Harnessing the Technology of Cloud Computing with Supply Chain Management

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Abstract

Supply Chain Management has become a mature discipline where it is no longer a question of whether you use Supply Chain Management in your business, but the extent to which you have incorporated the full potential of the SCM concepts and tools. Likewise, the discipline of Cloud Computing while not at the same stage as Supply Chain Management, is rapidly expanding and more and more businesses are adopting it to enhance their IT functions. This paper explores the extent to which Supply Chain Management Systems use the emerging technology of Cloud Computing in increasing the efficiency of their system.

Initially, the two concepts are surveyed in the literature to see where we stand with respect to harnessing the emerging technology to the established business tool. The second part of the paper will explore the parts of this marriage that provide more benefits with respect to operational challenges. Finally, suitable qualitative and or statistical analysis will be included. Alternatively, an example of a firm that has successfully established a Cloud Computing based Supply Chain Management System will be discussed in lieu of the analysis. We can describe Cloud Computing as the delivering of infrastructure, platform and software in a service model based on a pay per-use model provided to the customer. In the market, this differentiation is denoted as Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS).

The paper will conclude with our opinion of the future for such technology based Supply Chain Management Systems, in the business world.

Keywords
Supply chain management, Cloud computing, productivity improvement

INTRODUCTION

The topic we have chosen is not new. A number of works have focused on the relationship between Cloud Computing and Supply Chain Management. To mention a few, Holger Schrodl (Schrodl 2015) has talked about assessing the adoption of Cloud computing in Supply Chain Management using a Supply Chain Operations reference (SCOR) model based assessment tool. Tiwari et. al. (Tiwari, 2013) have analyzed the use of cloud computing with Supply Chain Management. Finally, Michael Dominy (Michael, 2012) has explored the impact of Cloud Computing on Supply Chain Management. In this paper, we plan to look at the evolution of the two disciplines and then suggest possible trends for the future. Before we address the harnessing of an emerging technology with an established Management discipline like Supply Chain Management, we will first discuss the concerned discipline and the related technology. This will be followed by exploring the advantages and challenges in connecting one to the other. Which will be followed by an example where this harnessing of technology to the discipline has been accomplished. The paper will close with some reflection on lessons learned and the potential for future development in this area.

SUPPLY CHAIN MANAGEMENT

It is widely accepted that the term "Supply Chain Management" was coined by Keith Oliver in 1982, when he was trying to explain the concept of integrating the management of inventories throughout the different stages of manufacturing a particular end product. For example, if you consider the manufacture of an automobile, you can focus on the factory that assembles the final automobile, which is the "Assembly Line Factory". However, that is only the final stage of the manufacture of the automobile. The automobile is made up of thousands of parts, and some parts or sub-assemblies are themselves made of other parts and so on. If you are only concerned with the "Assembly Line Factory" then you would keep track of all the different parts that go into making the automobile and keep an eye on when the parts are at a low level of inventory. In that case, you would check and make sure that the replenishment of that part is on its way and that it will reach the factory before you run out of that particular part. This is how most manufacturers used to function when they were one among many manufacturers of the same product. As companies started to grow and also integrate vertically, they found themselves managing a group of factories, each being dependent of the performance of others and also contributing to the performance of other factories. As a result, managers were not only managing the inventories of one factory but a group of factories, each connected with each other. For example, the automobile final assembly plant was not only concerned with the levels of inventory of the various parts in that factory, they were also interested in the inventory levels of factories where the parts they use are manufactured. In other words, the assembly line factory is not only concerned with the engines they have in stock, but also the parts that are needed to manufacture the engines, by a supplier company. In the past, if the engine supplier was missing his delivery schedule, you simply went to an alternate supplier. But now, you are using engines made by a company that is part of the parent company and hence we cannot replace them with another company. This problem of managing the inventories across related factories is what Keith Oliver was trying to accomplish by referring to the task as Integrated Inventory Management (I2M), which was later described as Supply Chain Management, which was more indicative of what is accomplished by this discipline.

While vertically integrated companies were the first to use the Supply Chain Management approach, other companies were soon to follow as they realized that the participants of a supply chain need not be part of the same company. These group of companies that were independent from a business point of view were nevertheless dependent on each other from an operational point of view. We will now trace the different phases of the development of "Supply Chain Management". According to Dinesh Jain et. al. (Jain 2010) there are six phases in which the development of Supply Chain Management can be traced through. The six phases are 1. Creation Era, 2. Integration Era, 3. Globalization, 4. Specialization Phase I, 5. Specialization Phase II, and 6. SCM 2.0.

