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Mobile e-Services: State of the Art, Focus Areas, and Future Directions

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ABSTRACT

E-services are services delivered over the Internet. Such services have different properties and dimensions, e.g. targeting different sectors, being accessible through different channels, or intended for frequent or infrequent use. Throughout this article the authors address e-services from a mobility perspective. They do this by 1) positioning mobile e-services within the research field; 2) reviewing related work on mobile e-services; and 3) presenting and examining existing challenges (both difficulties and opportunities) when combining mobility and e-services. They see mobile e-services as the next generation of internet-based services and discuss important focus areas and future directions, giving extra notion to challenges and opportunities in the areas of acceptance and adoption, availability anytime and anywhere, and co-operation. In turn, these areas potentially set the scene for enhanced e-participation.

Keywords: Acceptance and Adoption, e-Services, Mobile e-Services, Mobility, Survey

1. INTRODUCTION

Mobile computing is defined as using portable computers capable of wireless networking (Forman & Zahorjan, 1994). This is what the International Telecommunication Union (ITU, 2002) denote as *terminal mobility*, i.e. *the ability of a terminal to change location [...] and still be able to communicate* (p. 2). Throughout the last decades, computing enabled by devices with wireless interfaces has been part of a greater computing infrastructure, but this has

rapidly changed as recent statistics show that the mobile computing paradigm in many ways has surpassed computing in fixed networks. ITU (2013) reports that the number of active mobile broadband subscriptions superseded its fixed counterparts in 2008, and as per now, the estimated ratio is almost three times as high (more than 2 billion active mobile broadband subscriptions compared to almost 700 million fixed).

Besides terminal mobility, there are three additional mobility types, namely user mobility, session mobility and service mobility. *User mobility*, or personal mobility, (ITU, 2002) is when the user can maintain the same iden-

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tity regardless of terminal or network, either through roaming or while maintaining active data streams and sessions. The latter is called is called continuous user mobility, or *session mobility*. The fourth mobility type, *service mobility* (Held & Ziegert, 1999), is about making services available anytime, anywhere, and thus dependent of the other three. Mobility reaches into all areas of computing and information-based technologies and, as the last mobility type implies, e-service research should eminently be such an area.

Definitions of e-services vary (and will be discussed in the next section of this paper), but a central component is the delivery of services through the Internet (e.g. Rowley, 2006). E-services are used to automate customer and citizen relationships, deliver and manage information, and have in many ways transformed markets and competition in supporting new value chains and structures (e.g. Lu, 2001; Sharma, 2007). Furthermore, e-services have found its place in the convergence of services and goods. Whereas goods are tangible and consumed separate from the moment of production, and services are intangible and consumed while produced, e-services are intangible but separable from the moment of production, thus becoming digital goods. (Hofacker et al, 2007; Scupola, Henten & Westh Nicolajsen, 2009). There is no doubt that e-services have grown to be an essential element (as a commodity, as well as an enabler) in the societies of the information age.

Research (e.g. Di Guardo, Galvagno & Cabiddu, 2012) shows that there are still large gaps to fill within the e-service area, especially regarding what aspects are unique to specific subareas or contexts. The main purpose of this article is to shed light on e-services from a mobility perspective. Our efforts are threefold. First we want to position *mobile* e-services within the research field, mainly through a review of e-service definitions and dimensions. Secondly, we will review related work on mobile e-services, to produce an overview of the state of the art in this subset of e-services. Third, this work will give us a basis for presenting

and discussing existing challenges that have to be addressed by the research community, to overcome difficulties as well as making good use of the opportunities mobile e-services give rise to.

1.1. e-Service Definitions

There are many different definitions of e-services. Early definitions (e.g. Tiwana & Ramesh, 2001; Rust & Kannan, 2003) often derive from (traditional, non electronic) service definitions, paired with new networking paradigms, i.e. the offering of non-material goods, e.g. *deeds, efforts, or performance*, to use Hoffman and Bateson's (1997, p. 5) words, through ICT technology. Grönroos et al (2000) problematize the definition by dividing it into a technical dimension, i.e. how the service is delivered, and a functional dimension, containing the outcome of the service. Tan, Benbasat and Cenfetelli (2013) adopt the similar notions of *service delivery* and *service content* (p. 77).

Surjadjaja, Ghosh and Jiju (2003) stress the importance of interaction between the service provider and the user in their definition, so does e.g. Rust and Lemon (2001), and Boyer, Hallowell and Roth (2002), underlining that e-services are not only Internet delivered, but also consumer driven. Rowley (2006) focuses on the nature of e-service delivery, but also on the importance of information and the user's role, when technology mediation is described as *a defining characteristic of e-service* generating *two inherent characteristics: e-service as information service; and e-service as self-service, each of which in their turn contribute to the nature of the e-service experience* (p. 344). An increased user involvement in the service delivery is also stressed by Scupola (2008a).

The least disputed aspect when examining definitions is the delivery of the service, often with a beneficial effect on value-making. For example, Javalgi, Martin and Todd (2004) state that *international delivery of services through electronic means is creating value in the supply chain*. There is a strong consensus throughout

the research field that e-service delivery resides on technology mediation. Rowley (2006), as mentioned before, identifies technology mediation as a defining characteristic. Scupola (2008a) describes e-services as *services that are produced, provided or consumed through the use of ICT-networks such as Internet-based systems and mobile solutions* (p. i).

Adding these different definitions together, one ends up with something like the often cited definition by Hofacker et al. (2007, p. 16): *an act or performance that creates value and provides benefits for customers through a process that is stored as an algorithm and typically implemented by networked software*. This and other somewhat general definitions have since been extended by researchers in different directions. Scupola et al (2009) differentiate between codified e-services and other e-services, the first including knowledge delivery rather than mere data or information delivery. Chen, Yuan and Mingins (2012) identify integrated processes within e-services, requiring both automated and manual processes, fully or partially implemented by networked software and highly interactive.

1.2. e-Service Dimensions

Besides being described through explicit definitions, e-services can also be examined by its different dimensions or property values. For example, e-services can target different sectors, allow different kinds of interaction, and (which is the core of this article) embrace the mobility paradigm to different extents.

