Today's and Tomorrow's Mobile Technologies in Supply Chains

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Abstract: The advance of mobile technologies has attracted much attention in recent years. The competitive environment forces many companies to involve the latest mobile technologies and systems in their supply chains especially where customer focus is the main issue. Here the main motivation is that the industry players need a systematic approach to be able to maintain their position and grow in the market by responding to customer demands more quickly with lower costs in total. Therefore, significance of a well-managed supply chain has been growing day by day and mobile technologies including smartphones, tablets, mobile applications and lastly Internet of Things (IoT) have already become one of the most important parts of supply chain management. This results in a new definiton as "mobile supply chain management". To understand its benefits, the drivers of mobile supply chain management are explained in detail by giving their use areas in the industry reviewing literature remarkably. At the final stage, new trends and proposals are stated by considering mobile technologies taking new grounds in supply chain management and future topics such as robotics and autonomous vehicles are mentioned as well. In this paper, it is aimed to explain the role of mobile devices, applications and IoT well in terms of characteristics of mobile supply chain management.

Keywords: Mobile supply chain management, smartphone, tablet, mobile application, Internet of Things

1. Introduction

When mobile phones have been introduced in our lives, they have been used for communication between people either via voice or via text mesagges (SMS). Later, the need for relaying more information such as images or pictures was emerged thus MMS (Multi Media Services) messages was developed. Because of the need to reach more information by people while they are on the move, mobile internet connection capable phones were developed. In addition to this, these mobile phones have been also equiped with either new hardware or softwarre tools. For instance, from hardware point of view, the smartphones have been enhanced with powerful processors and RAMs; bigger and high resolution screens; many connection capabilities; and also auxilary tools such as digital camera, GNSS Receiver, acceloremeter, magnetometer etc. These hardware based tools provide the mobile phone powerful processing capability and faster response, sharp pictures, case dependent selectable connection type and useful inputs for applications, respectively. From software point of view, Microsot Office, or Acrobat Reader programmes provide the mobile

phone to view, save, or highligth the documents as in the laptop or desk top computer usage. Mobile phone manufacturers have been equiping their phones with the cutting-edge connection capabilities such as 2G, 3G, 4G, WLAN, Bluethooth and NFC (Near Field Communication), thanks to the increasing demand of the faster internet surfing from the customers. With the help of these connection capabilities owner of the mobile phone has a high speed internet surfing as comperable to internet speed provided by via cable. Furthermore, mobile phone user has a chance of choosing the connection type among many to stay connected to internet or the local area network (LAN) in a case dependent. These kinds of mobile phones are called as "smartphones" in literature because of their multitasking features and connection capabilities. After the evolution of smartphones, tablets have been introduced to market. Tablets were developed to fill the gap between smartphones and laptops from mobile internet connection point of view. They have bigger screen, better battery life and better processing capability than that of smartphones but they are heavier than smartphones and they do not have phone capability (except via internet connection). While smartphone and tablet technologies are growing, operators are also growing their infrastructures to support faster internet connections such as 2G, 3G, or 4G respectively. Furthermore, growing number of entrepreneurs have been developing applications for the operation systems used in both smartphones and also in tablets.

Multi-purpose usage and also stay connected internet capabilities drives the attention of people to buy a smartphone. Trend of owning a smartphone has become a lifestyle [1]. When needed more processing power and longer usage while connected in the internet, tablets have been chosen instead of smartphones. Because of these trends, smartphone shipments rised by 40 percent in 2013 to exceed the 1 billion unit threshold and $266 billion in value furthermore it is forecasted that smartphone shipments will be 1.89 billion units by 2018 [2]. Also in 2014, it has been seen the increasing of the number of mobile-connected tablets by 1.6 fold to 74 million [3]. In Figure1 global mobile devices growth are shown. In a result of increasing number of shipments of smartphones and also tablets, it is forecasted that network traffic will also increase. Per month in 2019, 4 GB of data traffic will be generated by the average smartphone, this presents a five-fold increase when compared with the average data

usage of 819 MB per month in 2014 [3]. By 2019, nearly double data traffic will be generated by the mobile-connected tablets (including 4G Tablets) when compared with the data traffic in 2014 [3].