Creation Era

Even though the term "Supply Chain Management" was coined in the early 80s, parts of the concept were employed as early as the turn of the century (1900) with the use of the assembly line by Henry Ford. A number of practices in improving the efficiencies of manufacturing and distribution can be traced to the first half of the twentieth century. In general, the two major aspects of the "Supply Chain Management" discipline are to increase efficiency of the supply chain and reduce or eliminate duplication of tasks. Along these lines, there have been number of developments that can be classified under Management Science or Operations Research, during the first half of the twentieth century. While these techniques and algorithms like time motion studies, logistics based studies, and scheduling algorithms are

really part of Management Science and Operations Research, these also formed the foundations on which future developments in Supply Chain Management concepts were developed. Hence these have to be included in the "Creation Era" of Supply Chain Management history. Of all these foundational developments, the assembly line used by Henry Ford would qualify as the most important development. Taken mostly from the History.com source, we find that Ford practiced continuous improvements long before it became a buzz word. Starting with about $1,000 for the earlier versions of the Model T, by the mid-1920s the price came down to around $350 and was affordable by most Americans. In its most refined stage, Ford's Model T assembly line consisted of 84 separate but simple steps by which the automobile was assembled. This was a result of constant improvements to the process and sequence of manufacturing. Ford also used the help of Fredrick Taylor, the father of Management Science, to improve each of the 84 steps by using applications of Time and Motion studies that Taylor conducted. In addition to streamlining the manufacturing process, Ford also introduced concepts of conservation by using the packaging in which his engines were delivered by the Dodge brothers to making the floor boards for his Model T. Charles Sorensen (1956) (one of the chief collaborators with Ford on his assembly line) in his book has stated that developing the assembly line was not as hard as coming up with a system to handle all the numerous parts and sub-assemblies to arrive at the right station at the right time. This proves that they were thinking of this problem in the beginning of the century, which eventually developed into the concept of Materials Requirement Planning (MRP). While most people associate the "Assembly Line" with Henry Ford, it must be pointed out that this concept existed in other manufacturing arenas long before Ford introduced it to the manufacture of the automobile. What he did do is that he used the assembly line in such a large scale that the benefits of the process was very dramatic and significant to reducing the cost of manufacturing.

Integration Era

This phase starts with the use of Electronic Data Interchange (EDI) in the early 60s and includes a number of computer based developments that contributed to the efficiency and quality of manufacturing as well as distribution functions, all the way till the 1990s with the introduction of Enterprise Resource Planning (ERP) systems. While the EDI technology removed the human error involved in data entry, the ERP systems focused on integrating all the sub-systems of business into a seamless master system of the firm. In between, the concept of Materials Requirement Planning (MRP) developed along with the development and wide availability of computers. The concept of MRP is really a series of logical computations based on the Product Structure Tree (what parts/sub-assemblies the product is made-up of and in what sequence they must be assembled) and the logistics (availability, lead time, usage) of the concerned parts. While this is not rocket science, it is an overwhelming task of keeping track of the various parts and sub-assemblies, not to mentions the breakdowns. With the development of more and more powerful computers the use of MRP systems kept increasing. Once the MRP system was in place, the logical progression was to integrate the MRP to all the other business systems that were being simultaneously being developed, which led to ERP systems of different degrees of sophistication.

Globalization

Starting with this phase there is a lot of overlapping of the different phases. However, each of these four phases consist of specific group of developments in the evolution of Supply Chain Management. For example, the globalization phase represents the practice of more and more manufacturers willing to source their raw materials from all over the globe and at the same time be willing to service customers also all over the globe. One other development contributed greatly to globalization. That was the introduction of the standard large size containers that was compatible with the different modes of transportation, like air, sea, truck and rail. This resulted in efficient transfers from one mode to the next and so the logistics managers could consider a vast variety of multi-mode transportation solutions. However, globalization came with problems of its own. There were issue of quality and quality control as the vendor was not located around the corner for surprise visits of quality checks. Further, the lack of proximity also prevented the sourcing company from helping their vendor in aspects of engineering and manufacturing. The second issue this raised was that of transportation. More specifically, the lead time for the movement of goods and the uncertainty connected with those lead times. In addition, there were smaller but critical issues regarding trade, customs and political considerations as more than one country was involved in global transport. Nevertheless, solutions were found and adjustments were made and Globalization was here to stay.