1.2.1. e-Service Sectors

High level definitions distinguish between e-government and e-commerce, where e-government addresses the public sector, and e-commerce deals with the activities of commercial stakeholders. The border between these categories can often be blurry, as many services are produced as a result of partnerships between public and commercial actors. (Wihlborg, 2005) Sometimes, the notion of e-commerce is subordinate e-business, encompassing both e-

commerce and e-services, defining e-commerce as the buying and selling of immaterial goods, while all the interaction between the service provider and the user is mediated by the Internet when it comes to e-services (Cox & Dale, 2001; Surjadjaja, Ghosh & Antony, 2003). Cost efficiency and scalability are two important benefits of e-services that drive development in this area (Laudon & Traver, 2013).

Grönlund and Ranerup (2001) have defined a set of e-government dimensions, where e-services are the effectuation of services between officials on one hand, and citizens, the commercial sector and organizations on the other. E-management encompasses the services issued and effectuated between administrative officials and elected officials (e.g. elected politicians), while e-democracy is about participation and influence of decisions. E-democracy can in turn be divided into the distinct areas of e-participation (taking part in governmental decision making processes) and e-voting (Lee et al, 2011). Improved transparency is often emphasized as a key benefit of e-services in this particular sector (Alghamdi, Goodwin & Rampersad, 2013). A survey of trends within the e-government area can be found in an article by Islam and Scupola (2011).

Scupola et al (2009) identify four main groups of e-services categorized by which type of organization or role stakeholders belong to. Business-to-Business (B-to-B), Business-to-Consumer (B-to-C), Government-to-Business (G-t-B) or Government-to-Consumer (G-t-C), and Consumer-to-Consumer (C-t-C). As pointed out by e.g. Markaki, Charalabidis and Askounis (2011), and Bhattacharya, Gulla and Gupta (2012), e-services can also support Government-to-Government (G-t-G) activities. The relations are depicted in Figure 1.

1.2.2. Interaction

The grade of interactivity in an e-service is traditionally associated with the chronology of the evolving e-service paradigm. Early e-services were unilateral in terms of communication, e.g. downloadable information folders or digi-

Figure 1. Relations between consumer, government and business

tally delivered commercial material. As web technology evolved, e-services became more interactive, making use of the read *and* write capabilities of Web 2.0. Examples are web-based forms for making citizen proposals, simple subscription services, and web shops. A third wave of e-services went beyond the mere bilateral exchange of information, giving users access to service functionality regardless of terminal or network used. An important enabler was authorization technology, emitting publicly or privately electronic IDs. Examples of third wave e-services are e.g. e-banking, internet-based tax declaration and digitalized application services (Johansson & Andersson, 2013).

As with many other paradigms, e-services of different grade of interactivity still co-exist, and thus qualify for a dimension of its own when it comes to categorizing e-services.

1.2.3. Frequency and Continuance

Another important dimension of e-services is the anticipated temporal usage patterns. These can be described through the notions of frequency and continuance (Whilborg, 2005). Frequency is the rate of recurrence of which the user will consume the service. For example, paying bills through an e-banking service is likely to incur more often than taking a home loan. Continuance is the anticipated length of the relation between the service consumer and the service provider. For example, a service helping the user to find the way to an attraction in a big city is likely to be consumed for a shorter while compared to a online service helping the user to plan a two year work project. In a B-to-C context, continuance is often referred to as consumer (or customer) loyalty, thus denoting a continuant use more closely connected to

service quality factors like perceived value than the more objective categorization in Whilborg's classification (Chang, Wang & Yang, 2009).

Frequently used services and/or a high degree of continuance leads to the development of trust between the consumers and the actor offering the service. Research on trust forms a branch of its own in the e-service research agenda (e.g. addressed by Al-Dabbous, Al-Yatama & Saleh, 2011; Park, Chung & Hur, 2011); Jairak & Praneetpolgrang, 2013).

1.2.4. Channels

Different categories of end-users prefer different types of interaction with service providers. Taking on a multi-channel approach has therefore become an important strategic decision for various entities aiming at serving large populations of heterogeneous groups. Typically, not only a website is offered, but also solutions for smartphones and tablets in combination with possibilities for making calls to semi-automated call centers. Moreover, the diversity in terms of mobile platforms require even further specialization of applications and services to take advantage of each of those platforms. Today, web-based approaches with HTML5/CSS3/JavaScript in combination with frameworks like JQuery¹ and Sencha² represent a popular way of achieving channel heterogeneity in a relatively easy way if deploying different versions on different platforms is not preferred. Also, using hybrid WebKit/Native type of solutions is yet another track to follow when developing multi-channel applications and services. Finally, cross-platform development can be done using thin native clients that provide access to native APIs or render web-based applications with a native look and feel. (Abolfazli, Sanaei, Gani, Xia & Yang, 2014).

1.2.5. Process Integration

E-services have paved the way for process integration across functional areas and technology boundaries. Typically this includes complex processes involving a number of different authorities being responsible for specific parts of a chain. Examples are found in e-services

handling start-up of new companies, tax declarations, and management of real estate legal documents. Important technology building blocks to achieving this include web-enabled workflow management, single sign-on solutions, and technologies for orchestration and choreography (Peltz, 2003). Lately, lightweight integration technologies like mashups, gadgets, and pipes have gained interest. The use of such techniques typically allows for easy, fast integration, frequently made possible by access to open APIs and data sources. (de Vrieze, Xu, Bouguettaya, Yang & Chen, 2011).

1.2.6. Mobility

When it comes to key user values for e-services, mobility, as in the combination of localization and portability, is definitely one of them (Ihlström Eriksson & Svensson, 2009). As presented in the introduction, the mobile computing paradigm has had a huge impact on information technology. The very nature of the mobile landscape effects where, when and how services are innovated, developed, maintained and also used (Scupola, 2008b; Johansson & Andersson 2013; Nikou & Mezei, 2013). A mobile e-service can be available not only anytime, but also anywhere. Mobility crosscuts all sectors; mobile e-services are *critical for improving user-to-government communication effectiveness and maintaining relationships* (Hung, Chang & Kuo, 2013, p. 33); technology innovation in the area *leads to the creation or evolution of business models* (Kim, Choe, Choi & Park, 2008, p. 763), and *the future of mobile telecommunications relies on the development of mobile Internet services* (Bouwman, Carlsson, Molina-Castillo & Walden, 2007, p. 145). We foresee mobility as the most important dimension, designing the next generation of e-services.

