.

The potential savings (shown as a percentage of component parts of IT budgets) in comparison with possible cloud services expenditures in different deployment models are presented in Figure 5. (Centre for Economics and Business Research, 2010).

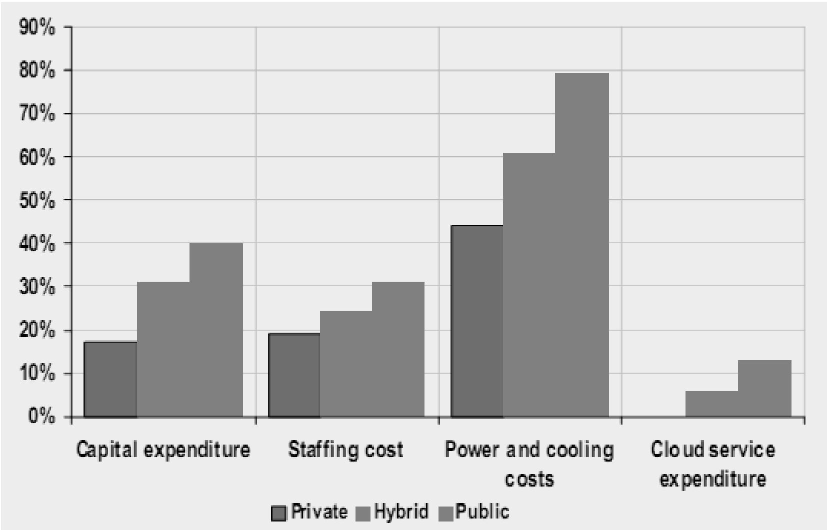


Figure 5 Savings as a % of component parts of IT budgets.

The next decade will meet widespread centralization and virtualization of the world's computing power and by usage cloud computing new economies of scale will be delivered. Cheaper devices will seem more powerful, as computing power can be easily moved to the cloud. Development and deployment of software and applications, multimedia content and public data repositories to poor and excluded groups will be faster and less expensive. Cloud computing will also drive innovation in new services and experiences that leverage supercomputing capabilities. Data mining, analysis and intensely realistic simulations will have widespread applicability in the public sector e.g. health, education and private sector. Considering private sector in the short term, cloud computing will be, or already is, served by large, commercial clouds like Google and Amazon, e.g. the United Kingdom's national "G-cloud" initiative can be seen as a promising model for the megacities. Government clouds will reduce IT costs for governments (Figure 6), and potentially provide a platform for small businesses to deploy services and applications helping urban spatial and traffic management (Townsend, Maguire, Liebhold, & Crawford, 2010). Those solutions should be of specific interest to all citizens or other groups of cities' administrations stakeholders.

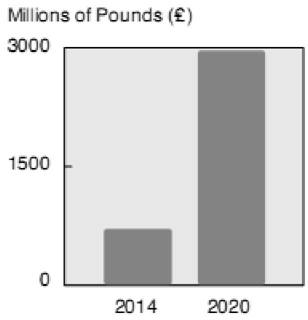


Figure 6. Annual savings from the UK g-cloud.

Obviously cloud computing is not a perfect solution. For example, on the problematic side, the "security" was cited by almost half of all government respondents (47%) of the KPMG study as their most significant concern, only exceeding the private sector slightly at 44% (Figure 7). Among the largest government entity respondents of the survey, the figure rises to 56%, the highest level of concern cited by any group. However, almost 80% said they would be more confident if cloud services were certified by a government body (KPMG, 2012).

