Advances in Internet of Things as Related to the e-government Domain for Citizens and Enterprises

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Abstract This work deals with the role of Internet and, specifically, of Internet of things with its advanced performances (i.e. Cloud technology), in the *e-government* domain. It is based on the multi-year direct experience of the authors committed to develop the complex digitalization process of the Italian Public Administration with the objective of yielding ever improved services delivery, with respect to quality and time, to citizens and enterprises. The underlying rationale is that since the Public Administration, in Italy, but in most developed countries as well, acts as a critical switching node for about 50 % of the Gross National Product, its internal machinery improvement achieved through a largely diffused advanced and well suited ICT solutions adoption, will strongly affect in a positive manner the national competitiveness, leading, in the end, to a better scenario for employment and wealth. Apps, open data and Cloud are keywords offered to the reader as basic seeds for the understanding of a proposed model and corresponding solution to deal with the complex problem of setting up both single and multi-Public Administration business processes. In both instances, a novel logical and technological model is introduced and discussed, strictly driven by the end user needs, on the front office side, i.e. by the real demand and not by a theoretical, often generic, technology offer.

1 Introduction

A Public Administration (PA) unable to accomplish its various missions as determined by law, constitutes a serious deadlock to the development of any country, and keeps far from it also potentially interested foreign investors, which do not feel

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properly protected by a too slow and inefficient machinery, difficult to understand from the outside world.

The main objective of this work is that of analyzing and defining strategical criteria in order to realize a knowledge information system of prototypal nature designed for the PA considered as a whole, resulting from a new modeling of organizational processes, based on a complete:

- document flow "de-materialization"
- introduction of activity and business process powerful workflow tools
- introduction of a semantic level able to ease document organization and an information smart access from citizens and enterprises, including the full tracking versus time of their instances to the various reference PA over the territory
- development and use of Cloud technologies for PA front-office and back-office applications.

The system is conceived to yield a series of services to the various end user categories, among which access to the citizen digital record and the enterprise digital record, support to the open publication of public data as produced by a given PA and to their integration with data from other PAs and, more in general, with other open data, as ruled in the various countries and, for example, in Italy by the Digital Administration Code (CAD), according to the laws n. 82/2005 and n. 235/2010 and their further modifications and integrations.

Following a deep analysis of the information system status currently installed at the various hosting PAs, it is evident the need of re-thinking the nature and architecture of such systems. The main reasons are related to the obsolescence of the running systems and to the architectural model previously adopted, such as the client-server one. Such considerations do not allow an easy evolution of such systems towards new and more performing solutions. Furthermore, the expected increase of data as generated by document and information de-materialization in each single PA and those expected from the opening of the internal processes from and to the citizens (trend known with the denomination of *big data* or *data deluge*), will lead to the point of the need of reconsidering also the tools supporting such data persistency to be able to manage data amount of the order of peta or exabyte for each single PA [4].

To such extent, it is worth to mention some technologies potentially capable to optimize the use of processing and storage resources:

- **virtualization**: it allows to disentangle the applications from the underlying hardware, yielding in an optimal resource usage at run time, reducing management and maintenance costs, as well as, if properly monitored, energy consumption, also making easier disaster recovery procedures, service quality and operational continuity
- **Cloud technologies**: it is based on virtualization techniques usage and it allows resource sharing among different administrative entities (*tenant*), yielding to each of them the feeling of having available infinite resources and, at the same time, making possible cost attribution only as a function of their real use. Such an approach keeps also into account the adoption of programming languages based on parallel

and logic-functional paradigms, which better fit the dynamic and distributed nature of the new applications on the server-side

- **no SQL databases**: this is an approach to heterogeneous data storage and access, promoted in 2003 by Google researchers and also adopted by other relevant Internet providers, which removes the limits in performance and scalability of current solution of commercial databases as applied to *big data* contexts.

The realization of the prototypal system should adopt the most innovative techniques both for the development of software modules (*apps*), also by taking into proper account the guidelines on "reuse by parts", and for the development of user interfaces highly usable, by taking advantage of the interaction features as offered by mobile devices.