Johansson and Andersson (2013) list four criteria for mobile e-services:

1. Full service mobility;
2. Increased functionality due to terminal and user mobility;
3. Cross-platform functionality;
4. Support for offline usage.

When supporting service mobility, the e-service should as much as possible be accessible regardless of terminal or network. This is both a question about application design (e.g. applications built with web technologies versus native applications, (e.g. Charland & Leroux, 2011; Andersson & Johansson, 2012)) and network availability (e.g. available network interfaces, network quality, and type of network subscription), but also e-service design, as the information management needed must be achievable even when e.g. using devices with limited input and output capabilities.

Making an e-service accessible from a mobile device is not a guarantee for true e-service mobility. There are many examples of e-services made available through SMS technology (e.g. ITnews, 2004; Suktarachan, Rattanamanee & Kawtrakul, 2009; Petrova & Yu, 2010) or the mobile web browser (e.g. Cui & Roto, 2008; Canuel & Crichton, 2011), but these might not take advantage of the fact that the user is mobile and that the device is located at a certain place at a certain time. Bouwman, Bejar and Nikou (2011) show that mobile services exploiting navigation and localization awareness and features stand out as the most innovative, and Johansson and Andersson (2013) argue that a truly mobile e-service should have an increased functionality due to the fact that the user and the terminal are mobile.

Availability anytime and anywhere should be extended not only to devices and locations. From a democracy perspective, this is extra important; for example, the i2010 action plan issued by the European Commission explicitly points out that *no citizen [should be] left behind*, and that *all citizens benefit from trusted, innovative services and easy access for all* (Lörincz et al, 2010, p. 5). One of the best means to reach a broad availability is cross-platform design (Andersson & Johansson, 2012). This also becomes important in the business sector, where enterprise employees often prefer to use their private devices instead of corporate-issued smartphones even when carrying out work-related tasks and communication (Abolfazli, 2014).

Being mobile unavoidably means that users can move in and out of network coverage. Sometimes the user might even willingly turn off the network interface, e.g. due to security and privacy reasons, or cost. (Ilarri, Mena & Illarramendi, 2010; Granlund, Johansson, Andersson & Brännström, 2013). A mobile e-service should therefore support offline usage, either fully or through functionality adaptation, allowing continuous service usage with some limitations. Exploiting the local storage of the mobile device (temporary or permanent) is an important aspect to consider when designing for mobility in different contexts.

2. STATE OF THE ART OF MOBILE E-SERVICES

Though emerging from a very recent technology paradigm, there are many examples of mobile e-services partially or even fully manifesting criteria such as full service mobility, increased functionality due to terminal and user mobility, cross-platform functionality and support for offline usage. In this section we describe the state-of-the-art of the technology used for mobile e-service development, and also give examples of case studies around such services.

2.1. Mobile e-Service Technology

When it comes to mobile e-service mediation, no single technology stands out as the best alternative. Research shows that mobile e-service consumption is context-dependent, and that different stakeholders can prefer different technology paradigms (Huy & van Thanh, 2012). However, when comparing aspects like innovation and features of the different mediating technologies, two main alternatives emerge, being mobile web and apps. Mobile web (W3C, 2010) is the adaptation of web pages for mobile devices, with properties such as cross-platform functionality, accessibility, and mobile-friendliness as guidelines. As touched upon in the “Channels” section of this article (and further discussed under the “Availability Anywhere, Anytime” headline), the emerging

HTML5 standard provides many tools for developers to deliver and adapt content for a mobile setting. Semantic elements, browser feature detection, client-side offline storage, and non-proprietary solutions for multimedia and graphics all contribute to mobile e-service delivery through the web browser. Combined with responsive web design (Marcotte, 2010), allowing elements to adjust to different screen resolutions and/or dynamically removing and adding content, functionality and navigation due to resizing the browser window, cross-platform functionality is stressed.

Apps, in the notion of “traditional” or “native” applications, are designed for specific devices and/or operating systems. Mobile e-services based on native app technology often exploit device hardware and operating system-specific features better than services delivered through a mobile browser. The same can be said about the GUI, as developers know beforehand which subset of mobile devices their services target. As the native app per default is installed on the mobile device, offline support is often solved automatically by having all content stored locally. Another (indirect) advantage of the native app is the marketplace which offers a platform for distribution and payment (Charland & Leroux, 2011; Bergvall-Kåreborn & Howcroft, 2013).

Web apps are apps designed using modern web technology and JavaScript. Essentially mobile web, web apps adds mimicking of native app look-and-feel. Web apps inherit the cross-platform functionality of mobile web, but run in full screen and can be added to the homescreen like native apps. As web apps (at least in theory) can be supported by all modern web platforms and do not need separate versions for different devices of operative systems, development is normally both faster and cheaper compared to native apps. A change in a web app also updates immediately, while native apps need to be actively updated by the users. Service providers do not need to share their revenues with marketplace owners, but marketing becomes harder as the user must have knowledge of the web app URL to consume the

service (Charland & Leroux, 2011; Huy & van Thanh, 2012; Abolfazli et al, 2014).

Mobile e-services based on web technology can also be delivered through hybrid solutions, making use of the strengths of native applications to enhance the web-based services. The Swedish municipality of Skellefteå offers its citizens e-services through a free application called “My Skellefteå” (Johansson & Andersson, 2014), available for both iOS and Android. The applications function as web-browsers, dedicated to present mobile e-services developed within the municipality framework. The browsers have enhanced and purpose-specific functionality for e.g. camera access and push notification. Service support is also available on the server side, offering libraries for information retrieval, statistics, alerts, and user dialogue that the developer can integrate with the e-services. The actual e-services are all html5, which allows for cross-platform functionality on most modern devices. Different hybrid solutions for accessing native APIs also exist, from methods already present in HTML5 and related frameworks, to cross-compilation and the packaging of web apps as native apps (Puder, Tillmann & Moskal, 2014).

2.2. Case Studies on Mobile e-Services

The 20 examples of mobile e-services we present in this section (see Tables 1-3 in the Appendix for summary) by no means form a complete list of projects in the field, but can nevertheless be seen a representation of the most scientifically and/or technologically interesting advancements in the area today, i.e. the state of the art of mobile e-services. *Nota bene*: the mobile e-services presented here all appear as cases in and/or outcomes of recent research, as for inclusion in this article giving them precedence to common e-services like Google Maps³ or Apple’s Find My iPhone⁴. Highlighting these cases should, besides exemplifying state of the art mobile e-services, give value to researchers in the area by being made known, and by extension give scientific insights.