As can be seen from these statistics, technology priority will be given to mobile internet connection and devices by companies. This growing attention to mobile systems by people can be called as the mobile bigbang and this mobile bingbang will bring radical changes to corporate management styles [5]. So, the question is how to implement this mobile technological change into supply chain managements and how do get benefit from these emerging technologies with applying in to our business.
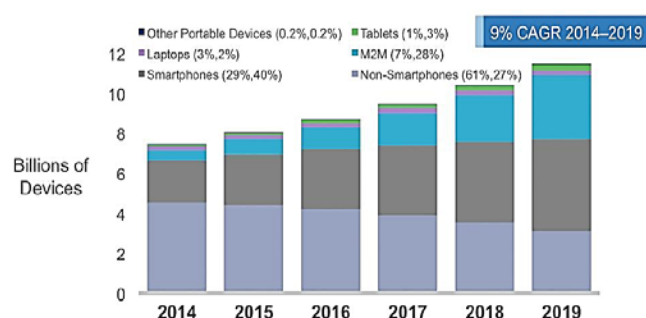

Figure 1: Global mobile devices growth [3]

Furthermore, in recent years mobile technologies have started to raise Internet of Things (IoT) approach. According to Mattern and Floerkemeier, "Internet of Things" was explained that changing system approach of remote identification of objects to smart objects have ability to communicate among each other or users [12]. It's also called the Internet of Everything or the Industrial Internet as a global network of machines and devices having interaction with each other [47].

Products having Internet of Things capability uses wireless interfaces such as NFC, Bluetooth, WLAN etc. With the help of Internet of Things capable products, companies are able to tie costumers to their services and program updates. As a result of that, company will have close relationship with customers more than ever.

In Figure 1, it can be also understood that M2M (machine-to-machine systems) has higher positive acceleration than others. It refers that IoT will dramatically be growing in the following years.

The aim of this paper is to understand the growing usage trend of mobile internet-connected devices (smartphones and tablets) and IoT to extract benefits from this trend to use in supply chains and to propose areas of usage in supply chains.

Examples of usage areas are supported to show the improvement of mobile internet-connected devices and IoT in supply chains. There is no doubt that changes in technology will drive supply chains over the next quarter of a decade in the more uncertain and complex business environment [29]. For that reason, supply chains need to be configured to manage the future environment and should be operated in real time by the inputs and also the information exchange among the five entities in supply chain; customer, retailer, distributor, manufacturer, supplier. This kind of real time supply chain management can be handled via mobile management thanks to the evolution of mobile internet connection capabilities, mobile devices and their prevalent usages.

This paper looks closer to mobile technologies in SCM and the structure of the paper is presented as follows. Firstly, background of the mobile devices is given. After the brief introduction of the mobile devices evolution, mobile technologies in SCM are investigated in detail. Based on the literature review in the related area, drivers are pointed out and then usage areas of mobile devices and IoT are explained. Finally, according to the recent studies mobile applications are introduced and future studies are clarified.

2. Background

Early mobile devices came into use in supply chain during the late 1990s as "stand alone" devices. These units were different than todays` integrated mobile devices. Early devices needed to use external modems and reading modules to catch and to transmit the data whereas an integrated device did not exist to handle different tasks in that time [13].

Multi tasking devices such as handheld PC, PDA (Personal Digital Assistants) and others started to come up with the mid-2000 era. Mobile phones of that time had very limited features like small keyboard, 150x150 pixels resolution and up to 12 lines of text capacity in their screen. Smartphones having more enhanced features enabled bigger screens with their higher capabilities in processor power, memory, storage etc. They are able to operate browsers as well. In the recent years, enormous technological improvements and developments in tablets, smartphones and also the relevant applications have created lots of chances in order to improve business processes [13].

Nowadays mobile computing has provided an important opportunity to enhance greater process by means of Apple iPad. The device enables new chances for the next generation of mobile communication with its internal storage capacity, processing power, size, portabilityand various connection features. The main advantage of this device is its flexibleoperability with other smart devices and numerous applicationswhich are reachable from every place when connected to network somehow.

Today, there are many tablets to compete against iPad in the market which are produced by Sony, Samsung, HTC and Motorola. Tablets are also getting higher market share day by day as seen in Figure 1 because it already becomes complementary product to smartphones when the bigger size device and higher processor power are required in especially business environments. In addition, it is not hard to say that the tablets are regarded an equivalent device against laptops and even PCs used as enterprise solutions in the offices.

On the other hand, wireless communication technologies mostly started to be developed at the beginning of 1990s. The first mobile internet came up with GPRS and EDGE systems providing 100 kbps roughly and triggered to develop current smartphones. Especially the launch of iPhone in 2007 and then extension of 3G mobile communication all over the world have remarkably boomed smart devices trend in the individual and business life. Generally speaking, smartphones have been seen the smaller alternative of the tablets. Smartphones and tablets have been carried to provide communication and social interaction for both in business and personal lives.

The trend of mobile business-to-business (B2B), employee-to-business (E2B) and business-to-employee (B2E) solutions has begun to quickly increase by means of the competitive conditions and enhancements in mobile communication and systems [14]. Ultimately, in logistics and transportation area, smartphones and tablets have obtained a significant role to handle supply chain activities for professionals anywhere not only with connection but also without connection thanks to the offline capability of some applications.