Another important aspect for system success, will be its independence from the application domain, in order to obtain a product easily usable in many PA sectors (portability and scalability of the prototypal solution). Of course, the strategic design criteria do not refer only to technological profiles, but also to the normative ones, thanks to a careful analysis of the various constrains which limit a full digitalization of the administrative process, area internationally known as e-government, in order to guarantee that when the system is realized and in place, it will fit the numerous current laws and ready to implement also new tools which will be in turns later regulated, until even to prepare new proposals "de jure condendo".

It is worth to mention that the PA innovation need meets a relevant connection item of the Horizon 2020 European Union (EU) program for two main reasons:

- reason number one is that, for the first time, Horizon 2020 joins, inside the same framework, Research&Development and Innovation (until FP7, included, the situation has been different)
- reason number two is due to the observation that in Horizon 2020 the content titles for Research&Development and for Innovation are named in its third part only: Societal Needs, to represent as the new knowledge production (Research& Development part) and Innovation (which includes larger and more differentiated dimensions, such as the anthropological, the social and the economic ones) is mostly driven (see quantitative aspects about the resource distribution over the three aforementioned chapters) from the *demand* of providing adequate solutions to concrete needs of citizens and enterprises and *not* from the offer of even advanced technological solution looking for problems. *In fact, the main need is to yield value to citizens and enterprises of the various countries through a more efficient PA thanks to the use of advanced ICT technologies, such as Cloud, in order to provide services in such a manner to be law-compliant and economically sustainable.*

For what it concerns the aspects related to new ICT technologies, it is necessary to keep into account the activity lines of the European Research Area (ERA) and for the industrial and technological leadership in the ICT domain:

- **development, diffusion and functioning of ICT based electronic infrastructures**: the PA need allows to make available either for the PA itself or for other

institution data related to the various activities (with respect to the privacy-law constraint), also historical data in order to perform analyses and studies from various disciplines researchers, either scientific and humanistic ones, achieving an incentive effect for the industrial context development

- **next generation processing: advanced information systems and technologies:** the ways of application development, particularly the server-side ones, since they must be compliant with specific maintenance requirements, laws, technical rules and certifications, reuse and migration, will allow the experimentation of paradigms different from object-orientation, in order to better take advantage of the parallel and distributed features of Cloud (for example, parallel and logic-functional languages)
- **Future Internet: infrastructures, technologies and services:** the approach to shared development and reuse of applications starting from open specifications is coherent with the concept of Future Internet [3] as currently promoted.

2 Qualification of the Socio-Economic Relevance of the Proposed Solution and of its Positive Fallouts for End Users Resources Use and Optimization

The strategic criteria which constitute the basis of the envisaged solution reflect the vision of a logic based on three words: LAW-ECONOMY-TECHNOLOGY, capable to offer the best guarantees about the final prototype either for the research partners or for the industrial ones, because it calls for new knowledge production (and therefore research activity) able to optimize as efficiency regards the crucial PA bottlenecks. Such an optimization, will in turns make more competitive each country (the PA, each year, does intermediate relevant amount of the Gross National Product), according to a regulated framework ruled by the various laws which are in force in the various countries.

The envisaged solution can be synthesized in the development and use of Cloud technologies for the PA front-office and back-office.

In the following, the Cloud as applied to e-government is described, in order to understand its potential for the qualification of the socio-economic relevance of the matter presented in this work.

The Cloud concept has various definitions in the literature. Considering the authority of the source, the USA NIST definition is considered:

> Cloud computing is a model to access through Internet to a pool of assemblable processing resources (networks, servers, storage, applications and services) which can be easily allocated at the time of need, and similarly can be also easily released when no more needed, leaving to the providers the operational management task of such resources [5].

One of the main point of strength of Cloud is the one of being capable to provide almost unlimited ICT capacities directly available through Internet, therefore from any point where a network connection is present and almost with any device: desktop,