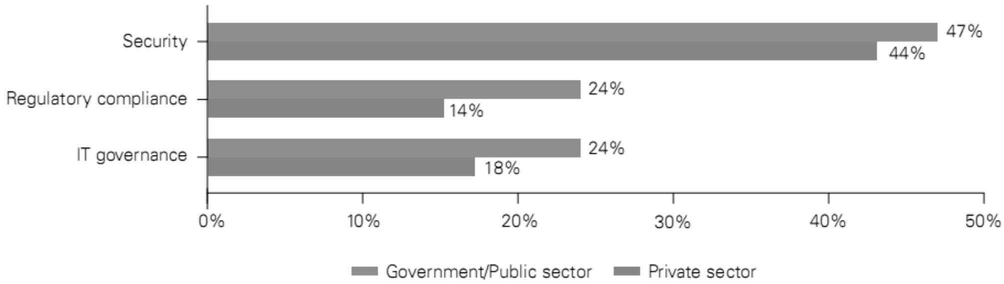


Figure 7. The top challenges or concerns in adopting a cloud environment.

Cloud computing has also been recognized as an interesting solution in logistics management. For example, the working group "Future Topics of Logistics" of the Scientific Advisory Board of the BVL quotes a concept of "Cloud Logistics" as "an environment of "virtual" systems that facilitate supply chains' overall coordination and use of distributed resources, capacities, processes, and services from supply chain partners. These systems are based on advanced information and communication technologies that leverage modern Internet services." (German Logistics Association, 2012). In the similar manner the term "Supply Chain as a Service" (or Logistics-as-a-service) can be understood (Leukel, Kirn & Schlegel, 2011). Cloud computing can solve the fundamental logistic problem of providing the right commodity or service, in the right quality and quantity, at the right location and time, to the right customer, at the right price for computing resources (Delfmann & Jaekel, 2012).

At the same time the following concerns must be addressed in the cloud logistics development and implementation (DHL Customer Solutions & Innovation, 2013):

- high diversity of business models and offerings referring to cloud logistics (single service providers, platform providers, etc.),
- several cross-company projects working on the implementation of cloud logistics service marketplaces in Europe with mostly transnational or regional scope, and
- no clear evaluation of cloud logistics users cases and business models for different types of logistics providers.

## 4. Smart City on cloud computing model

The cloud computing model gives unique opportunity to design city logistics infrastructure in the way that it is easily adaptive to changing transport demands. To meet this opportunity it is extremely important to standardize infrastructure, platforms and applications necessary to provide maximum efficiency from the systems and other available resources. Standardization accelerates technology diffusion helping to manage the city in a sustainable manner having in mind the holistic impact of decisions taken on different dimensions and systems in cities' activities.

Cloud computing will be a powerful enabler of both digital-city and digital-society initiatives because it makes massive computing and storage power and sophisticated applications available to anyone: an individual, small business, Non-governmental Organizations, local authority or a large metropolitan government. As cloud computing services become more mature and trusted, in the short term they will reduce the threshold of funding and technical knowledge required to implement new applications. This can drive a wave of ICT-enabled innovation throughout cities and society. The example of IT usage in digitally enabled cities is presented in Figure 8. (Hodgkinson, 2011).

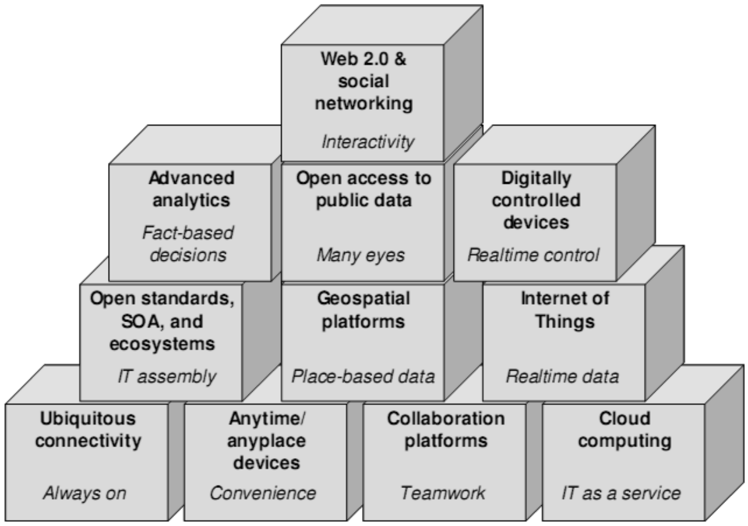


Figure 8 IT building blocks of digitally enabled cities.