Using of the smartphones and tablets in supply chains are cheaper solution than that of desktop or laptop computers for the same task. Roughly, it is half of the cost [30]. Though it is cheaper solution, for some small companies this cost even can be

considered high. At this point, these companies can try to deploy BYOD (Bring Your Own Device) approach alternatively [32]. In this approach, company wants their employees to use their own smartphones or tablets while they are working in the company.

Over the past 25 years, the Internet has been developed from a small local network to a worldwide network. Finally, the term "Internet of Things" was firstly mentioned by MIT when approaching to 2000. It means devices and systems connected whole world by communicating amongst smart or non-smart objects through wired and wireless technologies [40]. According to Gartner forecast, 4.9 billion connected things in 2015 will reach up to 25 billion by 2020 and then IoT will considerably increase with the prevalence of connected cars [42].

As seen in Figure 2, Internet of Things carry three dimensions "any thing" communication to the information and communication technologies which already provide "any time" and "any place" communication [41].
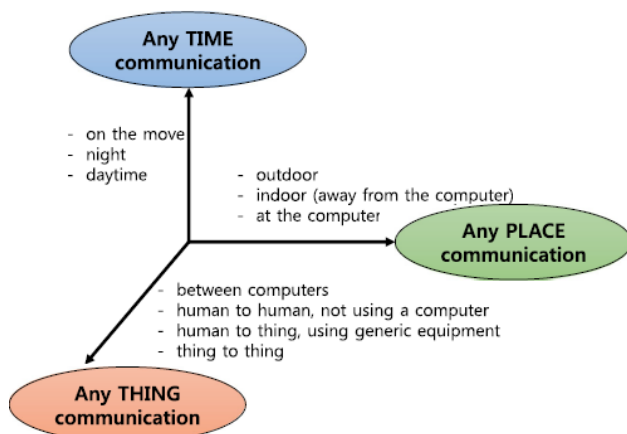

Figure 2: The dimensions of the Internet of Things

3. Mobile Technologies in SCM

Main objectives of all businesses are simply to increase profitability, customer satisfaction and market share [31]. These objectives can be reached by manufacturing innovative products and by improving supply chain effectiveness. By manufacturing innovative products, business can lead the industry and this ensures bigger market share. By improving supply chain, business can reduce total cost of the product and this ensures higher profitability. To be able to reduce the cost of the product and to get higher profitability, supply chains should be managed in real time as much as possible to satisfy the customer demand

which is the purpose of the supply chain. Furthermore, real-time supply chain visibility or fully mobile supply chain structures are required by the companies because of the enhancement in the omni-channel retailing [32].

Supply chain consists of retailer, distributor, manufacturer and supplier segments. Among these segments there are three flows; information, product and funds. To satisfy the customer demand in time depends on efficient and quick information exchange between these segments. For example, Apple, in addition to its innovative products, manages the supply chain effectively so that it is located in the first place in Gartner Supply Chain Top 25 List. As a result of reducing total cost of the products it has obtained higher profitability [31].

So the question is how the supply chain can be done more efficient. To be able to have robust information exchange between segments, mobile internet connected devices can be used since with the usage of these devices, in a company among managers and employees and also among supply chain segments real time feedback and information exchange can be secured. "Enterprise mobile management" and "mobile device management" are the terms which are used for this type of business [30]. In general, it is possible to do with mobile supply chain management (mSCM).

Mobile SCM means that the use of mobile applications and devices to help the execution of supply chain activities and then support firms to reduce the cost of the products and processes to provide fast responsiveness and to gain competitive advantage. It can be improved by integrating mobile technology to the existing IT systems and removing dependence on wired systems in the process. This enables firms and users flexibility to apply wireless technologies to any IT enabled supply chain functions and extends existing SCM capabilities [15].

To realize the change, mobile SCM system or called as mobile enabling real-time management should be swapped with or integrated into the existing supply chain management system and then mobile internet-connected devices will be driving force behind the robust mobile SCM. For instance, the operations performed by field service employees are confirmed by using the mobile internet-connected device and automatically registered in the company's ERP system furthermore mobile internet-connected devices can also be used to gain access to databases and draw

up requests regarding, e.g. orders, inventories, account balance or to download data regarded products sold or serviced [1].

To achieve this flexibility, Bouzayani and Dhiaf used tablets and smartphones to develop the ERP distributed with a decentralized architecture. They developed a total real time supply chain management based on co-modelling of distributed IS (Information System) architecture and complex supply chain management [7]. These kinds of flexible real time SCM architectures should be implemented into companies to keep pace with the expectations of the customers. Information (communication, monitoring and control) and money exchange between supply chain segments will be done automatically by minimum human error thanks to the evolution from traditional supply chain management system to real time management system.