laptop, tablet, smartphone and other intelligent devices. Another fundamental point of strength arises from the fact that are just the service providers to be responsible for the hardware and software resources, of their maintenance, of their updating, security and of other essential resources. To Cloud clients, in the case study PAs, made free from the management duties, will be leaved only the task of identifying the services and the tools useful for their specific needs. In this way, the single client (end user) can focus the activities on its own core business leaving (like in outsourcing) to the service provider all the ICT support activities. Furthermore, the needed ICT services can be acquired in a fashion directly related to the specific needs of any specific moment. Well known examples of Cloud provided applications are Facebook, Amazon, eBay. For example, a given PA, will not need to acquire, maintain and manage large infrastructures for its information/knowledge systems, since it will have the possibility to acquire all or almost all the needed ICT services from a Cloud provider. Even today, many private enterprises of different size take advantage of Cloud services, and, by acting in this way, they realize consistent savings and improve their economic yield. For PAs, instead, still cultural and legislative barriers are present to use such service approach for what it concerns the localization and management of data of sensitive nature. In technologically advanced countries, such as the Republic of Korea (ROK), the USA, the United Kingdom (UK), Japan, Finland, programs to include Cloud as part of their ICT architecture are running, while instead some services have been already migrated on Cloud platforms provided by private enterprises. This has been accomplished to allow for the administrations and for other public institutions to reduce management costs and to obtain other improvements for the provisioning of qualified services to citizens and enterprises.

The service Cloud offering is relatively new and it is undergoing a great development. This fact implies that near to the numerous benefits as offered by this new way of conceiving ICT services, are still present, in view of including such services in the information/knowledge PA systems, limitations and problems which is important to tackle and solve. Particularly, large amount of work has to be carried out in terms of specifically customized applications at design and development level in order for them to be used in a Cloud context. For such reasons, new knowledge production is needed to study, experiment and evaluate both the requirements and the opportunities as offered by the Cloud, inside the framework of the processes correspondent to the services provided by PAs, particularly on the front-office side, the one more perceivable by citizens and enterprises and on which, even in recent years, less has been invested with respect to the back-office side.

Nowadays, PAs of developed countries are subject to heavy cost reduction policies, while, at the very same time, to the search of ways to improve the efficacy and efficiencies of their units. The Cloud is a key element for the PA modernization, by obtaining, at the same time, the result of improving its own efficiency while reducing costs. In the USA, the official Government web portal, USA.gov, has been moved onto a platform named Enterprise Cloud, produced by Terremark. USA.gov is one of the USA more visited Government website, with more than 100 million visitors per day, and it has been designed to function as access point to the information available on the public USA website. However, the online traffic underwent a very high degree of

variation under particular cases. Before the porting on the Cloud of the portal, in case of high traffic peaks, service delays or interruptions were frequent. Enterprise Cloud has been the answer to this problem. The effective porting required only 10 days, and the Cloud trial has been carried out in one weekend. Martha Doris, the *Deputy Associate Administrator of The Office of Citizen Services*, estimated that the porting onto the Terremark Cloud platform allowed a cost cut of about 90 %, by improving, at the same time, system performances and flexibility. As a consequence of such positive results, the DATA.gov portal porting onto the same Cloud platform is in progress. In the United Kingdom (UK), it has been decided to move some services over the Cloud. During 2011, it has been announced the creation of a private Cloud infrastructure named G-Cloud. G-Cloud is designed to include not only the Government data-center, but also to yield tools supporting working activities, to implement a private Government wiki and a mail server for the UK municipalities. It is currently running a study to identify applications and tools useful for the Government and available over the Cloud, which could be shared with other departments and public institutions. According to the running plan, 80 % of the UK public departments will make use of the G-Cloud platform, leading to saving of about 3.2 billion pounds per year on the expenses for ICT resources. Further to economic reasons, G-Cloud has also other motivations. There is an improvement on security, since all the information would be hosted in the Government private Cloud. Other services, mainly those of vital importance, would be separated by G-Cloud. Other benefits include the possibility of implementing good practices for what it regards energy efficiency. In Japan, the Ministry of Internal Affairs and of Communications (MIC) developed a plan named Hatoyama, introduced in 2009. The Hatoyama plan has the objective to create new ICT markets to act as a stimulus for Japan economy. As part of the Hatoyama plan, the Government is designing a Cloud national infrastructure, named Kasumigaseki Cloud, to be realized by 2015. Kasumigaseki Cloud will provide the platforms for the shared functions at the Government departments, in order to harmonize systems and processes, by reducing processing time. As a consequence, new investments in the order of various thousands of billions of yen are envisaged and, at the same time, the creation of 300.000–400.000 new jobs. In summary, the USA are trying to save money by using the resources made available by the Clouds of the private sector, discharging over them the costs related to the investment, operating management and updating of the ICT devices. Instead, the UK Government decided to create its own Cloud structure maintaining their ICT still bounded to the PA hands, but, at the same time, gaining the advantages offered by the Cloud. Japan, a country where high technology is largely diffused, produced a very ambitious plan to create new ICT markets and to use the Cloud either in the PA as well as in other sectors. On the other side, one of the barrier to a pervasive diffusion of Cloud services is given by the lack of reliable access points to the network. From this point of view, Japan is advanced with respect to the other countries, since wireless Internet connections are available almost everywhere.