Economic interests drive many mobile e-service projects. Value-addition through reduced perceived cost is a common incentive. Agent-based mobile shopper (Brown & Sankaranarayanan, 2011) employs intelligent agents that gather information about products from different stores on the users' behalf. In the initial prototype, location seems to be neglected, although vicinity to a physical store might be included as a user preference. Polar (Biancalana, Gasparetti, Micarelli & Sansonetti, 2013) adds user preferences such as e.g. time, day of week, weather conditions, user activity, and means of transport when giving recommendations. When compiling recommendations, data from social networks, user reviews and other web services is exploited, both as context data but also to produce rich recommendation results. Research cases also show other areas for the use of recommender systems, e.g. when developing services for mobile learning; the service recommends learning objects by taking into account the students' interests and collective preferences (Cazella, Barbosa, Reategui, Behar & Acosta, 2014).

One of the most basic features of mobile e-services is location-dependency. Map services, location-dependent information services, and tracking services all fall under this category. The Mobile Service Locator System (Mathkour, 2011) is a straightforward service allowing the user to find service facilities such as hospitals and supermarkets located in the user's physical proximity. The service also includes information about distance to each service facility. iTicino (Inversini & Violi, 2013) is an example of a mobile e-service aimed for tourists. Information about restaurants, attractions, activities etc. is provided along with dynamic weather updates and travel information. The user can also bookmark important information and create customized travels in the region through the user-centered "around me"-function. Other examples of travel services include the Real-Time Passenger Information application (RTPI) (Fagan & Caulfield, 2013), which provides transit information for coach passengers, allowing users to view information about next

arrival of relevant coaches on upcoming stops; and iTravel (Singhal & Shukla, 2012), providing the user with place search results, place details, and public transit information.

DisAssist (Lambrinos & Dosis, 2013) makes use of the Internet of Things (IoT) paradigm to provide a service helping disabled people to manage parking. Disabled people often have a limited number of exclusive parking spots, but these are often not enough to meet demands. Through multi-channel communication (allowing the user to access the service from a regular phone, a smartphone and/or a dedicated IoT device) between the user and the sensor-based system, directions can be provided to the nearest free parking space.

Instead of the user being informed about properties of the location, the users can inform each other or location owners or upkeepers about occurrences in the visited environments. In the G-to-C sector, services providing enhanced error report channels for the citizens seem to be particularly common. The Mobile problem report service (Juell-Skielse, 2010) allows citizens to use their mobile phones to take photos and register error reports to their Municipality administrators, communicating with the back-end system used in a corresponding 2nd generation e-service. Location data is retrieved through a national geodata register and automatically added to the report. A more recent variant of an error report service is the Munizapp (Lönn & Uppström, 2013), which is app-based and also allows for the municipality representatives to report back on received complaints. Reports are automatically registered in the municipality back-end, along with location coordinates. A similar service is Inform us (Johansson & Andersson, 2013), adding temporary offline storage of reports (in case of network loss), and a clustering mechanism facilitating report sorting for the municipality administrators handling the reports. The service uses an open source third party map tool for the retrieval of map data, and it also stands out as it is completely HTML5-based. As a result of this, cross-platform functionality is increased. Reddy, Estrin, Hansen, and Srivastava (2010)

examine micro-payments as an incentive to have users help out with data collection. In their GarbageWatch service, an application combining the possibility to take photos and tagging them (in the particular case study the mission was to map garbage cans and their contents) and their proximity to recycling clusters, is combined with rewards in the form of micro-payments. One of the payment models has the users compete against each other, being rewarded according to relative efficiency.

Sindbad (Sarwat et al, 2012) is a location-based social networking service, providing news feeds, recommendations and rankings that are all location-aware. It combines features traditionally found in social networks with location-based services functionality, creating a mobile e-service based on social and spatial relevance from the user's viewpoint. Comcare (Alakärppä, Hosio & Jaakkola, 2012) combines social networking with mobile e-health and sensor technology to create a service for elderly in need of wellbeing monitoring. Status updates are made to a community comprising of three circles; relatives, acquaintances, and professionals. Some updates are made automatically via sensors installed in the home, while other updates are made by the user (or circle members) through a mobile device.

The time machine (Holmgren, Johansson & Andersson, 2014) combines location-awareness with a map view and augmented reality to present information and photographic material about places from the past, the present, and also the future (adding representations of planned buildings, e.g. different versions of a new municipal travel center, opening up for citizens to comment or even vote for their favorite alternative). The time machine is based on HTML5 and WebRTC technology, testing the boundaries of today's state of the art in web-based mobile e-service design. Another trending technology is reality mining; the automatic collection and interpretation of information about social behavior and interaction with the surroundings. BOTTARI (Balduini et al, 2013) is an augmented reality app, providing personalized and location-dependent recommendations based on dynamically

calculated community opinions. For example, a user can get recommendations what to eat at a certain time in a certain area based on other users recent and/or long-time experiences.

Several modern e-services also include mobile sensor technology other than location-awareness. Roadroid (Forsslöf, 2013) is an application monitoring road conditions, measuring the vertical deviation of the road surface from its intended perfect form. The data is processed and then displayed using an internet-based map service as colored roads, where the colors indicate the quality of the road surface. Mobile Medical Monitoring (Sanna, Vicini, Bellini, Baroni & Rosi, 2013) lets users monitor different biological parameters such as heart rate and breathing using wearable patches communicating with smartphones, tablets and a web server. The data can be shared with professionals such as doctors or nutritionists in exchange for personalized help.

Modalities and areas of use also varies. Shared Geocaching (Procyk, Neustaedter, Pang, Tang & Judge, 2014) is a mobile e-service that allows pairs of geocachers to work together, while being at different locations. Video streams help the geocachers to see what the partner sees and subsequently share experiences over a distance. In the service prototype, certain equipment in addition to a smartphone is needed to capture video, but the service itself is not bound to a certain technology. For example, glasses that include smartphone functionality could replace these devices in a future version of the system. Gaming elements can also be found in crowdsourcing services; Urbanopoly (Celino et al, 2012) is a location-based game where users gather, compile and dynamically update urban data. As this activity is disguised as a Monopoly-resembling game, the mobile service makes use of reward mechanisms found in sports and gaming.