Until this point, we did not mention any differentiation between mobile devices used in areas of the mobile supply chain segments. We suggest that employee working in the field can use mobile internet-connected tablets instead of smartphones. Firstly, tablets have bigger screen than smartphones. This specialty is important when field employees are trying to read screen under the bright light. Secondly, tablets have longer battery life than smartphones. This specialty is important when employees are in the field continuously throughout the day. Thirdly, tablets have more processing power than smartphones. This specialty is important when employees access on, and load the data in the data base or draw up the request. Since all these actions need more processing power. At this point we assume that company`s mobile enabled data base structure should be well defined and also maintained well. It should always be kept in mind that mobile devices are still only as good as the information that's available [4]. Because mobile devices are only clients of the mobile supply chain management systems, database or information consumed by mobile devices should be kept rich.

Table 3 shows growth in devices and mobile data traffic according to device types. As mentioned before, the main factor providing tablets with more data consumption than smartphones is the increasing trend of tablets in business areas.

Amarnath claims that there are gaps in the existing supply chains operating at a process transaction

level and also suggest filling these gaps by IoT [33].

Table 3: Comparison of global device unit growth and global mobile data traffic growth [3]

Device Type	Growth in Devices 2014-2019 CAGR	Growth in mobile Data Traffic 2014-2019 CAGR
Smartphone	16,7%	60,1%
Tablet	32,0%	83,4%
Laptop	5,3%	22,3%
M2M Module	45,5%	102,7%

Moreover, more robust supply chains than the implementation of the mobile supply chain management can be structured via using the IoT based on virtual objects instead of real object observation. This new approach is based on IOT and Cloud Computing capabilities [34]. When this kind of ultimate supply chain structures are provided, supply chains have enough intelligent to monitor, control and decide autonomously without human input. This kind of virtual supply chain management system can be seen as today and future of the supply chain management systems.

The IoT copes with integrating information and communication technologies including RFID, wireless sensor networks, M2M systems, mobile apps etc. Thus, that can take part in many industries such as transportation, energy, healthcare, pharmaceuticals, retail, manufacturing, recycling and food traceability [44].

The evolution of fundamental IoT technologies can be seen in Appendix A. Network, software and algorithms, hardware, and data processing are the keys which are playing main roles in Internet of Things. In the table some important forecasts are also given for between 2015-2020 and beyond 2020 in terms of these key technologies [47].

4. The Drivers for Mobile SCM

Especially proliferation of smartphones has resulted in the rise of mobile supply chain management and triggered the new consumer behaviours. All these changes have required adapting new conditions and environment for the industries and determining new strategies to be able to remain competitive in the market [38].

Another point of view, there are two fundamental evolutions pushing mobile supply chain management in the last 20 years. These are

mobility and internet which can be considered together nowadays because these two innovations are already bundled with new generation mobile communication technologies [39].

As understood above, in supply chain management there are many drivers that enable the compliance of various mobiletechnologies and systems. The increasing necessity to internal and external integration within companies and also between business partners can be the most significant driver in this purpose [23, 24]. Its details and the other remarkable drivers are explained in the following subsections.

4.1. Integration

As mentioned before, internal and external integrations are quite significant factors for compliance of mobile devices and applications in today's business environment. The development of the mobile internet and mobile device based applications has provided a lot of operations that are cross in the functions of the company. The mobile technologies' adoption is usually driven by their capabilities to improve internal and external integration in supply chain management.

Internal integration is improved with the fundamental communication skills like voice calls and push-to-talkservices. Furthermore, the internal integration is increased over internet amongst employees by providing them withthe access of organizational data anywhere and anytime. Additionally, external integration is improved with mobile apps that provideeasy access to related information for final consumers, retailers, transporters etc. For instance, a company can acquire the location and situation of a delivery by using GPS over a mobile device and wireless data services [22].

4.2. Globalization

In supply chain management globalization is another important driver that enable penetration of smartphones, tablets and apps. Mobile networkssuch as 2G, 3G and lastly 4G can enableinvaluable means for mobile communication especially in remote locations with the lack of fixed landlines to communicate.

With the advances of mobile technologies, mobile communicationsystems in many countries have already exceeded the land line in terms of geographical coverage and penetration. It means that business environments and people are now tending to involve in entire transactions with other

companies easily via mobile communication infrastructures. In addition, today mobility is also practical and beneficial between different countries thanks to global roaming services provided by mobile network operators in almost the entire world whereas it was regarded abnormal to do international calls 15-20 years ago. Therefore, mobile communication has the potential to provide and improve business operations and transactions with the international firms in the global supply chains [22].

4.3. Mobile Information

Mobile apps are able to remarkably improve the communication velocity [26]. The usage of mobile application while moving eliminates paper-based work flows and can speed up the processes greatly. Furthermore, electronic signature and the information of delivery (time, person, place etc.) via mobile devices enrich supply chain management with more effective and arranged information processes.