From the described examples, it appears evident the tendency toward an ever increasing Cloud adoption, and that the Cloud will be most likely a dominant service model in the next years. Nowadays, the acquisition of very large Government ICT

structures is not more necessary and not more useful, since it is possible to acquire services on the basis of the need in any moment according to a centralized fashion. Since many Government structures or public institutions use the same class of applications, it is possible to consider the development of common ICT solutions based onto Cloud services. In this way, it could be possible to put in place strategies to allow reduction of the costs related to investment on new ICT devices, to their maintenance, to their updating and to their energy consumption. The Cloud could be therefore fundamental in the future for the PA ICT services.

For example, by looking at the future for ICT investment in the Italian PA, a potential useful model could be represented by a mixed solution between the UK G-Cloud and the Kasumigaseki of Japan. In fact, it is necessary to properly consider the legislative limitations on the possible localization of data of sensitive nature, which forces to use the already available ICT infrastructure, and, versus time, to include all the other public entities such as hospitals, schools, municipalities, by implementing a *Hybrid Cloud*. The public will have access to information through services made available for the citizens over a Public Cloud, while the Private Cloud will be used by the PA. Standard applications should be developed for similar institutions (e.g., municipalities). Furthermore, different approaches should be studied for institutions which have different missions, both for the nature of the institution itself and for reason related to data security (e.g., Ministry of Justice). It could also be possible to study set of services offered on virtual shops, where the end users could select the application type for their needs in terms of cost, performances and reliability, of course always being law requirement compliant. USA, UK and Japan, envisage in the Cloud the direction towards which integrate and evolve their information/knowledge systems, and are investing quite large amount of resources in this strategy.

From a research point of view, it has to be considered that while several tools and services on the Cloud are already available at a sufficiently robust and mature stage, there are also various interesting investigation directions related to the development of intelligent applications for workflow management either inside a given PA or for what it regards interoperability and information and data exchange among offices belonging to different PAs. As matter of fact, it is possible to make available for the citizens a centralized point to access information managed by various PA departments as, for example, it happens in the USA with the aforementioned USA.gov portal. Furthermore, it could be of interest, among the various potential research perspectives, the one of developing applications and adaptive workflows for processing procedures and documents inside a single PA or even to process complex procedures and documents involving more PAs.

3 Functional and Performance Requirements of the Proposed Solution

Starting from the state of the art on Cloud, workflow management, ICT applications running at the PA of some of the most advanced countries in this domain, and from the analysis of the availability of some commercial products for the PAs, the most important scientific and technological needs for the PAs have been identified.

Such collected needs have been then set inside frameworks of concrete operational activities of the PAs. In such pictures, some of the requirements that future research should fulfil have been identified. As matter of fact, the collected needs cover a larger domain with respect to that outlined by the pictures and correspondent requirements as reported in the following text. A more deep step of analysis is envisaged in subsequent phases, where further requirements could be derived from the expressed needs in conjunction of their inclusion into further applicative situations.

3.1 Needs List

From the studies carried out, the following needs can be identified (B).

B1. Improved application interoperability thanks to the adoption of open standard

a. *at data (secured) access level*
b. *at applications interoperability level.*

B2. Systems migration support to allow applications migration over Cloud platforms as offered by different providers, also with regard to disaster recovery functions, service maintenance, provider substitution.

B3. Service availability coherent with the operational needs on the basis of shared service levels and security and legislative constraints.