Growth, economic value and competitive differentiation of cities will increasingly be derived from people and their skills, creativity and knowledge, along with the capacity of the economy to create and absorb innovation. According to an IBM study, to compete in this new economic environment, cities will need to apply advanced information technology, analytics and systems thinking to develop a more citizen-centric approach to services (Hobson & Naccarati, 2011). The potential areas of cloud computing solutions usage are presented in Figure 9.

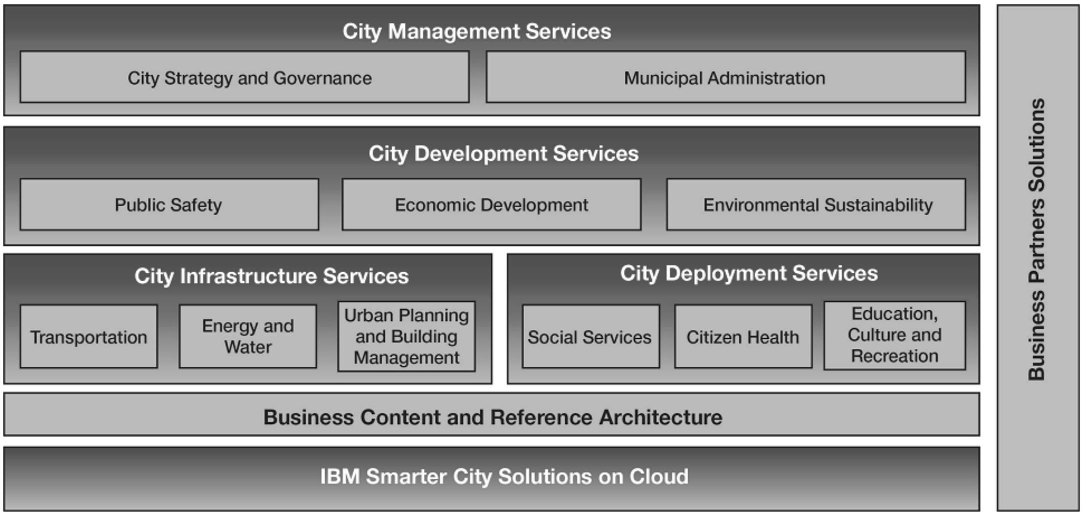


Figure 9 Potential areas of cloud computing implementation in possible Smart City domains.

The transition of urban public governments to the cloud computing model is revised or already adapted in the following countries: United States, United Kingdom, Canada, Japan and some chosen European countries (Australian Government, 2011). In most of the cases, the demand on computing power and technological innovations implementations comes from citizens or other groups of cities' stakeholders. This will force the need for a resource of computing power by cities' administration. Network interoperability and merging of the network and media technologies, IoT, machine to machine communication (M2M) allowing wireless and wired system to communicate with other devises of the same ability, will be necessary to cover the broadband demand in the public space of future cities. Those systems play an important role in a cities sustainable development helping effectively fight with congestion and its negative consequences.

A proposition of a safer way of guiding the Smart City within a rapidly changing environment of technologies, societal change, and business models can be based on four pillars (Schaffers, Komninos & Pallot, 2012):

1. "Share more – Develop less" – the development of a sharing and collaboration culture. It is about the exchange of applications among city authorities, the creation of communities of non-trading solutions, sharing and exchanging application software. This goes together with the use of free open source software. If existing free software and applications are not available, the closest solution is the cloud.
2. "Look forward" – the development of a forward thinking culture and a medium to long-term perspective. It is about understanding long-term, like 10 years horizon of events, watch and monitor what other communities do and learning from each other. This includes also sustainability strategy revision.
3. "Spend less" – it is about low-costs solutions. The standardization of solutions will accelerate technology diffusion and learning curves as city administrations become of their added value.
4. City authorities have to become aware of a number of existing methods for involving the users. The existence of a new technology stack of "cloud-IoT-linked data" does not guarantee the development of a new service based on these technologies. The recommendation is to promote a more proactive role of end users and citizens in services innovation.