In the meanwhile, instantaneous data transfer provides the execution speedthroughout the supply chain by means of performing information available in a real-time. Besides it connects different concerned departments or work groups directly with the notifications and alert mechanisms in urgent situations. Finally, order-to-delivery time is shorter and service management responsesmore quicklywith the help of mobile information.

4.4. Novel Processes

Dynamic and competitive environment in the market trigger the companies to use mobile devices and applications in order to handle operational business processes. The firms such as Mc-Donald's are popular worldwide because oftheiradvantageous position in the market and competitive power thanks to novel business processes. Thus, the requirement to maintain advantage in the competition can push companies to innovations and reengineering the business processes utilizing from mobile communication and systems [27].

4.5. Replace Unused Systems

In the last decade the world has come face to face with lots of technological developments especially in mobile communication. For example, it was impossible to send a video or even picture with

mobile phones via EDGE technology whereas many mobile opportunities already exist today including delivery of HD movie in a minute over 4G network. Of course there are a lot of examples similarly. Life cycle in the mobile technology makes some systems unused after a while and then companies need to replace them with the new types to pace with competition in the market.

4.6. Cost Reduction

As estimated before this research, efficient cost management is a very significant factor in complianceof any mobile device and application in supply chain management. With the purpose of decreasing operational expenses, managers in SCM always look for new methods to improve operations. Mobile devices and applications can simply supplysimultaneous information to SCM systems. Moreover, the complexity of entire supply chain can be decreased by using mobile technologies in the order-to-cash process [28].

5. The Use Areas of Smartphones, Tablets and IoT in Mobile SCM

Supply chains cover from manufacturing to customer relationship and include manufacturer, supplier, transporter, warehouse, retailer, and customer segments. Possible usage of mobile internet-connected devices will be explained deeply at this part of the paper.

Customers can use their mobile internet-connected devices, generally smartphones, to buy product via internet instead of buying from physical stores. In a short time, it will be ordinary behaviour to check the product price on internet before visiting a physical store to purchase a product or check the price of the product on internet using smartphone while in physical store and purchase the product on the internet if it is cheaper than in physical store before leaving there. These examples can be extended. With the help of recent technological advances especially in mobile internet connection, boundaries between traditional and internet retailing blurs. This evolution from brick and mortar model to internet model opens up new and limitless dimensions for customers to buy product.

As another expression, technology breaks down the geographical barriers while purchasing and extends the market area all over the world. This is called as "omni channel retailing" in literature. Quantum Retail Technology's Retail outlook 2012 defines omni-channel retailing that customers' freedom of choosing interaction channel which is convenient to search, get information and purchase the products for improving shopping experience [9].

To keep the pace with technological change, retailers need to adapt their business models to give quick response to market needs. Jayashree Ramanan and Ramanakumar analysed the growth of Indian retail sector and found contributing factors as disposable income, urbanization, dominance of the younger generation in spending, nuclear families, advancement in information and communication technology (ICT). Furthermore, they identified the trends in Indian retail as E-tailing, mobile internet, F-commerce, omni-channel retailing, cloud computing, RFID in retail, augmented reality, search engine, drone strike at the retail and Me-tail [10].

Improving customer experience is another important topic for retailers. Customers want to collect information about product before purchasing so retailers should support their touch points to customers especially websites. Bughin, Chui, and Manyika proposed that executives should examine the touch points to customers of their companies and try to improve these points to increase customer satisfaction [11]. Physical stores (Pros: able to walk in store, touch, feel the products, try on if it is we are able to find the correct size etc. Cons: product types availability depends on store size and region, business expenditure of store etc.) and digital stores (Pros: no regional boundries to find the product demanded, easily reachable since customer-retailer connection will be through internet, relatively more product types than physical stores, less business expenditure than physical stores etc. Cons: not able to walk in store, touch, feel the products, try on if it is wearable to find the correct size etc.). From retailer point of view, retailers should open up internet sites and also their internet sites should be adapted to mobile internet-connected devices' processes.

Scanning the barcode is other type of usage of mobile internet-connected devices. With scanning barcode, it is searched for the availability and the price of exactly the same product on internet. For instance, RedLaser application on smartphones can be used to scan the barcodes and search the price of this product. The main point of this type of retailing is that internet retailers should develop their applications to search for a product, give an

information about that product, supply customer reviews about that product, purchase this product, if this product not available take backorder or suggest similar product to customer. For example, EPCIS (Electronic Product Code Information Services) is used in meat supply chains to provide tracking and tracing information about meats to supply chain partners, customers and authorities such as date of slaughtering, place of birth, location of slaughterhouse, certificates etc. [6].

Another usage of scanning barcodes is to buy a product. Bughin, Chui and Manyika explained that advertisement displays have been placed in South Korean and Belgian subway stations by Tesco and Delhaize respectively. With the help of these advertisement displays, the products can be ordered and purchased from physical stores via the usage of smartphones by customers [11].