B4. Security

a. *data security (no-repudiation, high availability, compliance to laws and technical rules which are into force)*
b. *identification mechanisms (of people) and authentication mechanism (of documents) set according to a federated context, through trust mechanisms among different administrative domains and roles and rights delegation on resources*
c. *compliance to running rules of networking solutions related to virtualization.*

B5. Adoption of environments and methodologies Cloud-specific for applications test and development

a. *apps should be driven by user needs (PA personnel, citizens, enterprises), not from the hosting Cloud. Specific reference is made to current and possible research activities on self-configuring and, more in general, auto-configuring*, capable to look for an equivalent service to that present on another Cloud provider, in order to ensure transparency of it for the PA*
b. *languages with native support for parallelism and the analysis of large amount of data*.

B6. Support to persistency and shared access of large amount of data, in the order of peta- and esabyte.

B7. Business process and adaptive workflow systems over the Cloud

a. *business process should dynamically adapt to the variable resources availability and to legislative changes*
b. *business process could be distributed also on different Clouds of different administrations, during its execution, citizens and enterprises should be able to track in real time their instance status. Furthermore, each of the involved PAs should be able to monitor the overall process efficiency as a basis to the performance evaluation of its responsible managers (performance cycle)*.

B8. Semantic engines development for

a. *research, identification and indexing of services which can be assembled in new applications on demand*
b. *structured and un-structured information semantic integration*
c. *easy composition of services (where the description can also be provided in natural language), to be eventually made automatic in the future*.

B9. To adopt Cloud solutions for Open Data [6]. The advantages of such solutions include

a. *data publication made more easy*
b. *data presentation additional modalities*
c. *data interoperability*.

B10. Definition of innovative techniques to allow metadata generation and use to overcome

a. *the problem of existing legacy systems integration*
b. *privacy problems in data use*.

B11. Specific application frameworks

a. *management, execution and monitoring of PA processes*
   - *processes involving a single PA*
   - *processes involving multiple PAs*
b. *citizens/enterprises PA interaction*
   - *processes related to citizens PA interaction*
c. *health*

- *healthcare application tight constraints, as: sensitive data (privacy), need of sharing in an easy and trusted way the data among the different involved actors*.

The listed needs (B) in the following are inserted inside typical operational PA contexts, and from them some of the main requirements will be derived to be pursued in the research activities to be carried out.

3.2 Operational Scenarios

The operational scenarios described in this paragraph represent the context for the realization of the aforementioned listed needs, and for the subsequent research requirements identification. The relationship between needs and requirements is intermediated by the environment in which they have been inserted and, in any case, the requirement is proposed as a solution strategy for the need and, as such, is not the only way for the satisfaction of the need itself, but, more properly, the one considered as the most adequate on the basis of the status of the art and of its advancement perspectives both in terms of basic/applied research and of technological infrastructures.

3.2.1 Business Process Inside a Single PA

Figure 1 depicts how any Public Administration (PA) conducts its missions (as established by the law) by providing performances to citizens. Performances, in turns, are realized through the involvement of various cooperating services to achieve the objective.

According to the always increasing digital vision of the PA, services are operated through *apps*, they exchange data/informations (*open data*) and are carried out according to a pre-ordered sequence, i.e. service orchestration. Such services could use *apps* available on the PA Cloud and/or on other public Cloud (*Hybrid Cloud*). The procedures of services applicative cooperation to achieve the desired performance could give rise to the specification of a workflow of activities, which requires a correspondent document flow. Final result will be the performance provided to citizens or to another PA according to a controlled procedure. Availability and possibility to have access from anywhere and through any device to documents is ensured by the digital nature of the documents themselves. Document digitalization allows storage, preservation, access, operational continuity, for which, nevertheless, it is necessary to provide, for each PA, a detailed plan, according to specific technical rules.

The workflows of activities are normally automatic through the use of web-based applications and web services if they allow to

- control and coordinate the workflow of activities
- manage the resources to be utilized for the performance