The cloud computing model enables governments to realize financial, service delivery and operation benefits. It helps governments become "smarter" by gathering data about a city's environment, communicating essential information with other government entities and correlating situational events with historical data. Table 2 highlights potential values of deploying Smarter City solutions on the cloud computing model (Hobson & Naccarati, 2011).

Table 2 Examples of potential benefits of deploying Smart City solutions on cloud computing model.

| Benefits | Value Proposition |
|---|---|
| Financial benefits | |
| Lower upfront capital costs | There is no need to purchase or upgrade hardware and software resources |
| IT managed for you | Pay no addition costs for system upgrades because they are done behind the scenes and IT infrastructure is managed for you |
| Pay as you go | Pay only for the services that you use when you use them. |
| Architecture ans software | Scale your deployment at your pace so you have the time to plan and budget when toad departments, towns and other capabilities or services |
| Benefits for citizens | |
| Enable improved quality services | Use information for better decision-making. Anticipate problems to resolve them proactively. Improve coordination of resources to operate more effectively. |
| Other services from the internet | Enable citizens to access government information and services on the internet from multiple devices (for example, computer, tablets, smart phone and more. |
| Improve traffic management | Help city traffic managers visualize and analyze traffic conditions so that they can better manager incidents, improve commuter experience, reduce pollution and more. |
| Reduce water services disruption | Better manage inventory, supply chain and people associated with water assets, thereby reducing costs, decreasing downtime and improving overall efficiency. |
| Operational benefits | |
| Enterprise-level reliability and security | Experience affordable enterprise-level  and security capabilities in a cloud model |
| Quick startup | Hardware, operating system and software ready to be configured and customized as needed. Reduce 4-12 weeks of deployment cycle time compared to a traditional deployment model. |
| 24x7 support | Receive continuous support provided by IBM with assurance of enterprise-level backup, disaster recovery and managed availability. |
| Anywhere/anytime access | Get access when you need it with services available from a web browser. |
| Fast provisioning | Provision applications rapidly. |

As mentioned previously, logistics service providers play an important role in managing transport activities in urban spatial since they possess essential knowledge and experience in the planning and implementation of transportation routes. One of the global logistics providers – DHL – analyzed social, business and technology megatrends importance on future business in different time perspective. Figure 10 presents the key trends and their approximate timeframe. It can be helpful to derive new strategies, develop more powerful projects and innovations to compete in the future. It is worth noting, that both, urban/city logistics management and cloud computing model, are allocated as high important trends influencing new ways of doing business in the near future (DHL Customer Solutions & Innovation, 2013).