Specialization Phase I

In this phase, represents the trend of manufacturers focusing on their core competencies and opting to outsource all the non-core functions to the best vendor who could do it most efficiently and effectively. This was the reverse of the era when most companies were consolidating vertically as well as diversifying over a number of different markets.

While they were realizing the economies of scale as well as the power of being a big player in a field of smaller players, eventually, the sizes were too big to manage efficiently (like General Motors). Also, while the diversified holding of different companies in different markets minimized the collective risks (one market may be down but two or three others may be up), top management did not have the expertise to strategically manage in different markets. This was especially true since globalization became a common strategy that most companies adopted. With globalization, the competition was no long in the neighborhood or regional. The whole world become the arena for business and competition became fiercer on a near continuous basis. Corporate America after being the leader in industry after industry for several decades, found itself competing just to maintain market share. There were new players in the market and there were more players seeking a piece of the pie. This meant that established corporations needed to get efficient and effective in a hurry or they would become the "also ran" in the business race. As a result, the corporations retained the units of manufacturing in which they had the most expertise and divested or out sourced the units that they were less knowledgeable about.

Specialization Phase II

In this phase, we see parts of the Supply Chain providing their expertise to customer companies as a service as opposed to managing that function for a specific company or group of companies. Companies like UPS and FedEx, which previously served as transport facilitators, started to offer inventory services, scheduling services and whole lot of others so that they became logistics service companies instead of mere transportation companies. It was just a natural progression for them (and others who saw the opportunities) to offer full-fledged Supply Chain Management services to client firms. Companies like Dell Computers used delivery companies to serve as their regional warehouses in addition to delivering their products to customers. These practices led from warehouse services to shipment consolidation also. For example, if someone purchased a computer system from Dell, the computer would be shipped to a UPS or FedEx warehouse nearest to the customer. Then, other accessories that the customer purchased will be shipped from other locations of Dell Company to that same warehouse close to the customer. Sometimes, some parts like printers, will get there from a totally different company that Dell has made arrangements with. Finally, UPS or FedEx will keep track of all the different packages for that customer, consolidate them, and deliver to the customer all at the same time. Of late, these delivery companies do not consolidate but deliver the packages to the customer as and when they arrive, thereby reducing their inventory and coats still further. They simply notify the customer that the shipment may be delivered in parts in some cases.

SCM 2.0

In this last phase, Supply Chain Management started to use the power of the World Wide Web to gain efficiencies and accuracies in the various aspects of function. This was a natural progression as more and more partners of a Supply Chain Management system are located at various points around the globe. While some large companies can build completely dedicated information systems for the various branches of their organization using leased telephone networks, the majority of consumer firms would have to develop theirs over the internet. This is the point of the evolution of the SCM systems that intersects the evolution of Cloud Computing.

We see the greater and greater use of the internet ultimately reaching a point where Cloud Computing in its present and future form will become an integral part of developing an efficient Supply Chain Management system. However, we are jumping the gun here and will discuss this fully after the next couple of sections.

EVOLUTION OF CLOUD COMPUTING

While the term Cloud Computing is more recent, the fundamentals underlying the concept have evolved over time. In this respect, there is a trait that Supply Chain Management and Cloud Computing share with each other. Just like Supply Chain Management is a stand-alone concept now it has its origins in Operations Research and Management Science. In the same way, while Cloud computing can be considered a unique concept by itself, it too has its roots traced to the development of computers.

The history of the evolution of Cloud Computing has a number of versions which all differ from each other in some small way, they generally are classified into 4 phases. We have taken generously from one such version by paraphrasing the contents of a history narrated by Arif Mohamad (Mohamad, 2009). Based on that version of the history, the four phases are: Grid & Utility Computing, Application Service Provision (ASP), Software as a Service (SaaS), and Cloud Computing. We elaborate on each of the phases below:

Grid & Utility Computing

This phase starts back in the 1950s during the days when Main Frame computers were the mainstay of the industry. While the computers were getting larger and more and more powerful, not everyone could afford to have their own mainframe computers. Also, while the powerful computers were very fast, their capacities were too extensive to most users of computers. This led to the arrangements where a single mainframe computer was being accessed by a number of users using data phone lines and dedicated data cables.