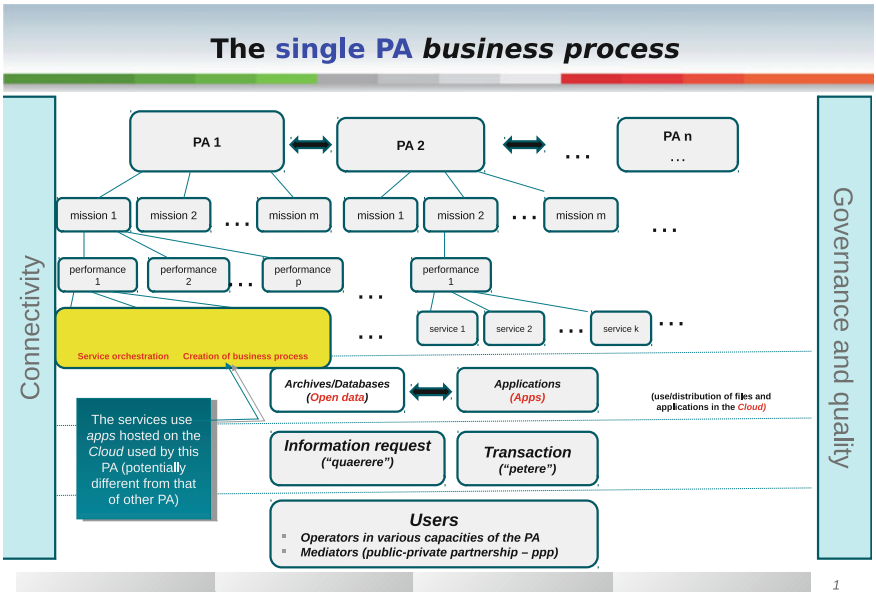

Fig. 1 PA missions, performances and services

- generate the document flow and monitor its status
- monitor and track the status of the entire performance while running
- act to overcome eventual advancement barriers during performance provision to the end user.

The future proposed framework envisages a large presence of mobile devices, such as smartphones and tablets, which will make use of *apps* available over the Cloud, assembled at the usage moment according to the specific user needs, both in the case of PA people or citizens and enterprises. Full realization of a workflow of activities fully compliant with PA needs is still today not feasible due to limitations in the status of art in relationship with what is represented in the following requirements.

Requirement 1-Definition of a new generation of adaptive workflow of activities to implement PA business processes. Such workflows should:

- be distributed over the Cloud
- include activities supported by *apps* over the Cloud and *open data*
- be able to learn from the use
- be able to re-organize the process of performance providing
  - changing the services execution order (while respecting the logic dependence constraints among them)
  - substituting those services that could constitute problem for an optimal execution of the performance with other services properly identified

  – changing the involved operators (or resources)

- be easy for management and re-configuration, limiting to the minimum the intervention of skilled ICT personnel, while, instead, allowing to the process conceiver (normally a PA operator) to directly specify and implement it.

Requirement 2-Definition of service orchestration adaptive techniques and of the connected workflow of activities. Such techniques should be:

- guided by the dynamic needs of the end user (PA, citizens or enterprises)
- configurable according to a continuously changing resource availability
- able to dynamically adapt themselves to context, law, data and/or resources nature variations.

Requirement 3-Definition of new methods and techniques for the design/development of the *apps* for the end users (PA managers and/or citizens and enterprises) such as "atomic" services composition, eventually made available by public Cloud providers. *Apps* should be composed in such a way to place the user and its demands to the center of the design process, by yielding customized products thanks also to the use of an "ad hoc" design process, but always open (*open source*), transparent, easy and re-usable.

Requirement 4-Development of methods, techniques and technologies for the deployment and operation on mobile devices, such as smartphones, of hardware embedded *apps*. Such *apps* should allow the interaction among different devices in a transparent way with respect to manufacturers, configuration, device operating system, enabling the information/services exchange in a native form.

3.2.2 PA Cooperation and Multi-PA Business Process

Figure 2 depicts the cooperation among different PAs to provide a performance. According to this scheme, the information/knowledge system enlarges from a PA to another one, becoming, in the end, multi-PA. The multi-PA business processes include activities carried out in different PAs, and it is therefore necessary to provide what it is outlined in the following requirements.