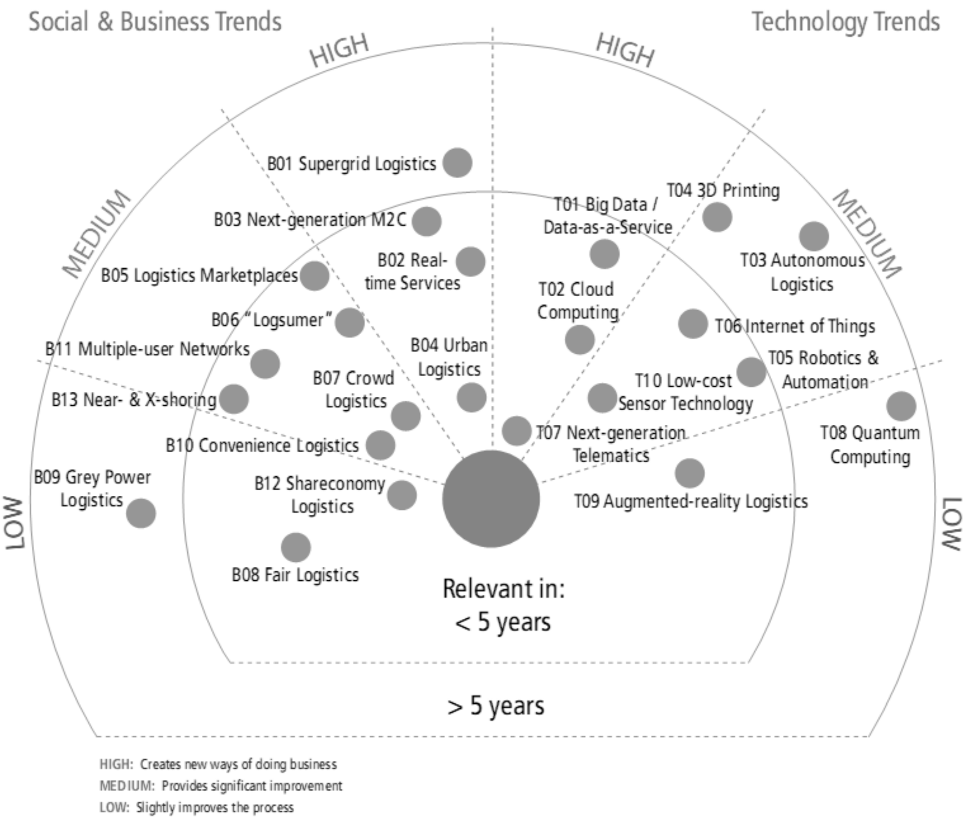


Figure 10 The Logistics Trend Radar.

As already stressed, the paradigm of cloud-based services is increasingly tangible for logistics activities specially when considering dynamic urban traffic problems. Cloud computing meets the challenges of complex, distributed, uncertain, volatile, and less-predictable logistics environments. Since it enables the provision of scalable service levels (e.g., fixed or flexible delivery times) without additional resources, services can be integrated into customized logistics solutions or removed dynamically with respect to changing volume requirements or to requested additional capabilities (e.g., compliance). Cloud computing and IoT are fields of special interest of current and future usage in Smart City projects development. The possible areas of their implementation are presented in Table 3. (Schaffers, Komninos & Pallot, 2012).

Cloud computing and the IoT are fundamental layers of ubiquitous connectivity on which stands a layer of open public data and advances analytics for fat reaction and real-time decisions. The open data trends have expanded to government data and many public agencies are providing access to datasets stimulating the creation of application for information retrieval and decision making, that can be successfully used within Smart City logistics projects.

Table 3. Internet Technologies and Smart Cities Roadmap.