Table 1 contains a summary of the works presented in this section. It borrows from morphological analysis (Buede, 2009), breaking down a phenomenon (in this case mobile e-services) into dimensions and shapes, where the dimensions, i.e. e-service sectors, interac-

tion, frequency and continuance, channels, process, and mobility, are categorized by the shape parameters in a so called morphological box. This categorization produces a table that in a qualitative way models the characteristics of the chosen phenomenon. Morphological analysis has been used in many research areas, and application to the specific field of mobile services has been shown by e.g. Kim, Choe, Choi and Park (2008).

3. IMPORTANT FOCUS AREAS AND FUTURE DIRECTIONS

There is no lack of open research questions in the area of mobile e-services. However, when compiling and analyzing the findings from our extensive literature study, many open issues can be sorted under the areas of e-service acceptance and adoption, availability anywhere anytime, and co-operation. It is our belief that illustrating the possibilities and challenges connected to these topics can guide future research.

3.1. e-Service Acceptance and Adoption

With the explosive growth rates of wireless broadband subscriptions and smart devices, one might think that e-service acceptance and adoption would come easy and automatically. Research (e.g. Revels, Tojib & Tsarenko, 2010; Bergvall-Kåreborn & Howcroft, 2013; Nikou & Mezei, 2013) however shows that this is not always the case.

In an Australian study, Revels, Tojib & Tsarenko (2010) point out satisfaction (and perceived enjoyment, also stressed by Bouwman et al, 2007) and perceived usefulness (also supported by e.g. Zampou, Saprikis and Vlachopoulou (2011), along with perceived ease of use) as the main drivers for consumers' willingness to adopt mobile e-services. Perceived cost on the other hand has a negative effect. These specific key factors for mobile e-service adoption were also identified by e.g Kim (2012). Indeed, relationships between different success factors have been extensively examined by researchers in the

field (e.g. Standing et al, 2007; Ghobakhloo, Tang & Zulkifli, 2013). Besides general preferences such as ease of use and responsiveness, usefulness along with application and service accessibility, individualization, location utilization, platform independence, service mobility, and two-way communication, were found as key components in mobile e-service design (Johansson & Andersson, 2013).

Bouwman, Bejar and Nikou (2012) stress the importance of not treating all users as "lazy user" (p. 77), and that different types of services might be adopted by different sets of users. Their solution is to rather look at the nature and form of the service, rather than its properties, trying to explain adoption factors. Simple communication services has been proven popular (Nikou & Mezei, 2013), and an international study encompassing subjects from Spain, Finland, and the Netherlands, marked mobile telephony, SMS, mobile e-mail, mobile Internet surfing, and mobile maps as the five most likely services to be still used in five years' time (Bouwman, Bejar and Nikou, 2012). Research also show differences in adoption patterns between men and women (Lee, 2011) and younger versus older users (Fagan, Caulfield & Meier, 2013). Different personality traits can also influence behavior in the mobile use context (Varnali, 2011; Tobbin & Adjei, 2012). Developer knowledge about user habits and preferences is a good aid when designing services that reflect user needs and anticipations (Hermansson, Söderström & Johansson, 2014).

If we raise our heads above the mere services and applications, we see that the e-service situation as a whole influences user acceptance and adoption. The quality of interaction (e.g. attitudes and information), environment (e.g. design and equipment), and outcome (e.g. punctuality and valence) are all important factors (Lu, Zhang & Wang, 2009). Temporal, spatial, technical, and functional dimensions must all be addressed, trying to answer questions concerning when, where, what and how respectively in e-service design, delivery and interaction (Heinonen & Strandvik, 2009). Users demand flexibility throughout the whole usage cycle;

information flexibility, when deciding if the e-service is worth using; customization flexibility, to personalize a service and/or combine it with other services; and support flexibility, i.e. the possibility to reach the service provider through different communication channels at all times (Jin & Oriaku, 2013). Cultural differences also matter (Su & Adams, 2010). Gummerus and Pihlström (2011) identify 85 different use situations for mobile e-services, which pinpoints the importance of context inclusion when trying to address challenges of mobile e-service acceptance and adoption.

3.2. Availability Anywhere, Anytime

Before even considering challenges connected to user acceptance and adoption of e-services, availability issues must be handled. Customers cannot adopt services that are not available, they will not even begin to use services that do not work with their technology infrastructures, and e-democracy without a broad user exposure is useless.

As fully mobile e-services are consumed through mobile devices, overcoming limitations in user and terminal mobility form challenges that must be addressed. Connections might go down, either because of bad network coverage, or battery shortage, device or network malfunction, or as a result of the device being turned off. Network quality or bandwidth might be insufficient to support all sorts of mobile e-services, or temporarily congested, making services unavailable. (Ilarri, Mena & Illarrendi, 2010; Väättäjä, 2012) Studies (Nikou & Mezei, 2013) show that content quality and Internet connection quality are determinant factors when it comes to adoption of certain services, such as e.g. mobile TV. Also from a business perspective, the quality of service of a network is emphasized as a fundamental aspect for the delivery of value-added services (Chen & Cheng, 2010). The variation of available resources in itself might also be a problem, as assumptions are risky. Other limitations e.g. consist of constrained memory resources, limited storage and possibly also processing

power compared to stationary computers, even though every new model of handheld devices produced becomes more and more capable. (Ilarri, Mena & Illarrendi, 2010) A Finnish study (Eriksson, 2012) exemplifies this in a good way, comparing user experiences of trip arrangements using stationary computers contra mobile devices, where mobile users have complaints about screen size, slow (or no) service responsiveness, and limited multitasking possibilities, while high end mobile users (i.e. users equipped with modern smartphones and a higher proficiency of mobile Internet) did not have experiences that were significantly different from users consuming the service through stationary computers.