Requirement 5-Definition of new methods, techniques and technologies for the distribution of the workflows of activities over different Cloud platforms in order to serve different PAs. Such methods, techniques and technologies should allow the realization of:

- workflows of activities distributed over different and interoperable platforms
- coordination among distributed activities
- interoperability at data (open and big) level and at application level (data exchange among services carried out by different PAs)
- transparent and easy cooperation among processes executed over different PA Clouds
- monitoring and supervision of the entire process from each single PA

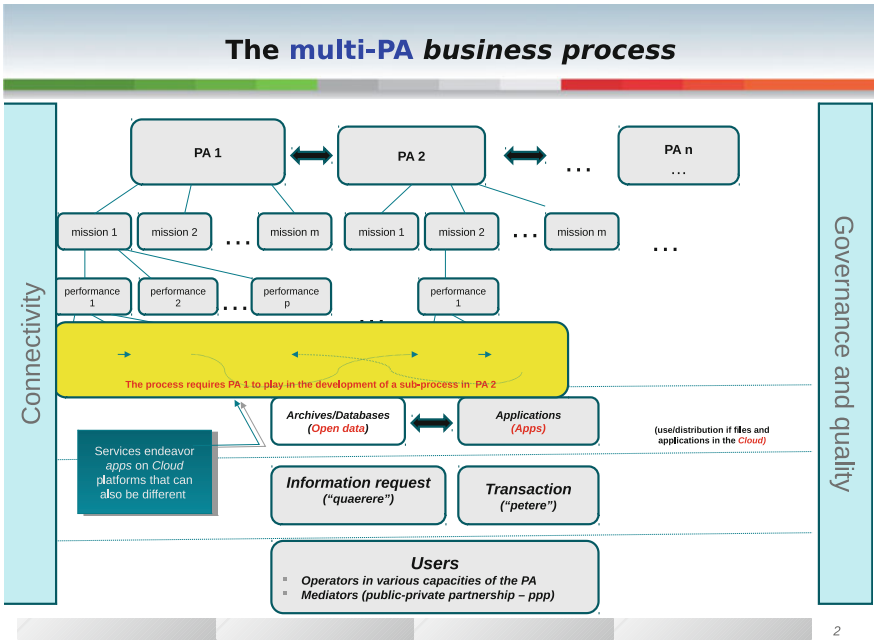

Fig. 2 The multi-PA business process envisages a cooperation among services of different PAs to provide the performance to the end user

- workflow flexibility to face real time variations
- components and workplan (or of part of it) re-usability (activities, supporting *apps*).

3.2.3 New Generation *Apps* for Personal Productivity

The availability of advanced and new services, made possible by the presence of a Cloud provider always devoted to new products development, allows to overcome the classical concepts of application software for personal productivity. Each system user (PA operators, citizens, enterprises) will benefit a customized *app* (or application, if he/she operates through a traditional PC terminal) specifically conceived for its duty. The *app* will be dynamically composed (on the fly) starting from basic services jointly assembled in order to provide only those functionalities required versus time (LEGO-like approach, a catalogue of *apps* which can be dynamically composed and re-used). New services will be, progressively, made available and they will be transparently (to the user) integrated inside the personal productivity applications, yielding new functionalities, easiness of use and enabling, in the end, a greater productivity. Such considerations are summarized in the following requirements.

Requirement 6-Definition of new methods, techniques and technologies to dynamically integrate personal productivity applications:

- available over traditional workstations (PC) and mobile devices through access to the Cloud platform
- dynamically composed at the moment of use starting from the needed functionalities, from the goals to be achieved or through selection from a catalogue as outlined in the following:
  - the user could select the interested functionalities (text processing, running project monitoring) or the target objective (e.g., ask for a certification/authorization, fill-in a module, plan certain activities or draft an account) or, also, he could select the modules which will compose the application starting from a components catalogue
- to compose various atomic services/components cooperating to realize the desired functionalities and, when it is necessary, to be present in a unique graphic interface.

Requirement 7-The lack of availability of the selected atomic services/components should not stop the providing of the required functionality. The system should be able to find other services/components such as to provide the same functionality or a very similar one (eventually informing the end user of a potential performance decrease).

The aforementioned 1–7 requirements have been derived from the previously listed needs as described in the points B1–B10. Further requirements will be necessary as the result of a successive needs analyses (e.g., from B7 to B10) and from their fine tuning.