Demand and search information of customers, and customer reviews about products via company specific application provide valuable information to manufacturers, suppliers, transporter, warehouse and retailer segments to asses their processes on products.

From manufacturer, supplier, transporter, warehouse, and retailer point of view; scanning the barcodes of the products by mobile internet-connected devices can be used to record transportation information (real time) of the product from retailers to customers (delivery tracking). With the help of this information customer can be informed about the status of his or her order. In addition to scanning labels, RFID (Radio Frequency Identification) tags can be used by transportation companies to provide information automatically about the product. Bughin, Chui, and Manyika explained that FedEx's Sense Aware Program uses devices included a GPS system, temperature, ligth, humidity, and barometric pressure sensors and these devices placed to sensitive packages to provide location and atmosferic information of the packages [11].

Furthermore, RFID enabled services can be used in especially in retail supply chains to adjust dynamic pricing of fresh and perishable products and also management of promotions in the store. With the usage of RFID enabled services, promotions can be monitored and evaluated to decide current and future promotion events. In addition, products that expiration date is approaching can be priced dynamically to create demand [35].

Additionally, it's pointed out that integration of RFID and cloud computing is vital to get real time information from customer orders and manufacturer plants, which enables optimized decisions on production scheduling and monitoring to accomplish faster with less cost (Guo et al., 2015). Then, Fan emphasizes impact of RFID technology on supply chain decisions with inventory inaccuracies as one of the main elements of IoT technologies [45].

Mobile internet-connected devices and mobile apps can also be used to send proof of delivery. This process can be done either recipient can put his or her signature on the screen by using a stylus or recipient's signature on the paper can be fotographed for further interrogations [1]. This usage is useful in transportation segment of the supply chains. With this usage, paperwork of tranportation processes is reduced, automatized (real time transportation information is provided) and availability of this information is increased.

Mobile internet-connected devices and mobile apps can also be used for field sales. With the help of this mobile solution, Karlsburger Foods Inc.`s field sales representative can provide electronic reciepts or paper receipts via carried Bluethooth printers. Furthermore, this field sales can be executed with connection or without connection. Thanks to the nuVizz mobile solution developed by nuVizz Inc. This mobile software allows drivers to complete the delivery even without connectivity because of built in offline capability of the mobile software [30].

Mobile internet-connected devices and mobile apps, especially smartphones can be used as mobile-payment devices among supply chain segments from customersto transportation segment. Bughin, Chui and Manyika examplified growing trend of mobile payment service in developing countries with the help of these services in ten month, more than a million mobile-payment subscribers have gained by Dutch-Bangla Bank Limited (DBBL) in Bangladesh [11]. Starbucks have used instant photo verification of buyers via Smartphone for payments [8]. Smartphones or tablets can also be used in credit card transsactions if they have contactless technology to capture the credit card information. However, in this type of usage, there can be security issues. To address these issues, transactions can be done via official applications on the credit card owner's smartphone or tablet.

Furthermore, Apple utilizes EasyPay system in itsown stores instead of traditional POS devices. iPhone users can easily complete their buying through an iOS application after scanning the product bar code. The other customers can request help from Apple staff for purchase. Apple use this system since 2009 in the stores by making purchase process much easier for customers and also its employees. Therefore, customers do not need to wait in the queue to buy product and can handle this in any place of the store thanks to mobile device. Besides the customers can sign the transaction with their fingers or e-pencil and then get the receipt via e-mail directly without any waste of hard-copy. In the following years this system is expected to become more popular in the world.

Similarly, Internet of Things has a variety of usage examples from production line to retail delivery. The IoT modifies business processes by enabling more precise and synchronized information in the flow of materials. For instance, UPS has already started to use IoT enabled fleet tracking technologies to decrease costs and enhance effectiveness of supply chain activities [47].

As another example, Disney has introduced a new wristband (MagicBand) with RFID chip which is serving as a ticket and connecting to Disney's database about visitors. Moreover, General Electric utilizes sensors in its jet engines, turbines and wind farms as a part of their IoT solutions [47].

Rong et al. studies Internet of Things from a business ecosystem point of view by using 6C framework to understand the IoT based ecosystem entirely. The 6C means context, cooperation, construct, configuration, capability and change [46].

In the meanwhile, it is obvious that social media usage has been growing, and people are sharing their needs, choices and pros/cons of products through these media channels. This kind of shared information can be used to create knowledge repositories by companies because the end user is dictating mobile consumption and driving the market [4].

6. Mobile Applications in SCM

Mobile applications have remarkably grown especially with the uptrend of smartphones and tablets in the market. Applications which are compatible with operate just like computer programs to handle some specific jobs in the mobile devices. Nowadays apps continue to extend their usage areas for individual users and also lots of companies from various industries. The adoption of the applications is really significant for the firms to keep up-to-date and follow trendsin the market.

