
A roadmap for research in mobile business

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Abstract: Mobile business research has arguably grown to become one of the most topical and complex eBusiness research areas in recent years. As a result, researchers face a plethora of interdisciplinary research challenges. Understanding the range of these challenges and confronting them requires coordinated research efforts, backed up by a holistic guiding approach. This paper aims at contributing to the future of mobile business research by proposing a roadmap to systematise and guide future research efforts, providing a methodical outlook to open research issues across all dimensions defining mobile business and prioritises future research in each dimension in the form of short-, medium-, and long-term research challenges.

Keywords: mobile business; wireless business; mobile applications and services; research agenda; roadmap.

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1 Introduction: the need for holistic research in mobile business

The proliferation of mobile and wireless communication technologies such as third-generation mobile telephony (Korhonen, 2001; Smith and Kollins, 2002), Wireless Personal and Local Area Networking (Rao and Parikh, 2003; Zimmerman, 2003; Burness *et al.*, 2003; Buttery and Sago, 2003), Radio Frequency Identification (RFID) (Smith and Konsynski, 2003) and WiMax has recently paved the ground for the development and commercial deployment of a multitude of applications and services. In essence, this capability emerged from the integration of cellular technology with the web (Saha *et al.*, 2002), which, over the last decade, witnessed an unprecedented widespread deployment and adoption primarily in the form of communication through the Global System for Mobile communications (GSM) (Rahnema, 1993). Furthermore, modern mobile handsets offer increased processing capabilities compared to their predecessors, which are almost equivalent to a desktop computer of the early 1990s. A typical mobile phone might include such specialised applications like games, a calendar, an organiser, and even synchronisation with a mail programme in order to store personal e-mail messages in the mobile phone. Moreover, recent mobile phones tend to have increased storage capabilities mainly through a storage card. Combining the aforementioned developments with the gradual decrease in the mobile phones' price, we can argue that modern mobile phones can be viewed as a commodity by most users; almost everybody uses a mobile phone while resting, working or travelling. To this end, a new class of applications and services emerged under the title '*mBusiness*' or '*mCommerce*', depending on the nature of the transaction involved (Varshney *et al.*, 2000). Location based services (Giaglis *et al.*, 2002), mobile marketing (Barwise and Strong, 2002), wireless community networking (Flickenger, 2002) and radio frequency-based item identification (Kourouthanassis and Roussos, 2003) are only a few examples of such applications that quickly gain prominence in both consumer and business markets. In short, *mBusiness* is a term that has been coined to denote the ways in which mobile and wireless communication technologies can be applied to address the requirements of users who need to access a varied range of applications and services through wireless access devices

while on the move. In this paper, we use this term to refer to communication, information exchange and transactions conducted over mobile or wireless networks. This definition includes everything we can do using a mobile phone or a wireless link connected to a computer network regardless of the technological platform used.

Over the past years, the research community was heavily involved in the process of identifying new application domains where the differentiating elements of mobile and wireless technologies could be deployed in order to enhance a particular application or service (Agrawal *et al.*, 2003; Varshney, 2003; Varshney and Vetter, 2000). These differentiating elements introduced by mobile and wireless technologies involve, among others:

- Applications and services that are *no longer localised* to the strict boundaries set by the desktop computer. Instead, an application or service could be accessed through a mobile phone, laptop or a Personal Digital Assistant (PDA) provided that it is connected to a mobile or wireless network.
- *Location identification* that has naturally become a critical attribute with the ability of mobility, as it opens the door to a world of applications and services that utilise information related to the geographical position of their users in order to provide value-added services to them (Giaglis *et al.*, 2002; Hightower and Biorriello, 2001).
- Applications and services that can be *fully personalised* since each end-user is one-to-one associated with his/her mobile or wireless handset and is distinctly identified through the SIM card embedded in the handset or the unique IP address assigned by the mobile network.
- The notion of mobility, which implies that information will eventually be accessible from anywhere, anytime. Computing artifacts can be embedded into the physical world, promising more than spontaneous availability of computational resources to the end users. Furthermore, they suggest new paradigms of interaction that are inspired by constant access to information and computational capabilities, creating a nearly 'ubiquitous' information and communication infrastructure (Abowd and Mynatt, 2000). Consequently, mobile and wireless technologies represent the enabling element towards total *pervasiveness* of Information Technology, where it can eventually be viewed by most people as part of the natural world.