Application Service Provision (ASP)

This phase is said to have started in the late 1990s. At this time, the industry started providing applications as a service. One of the first firm to provide this service was Salesforce.com in 1999, which pioneered the concept of delivering enterprise via a simple website. This type of a Service Firm paved the way for delivery of applications over the internet. This practice started with specialist firms and then was followed by mainstream software firms also.

Software as a Service (SaaS)

This next phase is identified with the entry into the market by Amazon Web Services in 2002. Amazon provided a number of services through their website including storage and computation. They also provided the service of "Human Intelligence" through their site Amazon Mechanical Turk. In this site, people could bring problems that customers need solved using software as well as human decision making skills. The web site then let "workers" bid for and pick up the tasks that needed to be solved for the customer. Later, in 2006, Amazon launched their Elastic Cloud Compute (EC2), which is a web site that allows small individual companies to rent computers to run their computer applications.

Cloud Computing

Cloud computing really took off with the onset of web 2.0, when technology giants like Microsoft and Google rolled out "killer apps" which brought all the features of cloud computing in a viable functioning mode. It is widely accepted that one of the true pioneers who initially had a concept of "Cloud Computing" was J.C.R. Licklider, the major force behind the development of ARPANET, with his concept of "Intergalactic Computer Network". This concept was proposed in the 1960s. The concept he proposed was for everyone to be interconnected and accessing programs and data at any site from anywhere. Cloud computing these days has evolved into providing Infrastructure as a Service (IaaS) and Platform as a Service (PaaS), in addition to SaaS. As a result, you can build and access all of your Information Technology needs entirely in a web based environment.

ROLE OF CLOUD COMPUTING IN SUPPLY CHAIN MANAGEMENT

Before we look into the role of Cloud Computing in Supply Chain Management, let us compare the timeline of the evolution of the two disciplines. We have grouped the two disciplines into four and six stages, respectively and they cover different periods of time. Table 1 below is helpful in comparing the differences in the time lines of evolutions of the two disciplines.

Table 1. Comparison of timelines

Discipline	1900-1950	1950-1990	1990 & up	1995 & up	2000 & up	2010 & up
Supply Chain Management (SCM)	Creation Era	Integration Era	Globalization	Specialization Phase I	Specialization Phase II	SCM 2.0
Cloud Computing (CC)		Grid & Utility Computing	Application Service Provision (ASP)		Software as a Service (SaaS)	Cloud Computing

Roughly speaking, the four stages of Cloud Computing maps into six stages of Supply Chain Management. While the time periods for the evolutions are broad estimates, there seems to be some degree of similarity in the timelines of the two disciplines. This is not surprising as most of what happens these days is not only global in scope but the different disciplines also seem to evolve in-step.

The two main characteristics of an efficient Supply Chain Management system are cost containment and performance accuracy. In order to do this, different partners in a Supply Chain Management system should share information with

others in the system and also make sure that their performance in the system is error free. The sharing of information can be achieved by using a good and effective information system. The second goal of error free performance would involve a number of factors and personnel. Typically, a good Supply Chain System is designed in such a way that all the partners have real-time information on all the parameters of the system. Once you are confident of the information, like how many orders are coming down to your facility and how fast they need to be filled, the partner can make plans for the work schedule in their plants. In addition to good information sharing, each partner in the system would have the tools to effectively plan production, manage their inventory and plant floor scheduling of the work (machines as well as the workers.) In other words, an efficient information systems keeps the partners informed and the partners use similar tools to manage their individual operations. Before the adoption of a Supply Chain System, these individual players of the system would optimize their individual operations, individually. While the optimization of each part resulted in the success of the system in general, the entire system was not optimized based on the principle that the whole is not necessarily the sum of the parts. Put differently, some of the optimization on a part by part basis affected some of the other parts negatively. The introduction of the SCM concept removed these deficiencies by making sure that the whole supply chain came first before consideration of the individual parts and their profitability. Such a plan is easy to implement when all the parts of the system were part of the same company. However, analysts were able to show that in the long run every one of the parts came out ahead when the whole system was successful. Nevertheless, in the cases where the parts belonged to different companies or firms, an equitable profit sharing of the entire chain had to be worked out among the partners.