Firstly, the most prominent advantage of these apps in SCM is having feature of location independence via mobile communication networks such as 3G and 4G anywhere as an important opportunity of mobility [17]. Moreover, mobile applications seem very useful for each level in the supply chain management. It means that mobile apps can be utilized by the managers, workers, engineers, drivers, and technicians etc. who are involved in this chain covering high, middle and low level employees in the companies [19].

In addition, mobile SCM apps enable information flow between different business functions throughout the supply chain. So, product flow is healthier when reaching to the final consumer in this way [15].

According to Umney, mobile technologies and applications provide companies many advantages with the help of speedy decision making, increasing productivity and reasonable costs. Besides, new generation of mobile communication helps SCM applications to enhance their usage by improving mobile or WiFi coverage [18].

Mobile SCM applications are classified as given in a matrix by Ruhi and Turel (2005). Bearer technologies and their relevant value chain activites can be seen in Appendix B. They classify the activities as logistics, operations, marketing & sales and service, and then list mobile SCM applications in the table with respect to their bearer technologies. It seems one of the most prominent taxonomies given in the literature so far.

According to Jenkins (2013), mobile SCM applications enable employees to be snychronized with the help of real time flow in the supply chain management. It seems an important factor to track all the process at the right time.

Similarly, Karlskind claims that optimization of workload is getting easier with the help of such applications used in the supply chain management. To direct the field staff to the right customer premises on time is possible with the GPS enabled devices and applications in this way. It decreases time to meet customer demands and increases total productivity of the business by the savings [36].

Lee classifies the IoT applications to three categories; monitoring and control, big data and business analytics, information sharing and collaboration. For example, smart home solutions are well known applications as a monitoring & control system so that IoT enabled devices can be monitored and controlled remotely through a smartphone or tablet [47].

In the meantime, IoT devices and sensors are collecting huge data and transfer to databases to be analysed or post-processed. That requires business analytics application in order to provide value-added services to customers. To give an example, Proctor & Gamble can measure and record the customers' brushing habits with the help of Oral-B electric toothbrush thanks to its big data capabilities [47].
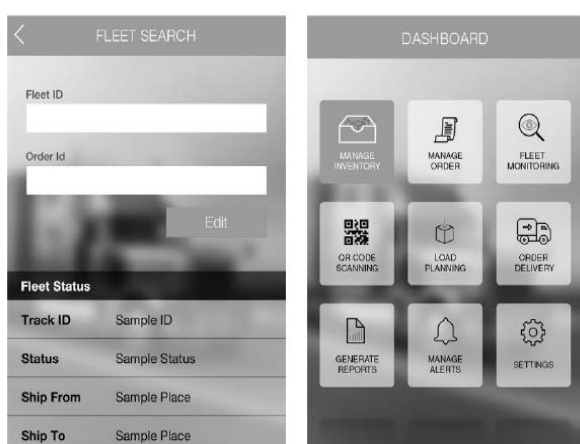
Figure 4: Supply chain management mobile app [21]

A sample mobile SCM application is pointed out in the Figure 4. It can be seen that many business functions are already accessible in the dashboard of application. Fleet monitoring, order delivery and inventory management are basic features of the application.

Nowadays, numerous supply chains have simply accepted the significance of mobile SCM and the accurate information in real time thanks to applications. Thus, they have already implemented mobile technology insupply chain management.

7. Conclusion

When the use areas of mobile internet connected devices are investigated, it can be concluded that tablets are more suitable than smartphones to be used in supply chains especially for company employees because tablets have bigger screen, better battery life and better processing capability than that of smartphones however both of them are

fragile. Especially the fragility of the tablets is the biggest problem in front of the usage in industrial environment of supply chains. To overcome this problem, ruggedized versions of tablets or ruggedized cases for conventional tablets should be developed to protect the tablet against unintentional fall, water spiling, dust and dirt while employees are working in the field.

Using mobile internet-connected devices, such as smartphones and tablets, are useful for all segments of supply chain to provide information about process or product in real time to response quickly to the customer demand. However, the integration challenge of the smartphones and tablets to existing supply chain can cost much higher than expected. So, the question is how much mobile data and integration of mobility devices to existing supply chain are needed. After this question is replied by the company management, integration level can be adopted or alternative solution can be considered.

One of the alternative solutions can be usage of cloud systems. With the usage of cloud system, real time supply chain management and logistics visibility can be achieved [32]. Besides the IoT and cloud computing provide a new approach with collection, transfer, storage and share information to enable better collaboration between supply chain components [43].