When it comes to service design, developers are often reluctant to work with old technology in a business where everything is moving (Bergvall-Kärebörn & Howcroft, 2013); the attitude that development for outdated devices is a waste of time is typical. However, in the notion of availability anytime, anywhere also lies the assumption that the user should be able to consume the mobile e-service even without having access to the latest hardware releases in terms of mobile devices. Likewise, owning a smartphone of a certain brand should preferably not exclude users from the service. In our view, cross-platform design is an important architectural choice to ensure availability for as many users as possible. Researchers (e.g. Lorenz, 2012) have suggested a model separating user interface from application logic, thus enhancing interoperability and granting the user more freedom in terms of choice of device when consuming the service. It uses the well-known Model-View-Controller (MVC) approach in a distributed setting as a basis. Evaluations of the proposed model do however give disparate answers to its feasibility, although interesting in its general design. Another way to meet challenges of cross-platform design is to design adaptable applications (Dalmau, Roose & Laplace, 2009), i.e. applications that can adjust user interfaces and functions to suit the device used for consuming the service. Methods for adaptation span from self-adaptation over adaptation through the

use of middleware platforms and frameworks, to centralized supervision. This can be realized for native applications using methods like identifying minimum device profiles, adding optional functionality in different contexts, separating events from static user interfaces, and as a developer be aware of differences in resolution and basic differences between common mobile devices. No matter how adaptable, native applications are still designed for a specific OS, forcing developers to design separate versions of the same application to support service consummation on heterogeneous platforms. In our opinion, a more promising technology to support cross-platform design is the emerging web standards and their related frameworks. As presented in the state of the art section, HTML5 (and its accompanying technologies JavaScript and CSS3) is platform independent, designed to deliver rich content without the need for proprietary plug-ins (Charland & Leroux, 2011). Besides these basic building blocks, there is additional technology that can be used to further strengthen the cross-platform capabilities. Feature detection is the ability to automatically identify which parts of the HTML5 language, available frameworks, device hardware, and OS features the application can use for its service delivery (Andersson & Johansson, 2012). For example, the the open source JavaScript library Modernizr⁵ can be included to detect HTML5 and CSS3 features in the browser installed on the user's device. This makes it possible to customize service functionality depending on the user's current platform. Responsive web design (Marcotte, 2010) is the application's ability to adapt the graphical user interface both according to platform, but also dynamically, e.g. as a result of window resizing. Combining modern web technology with feature detection and responsive web design produces a complete toolbox for cross-platform design, making it possible to develop for service availability anytime, anywhere.

An adjacent – and sometimes overlapping – technology that we believe could be used to meet heterogeneity challenges is context awareness.

Except the value-addition of e.g. location awareness (de Reuver & Haaker, 2009; Johansson & Andersson, 2013), a context-aware service could react upon its physical and digital environment and adapt itself to the circumstances and use conditions. Again cross-platform design is a good way to preemptively decide upon different ways to adapt an application to its host device. However, real-time context data could also be exploited to alter the service offered. For example, if network connection is lost, the service might offer different or limited functionality where a remote connection is not necessary, or if the battery levels of the mobile device used for accessing the service goes low, the application (along with all states) might be migrated to another device. (Johansson & Wiberg, 2012) An important question that researchers in the field still need to answer is where the intelligence in a context-aware mobile e-service should be located, if it should be managed centrally by the service provider (investing in a robust core infrastructure for context management), or if it should be handled by the end-user terminals (optimizing response time and privacy) (de Reuver & Haaker, 2009). The average mobile e-service usage takes place in a dynamic and unpredictable context, which makes it hard for content providers to foresee and prepare service content. Pre-caching could be one way to meet this challenge from a technical point of view, thus minimizing data signaling and reducing the potential damage of the loss of network connection. (O'Grady, O'Hare & Collier, 2010) Addition of context-awareness to a mobile e-service should however be approached with caution; e.g. a study by de Vos et al (2009) on location based mobile services shows that simply adding context-awareness features to the provided service rather decreased the perceived value from a user perspective, as many users were reluctant to share context data such as location information. Privacy is of high concern when designing for context awareness.

Research should also target the architectures used for the delivery of e-services. Innovative ideas like mobile peer-to-peer (MP2P)

networks could be applied to facilitate e-service retrieval increasing mobility while at the same time upholding consistency and scalability (Johansson, Åhlund & Åhlund, 2011; Victor Paul et al, 2013).

3.3. Co-Operation

There are many different stakeholders involved in the e-service area, the most apparent being the users of a service and the service owners. However, there are also innovators, coming up with the ideas for new services, and developers, realizing the e-services onto different computational and networking platforms. These developers may or (more often) may not be integrators, deploying the e-services and assimilating them with existing systems. Service maintainers work with the services after being deployed, upholding them and running maintenance and support. Administrators and operators manage service levels and oversees the delivery process, initially provided by service suppliers or third party service providers. (Kamal & Weerakody, 2010; Al-Dabbous, Al-Yatama & Saleh, 2011) A mobile e-service is dependent not only on the network and the service itself (a fact determined by the most reduced definition of an e-service, i.e. a service delivered via the Internet (e.g. Rowley, 2006)), but also of the mobile devices, a billing infrastructure, vendor operating systems and application design, content adaptation platforms, and content itself. Individual stakeholders don't have access to all the resources needed to develop, deliver and maintain these services, and thus co-operation becomes an inevitable challenge (de Reuver & Bouwman, 2011).

Hyper-competition in the area of mobile business not only has the undesirable side effect of availability restrictions (due to too much variation and lack of standards) but is also sometimes seen as a obstacle when it comes to co-operation during service development (Adams & Mouatt, 2010). The forms of co-operation can e.g. be contract-based, meaning that the different stakeholders are restricted by agreements that are legally binding and thus limit their actions, or they can be power-based,

meaning that one central stakeholder possesses most of the influence. Co-operation can also be trust-based, emphasizing joint decisions and a higher degree of freedom for the individual stakeholder. Finding the right balance is a delicate task. For example, too much contract-based governance during the development phase can hamper innovation, while too many actors depending on trust-based co-operation might find it hard to bring the ideas sprouted during the innovation stage to a finished mobile e-service. (de Reuver & Bouwman, 2011).

One of the most important stakeholders is the consumer. Consumer participation is desirable throughout the whole service process as consumers contribute with information and perceptions of the service quality and value, making it possible for service owners to monitor, evaluate and refine their services (Grönroos et al, 2000). Besides the trust and openness issues mentioned above, participation can also be hindered by a lack of knowledge and/or understanding of the organization of e.g. a municipality; Lönn and Uppström (2013) give an example where citizens use a mobile error reporting e-service that requires them to specify a certain administrative unit as receiver of the report. Without knowledge of the municipality organization, this hampers co-operation. We propose that developers of mobile e-services as far as possible should free themselves from assumptions that users have more than the most basic knowledge of structures such as service provider organization or administrative routines. Services relying on this information should provide translation and/or sorting procedures. For example, a similar mobile error reporting service (as in the already mentioned example) automatically stores GPS data to go with the report, automatically clustering error reports by location, which in a second round of sorting are forwarded by customer service personnel to the right administrative unit (Johansson & Andersson, 2013).