Cloud Computing can dramatically change this scenario if it is harnessed to the Supply Chain Management System. Using its Cloud platform, it can not only provide an efficient and effective communication system, but also deliver production and inventory optimization services to each of the partners on a cost effective basis. Cloud Computing can contribute to building an efficient information system to support any Supply Chain System. In addition to facilitating the sharing of information Cloud Computing can also help directly contributing to the success of the Supply Chain. As we shall show with an example later in the paper, an efficient Cloud based system can eliminate a number of links in a Supply Chain and Chain thereby making the system more efficient. Typically, any one branch of a Supply Chain consists of the original Supplier, Distributors, Warehouses, Retailers and the end Customer. With the use of Cloud based management of Supply Chains, some of the Distributors and Warehouses can be eliminated as the tracking methods and information are so much more accurate that additional inventory locations become unnecessary. This is the area in which we see the greatest advancements being made in the future. The contribution of Cloud Computing to Supply Chain Management will be similar to the contribution of Just-in-Time systems to the field of Inventory Management.

Just-in-Time systems were considered but were ruled out during the latter part of the twentieth century as academicians and practitioners had concluded that the optimal solution for inventory management was a balance between inventory costs and setup costs. No one had considered playing around with the "fixed" setup costs. Under those conditions, Just-in-Time inventory would be extremely expensive. Well, someone forgot to tell that to the Japanese production optimizers. They, in turn, worked on ways to reduce the "fixed" setup costs by experimenting with simple as well as complex solutions and lo and behold, were able to demonstrate cost effective Just-in-Time inventory systems. We must add that in addition to all the tweaking of the system variables, the Japanese also had their culture and discipline contribute to the success of the Just-in-Time systems. That is why Just-in-Time systems did not do as well in North America as they did in Japan. Nevertheless, Just-in-Time systems do also work in the west in general, but with a slightly higher inventory in the pipeline.

In the same way, we see Cloud based solutions to the Supply Chain Management systems not only providing the advantages of optimizing the sum of the parts instead of the individual parts, but also playing a key role in altering the Supply Chain System itself by reducing the number of separate nodes and links in the system. This contribution will be as significant as Just-in-Time was to Inventory Management in the 1990s. This is illustrated by the example we present in the next section.

AN EXAMPLE OF A SUCCESSFUL CLOUD BASED SCM SYSTEM

The example we present is the UPS logistics system, which is the Supply Chain system that United Parcel Services use to make sure that all their packages reach their customers at the right place at the right time. Most of what is said about this example is taken or paraphrased from the article by University of San Francisco in 2013. The 100 plus years old company has constantly tried to improve its delivery system to make them as efficient as possible by adopting the

very best of technology that is currently available. They started when there were no automobiles or trucks, but adapted them as they became the back bone of transportation in America. Then, when FedEx entered the market with their overnight package delivery, UPS was not far behind in incorporating air freight and overnight package delivery into their system. In fact, after a little head start, FedEx was challenged by UPS to such an extent in the next day air delivery segment that FedEx soon decided to start FedEx Ground so that it could compete with UPS on the air and ground services, combined.

To get a view of the enormity of the task, here are some snap shot statistics of the package delivery business from the view point UPS Logistics: In 2012, the company delivered more than 4 billion packages and documents to nearly 9 million daily customers in more than 220 countries and territories. To carry out these tasks, UPS used a fleet of more than 96,000 cars, vans, tractors and motorcycles, as well as 230 jets. To get this enormous an undertaking to flow smoothly through their system, UPS (just like any other Logistics company of the past) constructed a network of customer counters, local warehouses, regional distribution centers, and a variety of modes of transportation and operated them with the help of the latest in communication and processing hardware and software. All this was before the company pioneered the use of Cloud Computing in the Logistics business.

Without going into a lot of information technology details, the Cloud platform enabled the company to streamline the process and eliminating a number of facilities that were adding to the cost and delay to the efficient transportation of packages through the system. As a result, a number of warehouses and distribution centers were eliminated from the system and the company adopted a "Direct to Store" model to move the packages from the origin to their destinations, very efficiently. The process involved the breakdown of bulk packages into smaller packages at the destinations or gateways, for direct delivery to the stores or large special customers. After fine tuning the system for their own operations, the company has now moved to being a logistics service provider, for any company that needs to have the logistics portion of their operations optimized. Unlike the traditional IT service providers, these cloud based systems are faster to adopt by customer firms and easier to get up to speed for the customer personnel in operating through these systems. A good analogy to understand the cloud based system of logistics, from the traditional logistics is to compare between a meal that can be custom ordered by making a telephone call or online order and setting up a kitchen, installing the equipment, hiring the chef, buying the provisions and produce, and getting the meal custom made. Generally speaking, second scenario, well expensive up front will be more cost effective in the long run. But with Cloud Computing, in logistics, the first scenario is not only cost effective and efficient in the short run, but also so in the long run. While with any new technology, there is a learning curve and things are not peachy right away, it is not the same with Cloud Computing. All the learning curve and experience curve phases are undertaken by the service provider. For the end user, it is like a "plug and play" device. The impact of Cloud Computing is so positive that we might have to make an exception to the saying "It is better to teach a person to fish rather than give him fish to eat, as the former would feed the person for a life time as opposed to just this once." In the case of a Cloud Computing based solution, it is like giving the person fish to eat for a life time is more effective than teaching him to fish.