Barcodes on products should have standard types and give information about that product via the scanning label by using cameras of the smartphones or tablets. Companies should develop their own applications to search for a product, give information about that product, supply customer reviews about that product, and purchase this product. Furthermore, if this product is not available, backorder or similar product should be proposed to customer by the same applications.

Companies' fliers or ads on the shopping walls should have barcodes and when this label is scanned by using applications on the smartphones or tablets, customers can purchase these products on internet and these products should be sent customer. With a label scanner application, fliers should not be color since via application customer scan check the product images, its specifications and if it is available its reviews. If applications can be personalized, e.g. with the help of credit card information, customers' searching products can be identified and special discounts on these products can be proposed to customers. This results in collecting demand with less cost and less

uncertanity in demand when it is compared to traditional systems thanks to collection of real time information about products via mobile applications.

To conclude, the advent of 4th generation mobile communication systems (4G) has triggered internet of things and connected world. This approach refering any time, any place and any thing enables companies to manage their supply chain more efficiently with reduced cost and quick responsiveness in their operations in almost each step of supply chain. All the researches in the literature show that IoT will be dramatically significant for all industries to be competitive in the market. In addition, today's forecasts point out its prevalance will be getting more and more beyond 2020.

8. Future Works

It is clear that the future supply chain will be much more customized and automated with the help of mobile technologies including mobile devices, systems and applications that are much smarter than today's.

In a future work about this topic the other future technologies such as robotics, autonomous vehicles, 3D printing, intelligent machines and unmanned aerial vehicles (UAV) can be investigated in terms of their effects and use areas in the supply chain management. These are expected to take part in our daily lives by 2020 [37].

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APPENDIX A:

Evolution of key IoT technologies [47]

	Before 2010	2010—2015	2015—2020	Beyond 2020
Network	• Sensor networks	• Self-aware and self-organizing networks • Sensor network location transparency • Delay-tolerant networks • Storage networks and power networks • Hybrid networking technologies	• Network context awareness	• Network cognition • Self-learning, self-repairing networks
Software and Algorithms	• Relational database integration • IoT-oriented RDBMS • Event-based platforms • Sensor middleware • Sensor networks middleware • Proximity/ Localization algorithms	• Large-scale, open semantic software modules • Composable algorithms • Next generation IoT-based social software • Next generation IoT-based enterprise applications	• Goal-oriented software • Distributed intelligence, problem solving • Things-to-Things collaboration environments	• User-oriented software • The invisible IoT • Easy-to-deploy IoT software • Things-to-Humans collaboration • IoT 4 All
Hardware	• RFID tags and some sensors • Sensors built into mobile devices • NFC in mobile phones • Smaller and cheaper MEMs technology	• Multiprotocol, multistandards readers • More sensors and actuators • Secure, low-cost tags (e.g., Silent Tags)	• Smart sensors (biochemical) • More sensors and actuators (tiny sensors)	• Nanotechnology and new materials
Data Processing	• Serial data processing • Parallel data processing • Quality of services	• Energy, frequency spectrum-aware data processing • Data processing context adaptable	• Context-aware data processing and data responses	• Cognitive processing and optimization

APPENDIX B:

The classification of mobile SCM applications [22]

		Value Chain Activities			
		Logistics	**Operations**	**Marketing & Sales**	**Service**
Bearer Technologies	**GPS**	☐ Load Verification ☐ Vehicle Dispatching ☐ Package Tracking ☐ Asset Tracking ☐ Telematics		☐ Location-based Information Access ☐ Consumer Sales Promotion Campaigns	☐ Telemetry
	WWAN	☐ Advance Shipping Notifications ☐ Manifest Reconciliation	☐ Inter-office Integration	☐ Back-office Information Access	
	Cellular	☐ Delivery Confirmation ☐ Manifest Reconciliation ☐ Electronic Signature Capture ☐ Exception Notification ☐ Driver Contact	☐ Approval Workflows ☐ Managerial Contact ☐ Employee Contact	☐ Sales Promotion ☐ ATP/CTP Channel ☐ Reverse Logistics ☐ Location-based Push Services ☐ Sales Contact	☐ Service Contact ☐ Telemetry
	P2T	☐ Delivery Confirmation ☐ Exception Notification	☐ Employee Contact		☐ Employee Contact
	RFID	☐ Asset Tracking ☐ Barcode Scanning	☐ Barcode Scanning ☐ Telemetry	☐ Retail Space Replenishment	
	WLAN (Wi-Fi/ Bluetooth)	☐ Back-office Updates	☐ Telemetry ☐ Manifest Reconciliation ☐ Receiving & Payment Workflows		
		Mobile SCM Applications			

Acronyms Glossary:
ATP/CTP: Available-to-Promise/Capable-to-Promise
GPS: Global Positioning System
P2T: Push-to-Talk
RFID: Radio Frequency Identification
WLAN: Wireless Local Area Network
WWAN: Wireless Wide Area Network