Co-production, i.e. to include users in the design process (Schultze & Bhappu, 2005), is desirable if viewing mobile e-service consumers as more than passive users. Indeed, fourth generation e-services rely on interaction and

information exchange between the user and the service provider (Johansson & Andersson, 2013). The “My Skellefteå” (Johansson & Andersson, 2014) framework is an open initiative aimed towards the development of mobile e-services in the municipality of Skellefteå, Sweden. The framework is public and all e-services are based on open source web technology and templates and APIs provided by the municipality. Thus anyone skilled in HTML5 can develop mobile e-services for use within the municipality framework. This is a novel take on co-operation, blurring the borders between user, developer, and service owner. The SATIN platform (Bergvall-Kåreborn & Wiberg, 2013) simplifies user involvement even further, providing a toolkit for application development where the user don’t have to be skilled in programming to create, share and even sell apps. SATIN is based on a library of components (i.e. micro services or “agents”), a graphical composition area allowing drag and drop and the specification of component interactions, and a GUI editor. The resulting apps are all HTML5 and can thus be used cross-platform.

Hwang and Yuan (2005) discuss ambient e-services, using mobile peer-to-peer technology in combination with sensors to allow users of an e-service to co-operate. Modern smartphones by far equip the sensors, positioning systems, and wireless interfaces needed to realize such e-services, and we see many examples on the application markets that have been widely adopted and used, e.g. apps and services such as fitness-tracking community app RunKeeper⁶ or location-based social networks like Foursquare⁷. Recent studies (e.g. Bouwman, Bejar & Nikou, 2012; Johansson & Andersson, 2013; Nikou & Mezei, 2013) show that inter-user co-operation indeed can add value to mobile e-services.

3.4. Other Challenges

Like all other areas of ICT, mobile e-services are exposed to threats in terms of lack of security. Fraud, sophisticated denial-of-service attacks, and viruses are but a small example of malicious appearances that threaten the use, adoption and

delivery of mobile e-services (e.g. Ben-Asher et al, 2011; Beldad, de Jong & Steehouder, 2011). When providing confidential information, users demand security, privacy protection, e-service reliability, and e-service consistency (Jin & Oriaku, 2013). This is especially important when it comes to services like mobile banking services (Selvan, Arasu & Sivagnanasundaram, 2011) or e-voting (Obermeier & Böttcher, 2011). Security and privacy are also important for building trust, in turn linked to willingness of e-service adoption (Sahadev & Purani, 2008). These threats must be met through careful technology implementation and design choices, but also take user behavior into account. We acknowledge the challenges surrounding security issues but do not address them further in this article; e-service security is a research area in its own and should be investigated thoroughly in future work.

Another limitation of this study is that it mainly considers mobile e-services in the developed countries of Europe, North America, Australia, and Asia. Reasons for this include that the software adoption and integration frameworks needed for the integration of mobile e-services is not yet present in a broader context in some parts of the world (as in the case of the Southern Africa Development Community, see Ramtohul and Soyjaudah, 2013), and that more urgent challenges concerning e.g. social and economic development still hampers mobile entrepreneurship (Froumentin, 2011).

4. CONCLUSION

In our view, mobile computing is the most important computing paradigm to influence and enhance modern e-services. The anytime and anywhere availability of services gives birth to a new generation of mobile e-services that can capitalize on the fact that a user is at a certain place at a certain time, and from that information add value to the delivered service.

In this article we have pointed out a broad spectrum of ongoing research and innovation activities within the area of mobile e-services.

One important factor behind this trend is that the technological advancements and increased availability of new tools and emergent technologies have made a large set of e-services available in a mobile setting to large user groups. Another important factor is the willingness and preparedness from service providers to invest in new technology and new innovative solutions not only covering their own parts of the value chain, but to extend the coverage of their e-services to the entire process. A third important factor is the motivation from end-users actually using the new types of e-services delivered.

From the factors mentioned above, and as an overall conclusion, we argue that an important future direction of mobile e-services research and innovation will be in the area of increased participation by consumers. We believe that enhanced adoption, increased availability, and better (and more innovative) co-operation are important elements achieving that.

Our future work will address these issues and focus on the combined effect of further technology enhancements and service innovations on the one hand, and the increased availability and reach of those services to new user groups on the other hand. Of special interest is the exploration of mobile e-services in a G-t-C context, with the possibility of strengthening e-participation.

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ENDNOTES

- 1 <http://jquery.com/>
- 2 <http://www.sencha.com/>
- 3 <https://maps.google.com/>
- 4 <https://www.apple.com/icloud/find-my-iphone.html>
- 5 <http://modernizr.com/>
- 6 runkeeper.com
- 7 foursquare.com

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APPENDIX

Table 1. Summary of state of the art case studies in mobile e-Services (Part 1)