| REGIME | Short term (2014) | Medium term (2017) | Long term (2022) |
|---|---|---|---|
| Technological change<br><br>*(Dominant designs, emerging technologies, in teroperability)* | -CLOUD: Virtualization<br>-CLOUD: IaaS for smart cities | -CLOUD: Web platform<br>-CLOUD: SaaS for smart cities<br>-Content-context fusion | -CLOUD: PaaS for smart cities<br>-CLOUD: Service integration |
| | -IoT: RFID<br>-IoT: Speech recognition<br>-IoT: Open data apps | -IoT: Multimodal sensors<br>-IoT: Location aware apps | -IoT: Urban IoT platform<br>-IoT: Cloud based on to logies<br>-Content-centric networks |
| Industrial change<br><br>*(Networks of technology developers, alliances, standardization)* | -CLOUD: Large companies clouds, Google, MS, Amazon global clouds | -CLOUD: | -CLOUD: |
| | -IoT: Sensors into utilities and energy networks | -IoT: Alliances of large companies | -IoT: Large scale applications |
| Social change<br><br>*(Behavior, routines, values, preferences, demand, end-users)* | -CLOUD: Reduction of IT costs | -CLOUD: Security issues raised<br>-CLOUD: Disaster management addressed | -CLOUD: Continuity of service<br>-CLOUD: Learning curve |
| | -IoT: Experimental facilities<br>-IoT: A few city pilots | -IoT: Multiple city pilots | -IoT: Large scale demand for sensor-based city infrastructure |
| Policy change<br><br>*(Regulations, economic instruments, governance, agreements)* | -CLOUD: Transition white papers<br>-CLOUD: preparing to the cloud | -CLOUD: Pilots at city levels<br>-CLOUD: Legal and regulatory | -CLOUD: Whole smart cities on the Cloud |
| | -IoT: Preparing to the IoT | -IoT: Regulations and procurement | |
| NICHES of novelties | Short term (2014) | Medium (2017) | Long term (2022) |
| Technical change | -CLOUD: SaaS<br>-CLOUD: IaaS | -CLOUD: PaaS | -Higher capacity of broad band networking<br>Tele-immersive environments |
| | -IoT: Experimental facilities<br>-IoT: Open/linked data | -IoT: M2M in city environments | |
| Industrial change | -CLOUD: Private and hybrid clouds<br>-CLOUD: Hasting of G City services | -CLOUD: SaaS and PaaS in the main domains of cities | |
| | -IoT: Sensors for city environment alert | -IoT: Smart gird/Smart meters in cities | |
| Social change | -CLOUD: Pilot city application in city utilities, districts, and gov. | Large scale demand of smart city applications and services | |
| | -IoT: Sensors for city environment alert | -IoT: Embedded city intelligence proof of concept | -IoT: Extended demand for sensor over city networks |
| Policy change | -CLOUD: Government roadmaps to G service<br>-CLOUD: US reform of IT management | -CLOUD: Standards development adaption | |
| | -IoT: China encouraging Technologies for IoT | -IoT: FPB IoT PPP<br>-IoT: Harmonization of frequency bands | |

## 5. Summary

Concerns about the environmental impact of urban freight transport are growing along with population density and urban congestion. Awareness of the need for sustainable urban development is also on the rise and the coordination of traffic and congestion problems is receiving greater attention. Yet the need is urgent for more efficient and effective logistics management solutions that not only address costs but also fully tackle environmental issues such as noise, air pollution, vibration and visual intrusion.

By using the cloud computing model in urban management system, cities management, development and infrastructure services can gain:

- reduction of the total cost of provided services for citizens,
- more agility, flexibility, and elasticity, quick and cost-efficient reaction to less-predictable events and changing customer (citizens and/or other stakeholders) requirements,
- risk reduction, globally accessible services, easy and fast implementation, and
- strong support for sustainable development.

Smart City logistics on cloud computing model (Cloud Smart City logistics) is the concept of citizens' demand-driven flexible logistics infrastructure performance for the sustainable city of the future. It is available for any city government interested in sustainable development and efficiently fighting with negative congestion effects in a proactive manner. Cloud computing adaptation in Smart City logistics solutions allows achievement of customized, personalized, transparent and affordable solutions helping to solve current problems in urban spaces. It stimulates economic growth by easy interconnection with other systems between cities and on an international level. Smart City logistics with the help of instrumentation and interconnection of mobile devices and sensors based on the cloud computing model, which collects and analyses real-world data, improve the ability to forecast and manage urban flows and push city smartness forward.

Smart Cities highlights the route of spatial intelligence. Internet technologies promoting cloud-based services, IoT, real-world user interfaces, use of smart phones and smart meters, networks of sensors and RFIDs open new ways to collective action and collaborative problem solving. This can be successfully used by administration to support sustainable growth. Cities can significantly reduce congestion and develop economically, ecologically and socially by introducing Smart City logistics concept based on the cloud computing model with the benefits to all stakeholder groups.

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