4 Specification of the Technological Innovation Gap to be Filled and of the Level of Novelty and Originality of the Knowledge to be Produced by the Proposed Solution

During the last 5 years, the Cloud concept deserved the attention of the market and of the users, mainly, mass-market and small-business. As previously reported, the Cloud model is based on the demand providing of processing resources or data persistency starting from an homogeneous and shared pool of resources among various users, resulting in an infinite resource availability illusion [2]. Nowadays, the offered services according to the Cloud model are structured over three levels:

1. the lowest level, named IaaS (*Infrastructure as a Service*), yields basic services, such as process execution (*jobs*) or Virtual Machine (VM) and storage capacity for user files and data persistency, eventually with interfaces for network customization, firewall and other basic ICT resources. The first service of this kind has been introduced by Amazon, with its Amazon Web Services (AWS). The user has full control (as administrator) of its own servers (even if virtualized) and he needs to install all the required software to run its application (operating

systems, databases, application servers). On the contrary, the user does not have control neither on the physical infrastructure nor onto the selection of the physical resources supporting the virtualized layer, including, in many instances, the control onto applications for geo-localization

2. the second level, named PaaS (*Platform as a Service*), is a platform offering in a native manner (both expanding a IaaS and/or as autonomous solution) functionalities and resources needed for the implementation and execution of applications (such as no SQL databases or parallel computational models). Examples of this type are MS-AzureTM and Google App Engine. Over this platform, with heavy constraints on the syntax and on the behavior of the applications, the user-developer can create, maintain and develop applications needed by the end user. The developer does not concern about maintenance and evolution of the development platform, rather been focused onto the applicative logic and onto the interaction with the end user
3. the highest level is named SaaS (*Software as a Service*), and it provides (shared) access to applications from the end user. Examples of this nature are GMailTM or FacebookTM. The client does not own the application and therefore does not need to install, maintain or update such applications, but he cannot also customize, extend or evolve that application for its own specific needs. As matter of fact, the client gets only the right to the use of the application, which will paid according to its use or through some form of indirect remuneration (such as the possibility to receive commercial messages in the mass-market version).

All the Cloud currently commercially available on the market undergo three main limitations, which constitute barriers for their immediate adoption inside the PA context: the so-called *vendor lock-in*, the *compliance* to PA laws and regulations and the still present systems *non-interoperability*. The concept of *vendor lock-in* means the risk deriving from the adoption of proprietary non-standard solutions, which binds PA to a single provider, without the possibility to find easily on the market better quality or more convenient solution as substitutes, unless spending high costs for migration [7]. The term *compliance* makes reference to the problem of certification or guarantee that certain services or functionalities required by PA are compliant with laws and regulations which are into force in the various countries. This fact is highly debated inside the European and global ICT market, essentially due to the fact that each Member State or Nation has its own set of law and regulation constraints, sometime in contradiction among themselves. In this context, the market reacted with the identification and adoption of international certifications (e.g., PCI or ISO 27001/2), which should prove the adoption of attention and quality level in service provision. Such certifications are, sometime, used by single PAs for the selection of providers or in calls as proxy of regulation respect: such solution has the limitation to leave to the PA the duty of requirements settings to be regulations-compliant. This fact is easy to achieve for large institutions with properly qualified legal support, but less useful for small entities not fully aware of the various implications as deriving from the use of today technologies. In some European Union Member States (e.g., Germany [1]), the PA issued, through specific national organisms for this purpose,

guidelines for ensuring conformity of ICT vendors to national or local regulations: in such a way, single PAs are made free from the duty to decide the operational modalities to respect the laws into force and, at the same time, a unique and homogeneous indication to enterprises is given on how to refer and to take into proper account current regulations necessary to invest in solutions which can be adopted by more than a single PA and, therefore, more economic. Finally, are considered *non-interoperable* those technological choices on programming languages, Application Programming Interfaces (API), application stack or non-standard data formats which prevent the migration of a given application toward a new provider or the re-use of the application or of its data from another PA. The kind of application which should be developed, and which, obviously does not exist at commercial level, is based on the implementation of intelligent and adaptive workflow able to use either already available services or also new ones as support to the processing of workflow inside a department of a given PA, or even between departments of different PAs. Various technological gaps and races need to be tackled in order to implement such a system. In fact, consolidated models and tools to design and manage adaptive workflow do not exist. Furthermore, the most innovative identified strategy is the concept of a workflow able to automatically compose the services available to the end user for the achievement of his goal, even if this last one is going to be changed at run time. For this reason, it is necessary to call for new knowledge production as the result of original research activities important for both the theoretical and experimental development of such models and tools, offering also the guarantee to have available the various software components (*fragments*) needed as support.

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