Mobile e-Service	Provides	Sectors	Interaction	Freq. & Cont.	Channels	Process Integration	Mobility	Research Contribution
Agent-based mobile shopper (Brown & Sankaranarayanan, 2011)	Recommendation services for mobile shoppers	B-t-C	Bilateral; Authorization required	Medium frequency; Medium continuance	App (Java 2 Micro Edition)	Intelligent agents	Full service mobility; Increased functionality due to terminal and user mobility; Partial offline usage support	Utilizing the agent paradigm to enhance mobile e-service functionality
BOTTARI (Baldolini et al, 2013)	Personalized and location-dependent recommendations through reality mining	C-t-C	Bilateral; Optional authorization	Medium frequency; Medium continuance	App (Android)	Micropost streams	Full service mobility; Increased functionality due to terminal and user mobility; Partial offline usage support	Proves enhancement of mobile e-services through adoption of reality mining
Comcare (Alakärppä, Hosio & Jaakkola, 2012)	Communal activity-monitoring	G-t-C	Bilateral; Authorization required	Medium frequency; High continuance	App (Android)	e-Health data sharing and communication with (relatives and) professionals	Limited service mobility; Increased functionality due to terminal and user mobility; Partial offline usage support	Combines qualitatively different services, evolving e-health services
DisAssist (Lambrinos & Dosis, 2013)	Parking management for people with disabilities	G-t-C	Bilateral; Authorization required	Medium frequency; Low continuance	App (Android); Dedicated IoT device; SMS	Smart city system	Full service mobility; Increased functionality due to terminal and user mobility; Partial cross-platform functionality; Partial offline usage support	Utilizing the Internet of Things paradigm to enhance mobile e-service functionality
GarbageWatch (Reddy, Estrin, Hansen & Srivastava, 2010)	Waste bin status documentation	G-t-C	Bilateral; Authorization required	Medium frequency; Medium continuance	App (Android)	Connects data collection with micro-payments	Full service mobility; Increased functionality due to terminal and user mobility; Partial offline usage support	Examines micro-payments as an incentive to user contribution in information-dependent mobile e-services
Inform us (Johansson & Andersson, 2013)	Error report submission	G-to-C	Bilateral; Optional authorization	Medium frequency; Low continuance	App (Android, iOS); Browser (HTML5)	Municipal case management system	Full service mobility; Increased functionality due to terminal and user mobility; Cross-platform functionality; Offline usage support	Guidelines for the development of mobile e-services
iTicino (Inversini & Violi, 2013)	Mobile Tourist Guidance	G-t-C	Bilateral; Optional authorization	Medium frequency; Low continuance	App (iOS)	Limited in case study	Full service mobility; Increased functionality due to terminal and user mobility; Partial offline usage support	Usability study in a mobile tourism context
iTravel (Singhal & Shukla, 2012)	Location-based information and navigation help	G-t-C	Bilateral; Optional authorization	Medium frequency; Low continuance	App (Android)	Limited in case study	Full service mobility; Increased functionality due to terminal and user mobility; Partial offline usage support	Evaluation of different location-based services APIs

Table 2. Summary of state of the art case studies in mobile e-Services (Part 2)

Mobile e-Service	Provides	Sectors	Interaction	Freq. & Cont.	Channels	Process Integration	Mobility	Research Contribution
Mobile Medical Monitoring (Sanna, Vicini, Bellini, Baroni & Rosi, 2013)	Communal health-monitoring	G-to-C	Bilateral; Authorization required	Medium frequency; High continuance	App (Android)	e-Health data sharing and communication with professionals	Full service mobility; Increased functionality due to terminal and user mobility; Partial offline usage support	Combines qualitatively different services, evolving e-health services
Mobile problem report (Juell-Skielse, 2010)	Error report submission	G-to-C	Bilateral; No authorization	Medium frequency; Low continuance	Browser (WAP 2.0)	Municipal case management system	Full service mobility; Increased functionality due to terminal and user mobility	Explores possibilities and challenges in the e-government area
Mobile Service Locator System (Mathkour, 2011)	Service facility discovery and directions	B-to-C	Bilateral; No authorization	Medium frequency; Low continuance	App (Windows)	Connects clients, service providers, and administrators	Full service mobility; Increased functionality due to terminal and user mobility	Problematises location calculation for mobile services
Munizapp (Lönn & Uppström, 2013)	Error report submission	G-to-C	Bilateral; Optional authorization	Medium frequency; Low continuance	App (Android, iOS)	Municipal case management system	Full service mobility; Increased functionality due to terminal and user mobility; Partial cross-platform functionality; Partial offline usage support	Explores possibilities and challenges in the e-government area
Polar (Biancalana, Gasparetti, Micarelli & Sansonetti, 2013)	Location-based recommendation services	B-to-C	Bilateral; Authorization required	Medium frequency; Medium continuance	App (Android)	Limited in case study	Full service mobility; Increased functionality due to terminal and user mobility; Partial offline usage support	Extending the notion of context for mobile recommendation e-services
Roadroid (Forslöf, 2013)	Road surface measurements	B-to-G	Bilateral	High frequency; High continuance	App (Android); Browser (HTML5)	Integration ready; Translates measurement data to recognized standards	Full service mobility; Increased functionality due to terminal and user mobility; Partial cross-platform functionality; Offline usage support	Presents a novel smartphone-based solution for collection of road roughness data
RTPI (Fagan & Caulfield, 2013)	Real-time transit information	B-to-C	Bilateral; No authorization	High frequency; Medium continuance	App (iOS)	Real-time schedule management service	Full service mobility; Increased functionality due to terminal and user mobility	Examines the behavior of smartphone service users vs. website users

Table 3. Summary of state of the art case studies in mobile e-Services (Part 3)

Mobile e-Service	Provides	Sectors	Interaction	Freq. & Cont.	Channels	Process Integration	Mobility	Research Contribution
Shared Geocaching (Procyk, Neustaedter, Pang, Tang & Judge, 2014).	Exchange of experiences and help in geocaching contexts	C-t-C	Bilateral; Authorization required	Medium frequency; High continuance	App (Android)	Geocaching "game" context and community	Full service mobility; Increased functionality due to terminal and user mobility	Novel service evolution in the shared outdoor activity context
Sindbad (Sarwat et al, 2012)	Location-based social networking	C-t-C	Bilateral; Authorization required	Medium frequency; Medium continuance	App (Android); Browser (HTML)	Social network	Full service mobility; Increased functionality due to terminal and user mobility; Cross-platform functionality; Offline usage support	Combines qualitatively different services, evolving location-based networking services
The Time Machine (Holmgren, Johansson & Andersson, 2014)	Location-dependent information	G-to-C	Bilateral; Authorization only for additional functionality	Medium frequency; Low continuance	App (Android, iOS); Browser (HTML5)	Limited in case study	Full service mobility; Increased functionality due to terminal and user mobility; Cross-platform functionality; Partial offline usage support	Implements augmented reality in a cross-platform context to support mobile e-services
Unnamed prototype service (Cazella, Barbosa, Reategui, Behar & Acosta, 2014)	Recommendation of learning objects in mobile learning contexts	G-t-C	Bilateral; Authorization required	Medium frequency; Medium continuance	App (Windows)	Limited in case study	Full service mobility	Examines extended use of recommender systems in mobile e-services
Urbanopoly (Celino et al, 2012).	Urban data crowdsourcing through location-based gaming	G-t-C	Bilateral; Authorization required	Medium frequency; Medium continuance	App (Android)	Connects data collection with gaming and game community	Full service mobility; Increased functionality due to terminal and user mobility; Partial offline usage support	Utilizing gaming to enhance mobile e-service functionality

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