The result to the customer is manifold. UPS Logistics' Direct to Market model helps the customer companies to eliminate distributions centers and some warehouses, thereby shrinking fulfillment cycles and inventory costs. With lower number of parties in the supply chain, the potential for system failures or slowdowns are also greatly reduced. David Zamsky in an UPS Logistics white paper called "Inventory in Motion" (2005) highlighted the fact using Direct to Market strategies, one of their customers was able to reduce the shipping costs of supplying their numerous retails site from their multiple manufacturers in China, by over 20%.

In addition to making "Brown" (a nick name by which UPS is known because of their signature brown delivery vans) a very viable transportation solution for the future by using a cutting edge Cloud platform, the company is also going "Green" wherever possible. With over 10,000 vehicles in their fleet the company has constantly sought technology-driven improvements to its own logistics operations. Over 2700 of its vehicle fleet is now made up of electric, hybrid electric, compressed natural gas, propane and liquefied natural gas. In 2013, UPS announced the purchase of 100 fully electric vans in California that would cut the company's annual gasoline consumption by 126,000 gallons.

CONCLUSIONS AND CONCLUDING REMARKS

Based on all that has been discussed in this paper, we can confidently state that Cloud Computing is here to stay and more specifically, it is going to play an important part in making Supply Chain Solutions available to medium and smaller players in the future, if not the very near future. Our reasoning for this is that one of the main features of a Supply Chain Management system is the part played by logistics in its operations. The example of UPS Logistics described above has made it abundantly clear that there are plenty of opportunities using a Cloud based platform for Supply Chain Management systems to, have the cake and eat it too, figuratively speaking. More importantly, you can take advantage of such opportunities even if you are small player without the resources of big multi-national corporations. This field is going to get even better as the success of UPS Logistics will only motivate some more players to enter this market.

Before we conclude, we should caution that the solution of a Cloud based platform to support your Supply Chain Management system will be only as good as the Supply Chain system would allow for. In other words, you must first build a good and efficient Supply Chain system. Only then can you go about enhancing it with a Cloud based logistics solution.

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Biography

Srikant Raghavan, currently an associate professor, has been part of the faculty in the College of Management since 1987. Before this position, Dr. Raghavan worked for General Motors as a Senior Research Engineer and Tata Consulting Services as an Associate Consultant. In addition, he has taught at half a dozen academic institutions as a part-time or full time faculty. Dr. Raghavan holds a bachelor's in Physics from the University of Madras, a master's in Operational Research from the University of Delhi, a master's in Operations Research from Case Institute of

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Galia Novakova is a chief assistant professor in the Department of Computing Systems at the Faculty of Mathematics and Informatics (FMI), Sofia University. Her scientific interests are mainly in e-Government, Software Analytics, Cloud Computing and Big Data, Operations Management, Statistical Quality Control and Performance Measurement. She holds a PhD degree from Politecnico di Torino (Italy) and in the period 2002-2006 Galia Novakova was a researcher and lecturer at Politecnico di Milano. She has about 30 scientific (peer-reviewed) publications in international conference proceedings and scientific journals. Dr. Novakova has performed a postdoc research also in the USA (from 2010 through 2012) in the area of production optimization and financial engineering/investing. She has a significant practical experience as e-Government adviser (2013), corporate business consultant, project manager in an IT company and marketing and sales manager in the natural-gas distribution sector and pharmaceutical industry. She is currently teaching courses in Cloud Technologies and Architectures (undergraduate course), and in Supply Chain Management as well as Software Development Life Cycle (SDLC) Management in a Master course in e-Business and e-Government at the FMI, University of Sofia.

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