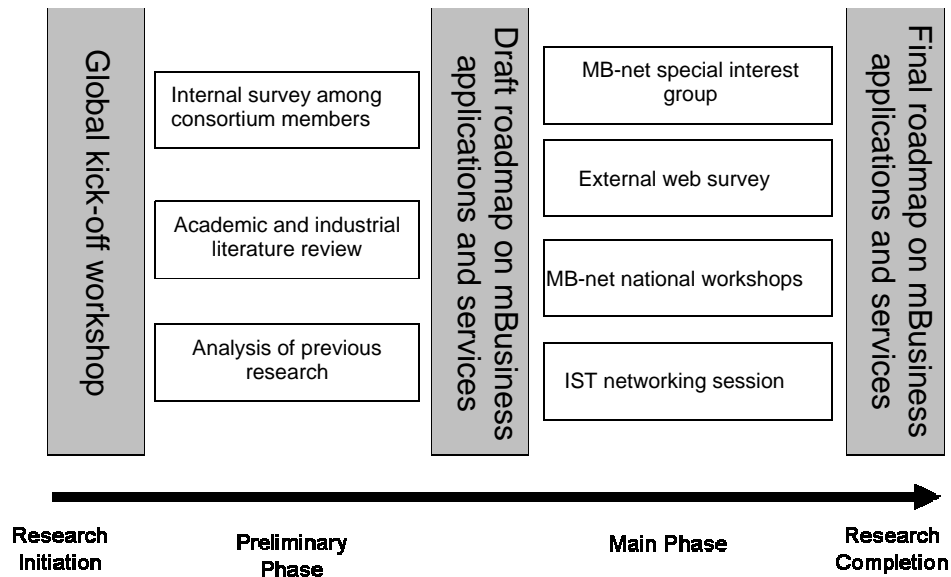
Confidently, mobile business involves a large array of applications and services (Vos and de Klein, 2002) that are not always easy to successfully conceptualise, develop and deliver. Despite the immense business potential of some of these applications, mBusiness is also characterised by a number of uncertainties and challenges, which have served to create a high-risk environment for research, entrepreneurial investment and strategy formulation. The uncertainties surrounding the future of mBusiness are not dissimilar to those of any new technology-driven and fast-growing application area. The absence of past data and the numerous possible future directions serve to create a complex landscape that is difficult to resolve even for the world's most highly acclaimed experts. While technological developments and standardisation efforts proceed at a rapid pace, many business challenges pertaining to the deployment and management of value-added services remain unresolved. There is considerable uncertainty as demand, competition, target markets, business models and value-added services still lack precise definition.

Arguably, understanding the numerous facets of mobile business requires a multidisciplinary research approach. Although individual and largely isolated efforts to define and tackle research issues in mobile business have been numerous, there has been relatively little work in defining a comprehensive agenda for mobile business research. An exception can be found in the work of Tarasewich *et al.* (2002) who classified open issues in mobile business research at the time. Their work has been of paramount importance for early research in the area and remains as a reference work to date. However, given the fast progress in the area, the need for an updated agenda for mBusiness research is vital. Furthermore, the work of Tarasewich *et al.* has been largely based on the authors' own viewpoints on what constituted a priority in mBusiness research during that period. However insightful this work might have been, it is still necessary to attempt anew at providing a definition and classification of open research issues in mobile business. This can be done through empirical research investigation and analysis, taking into account the viewpoints and priorities of the research constituency itself. This can be supported by recent efforts from several authors who recognise the importance for multidisciplinary research in global and national-related mobile issues (Yang *et al.*, 2004; Fraunholz and Unnithan, 2004; Kumar, 2004).

Following this rationale, this paper puts forward a roadmap for mBusiness research that defines and classifies priorities for future research on mobile business in a systematic and holistic fashion. We start by discussing the method that is followed to capture and synthesise the research issues as perceived by the global mBusiness research community. Then, we present this synthesis by discussing research priorities classified into four *research dimensions*, each of which is further decomposed into more specific *thematic categories* and atomic *research challenges*. This treelike classification allows the complexities, interdependencies and cross-discipline relationships between research issues to surface. Finally, we report on what the global mBusiness research constituency feels to be the priorities in addressing the research challenges identified, allowing us to create a chronological taxonomy of research challenges (classified into short-, medium-, and long-term ones) and thus enabling us to produce the final roadmap.

2 Research method

The roadmap development process followed a multi-step method aimed at engaging all stakeholders that are directly interested in or affected by developments in mobile business research (from the academia and industry alike). The method consisted of two main phases. In the first phase (Preliminary Research), 28 European research teams from the academia and industry were invited to contribute to the debate surrounding the future of mBusiness research. The results of this work were encapsulated in a Draft Roadmap, which was subsequently scrutinised and validated through an open process involving all interested global mBusiness research stakeholders (Main Research). Figure 1 schematically depicts the steps of the roadmap development method.

Figure 1 Roadmap development method

2.1 Global kick-off workshop

The basis for the esoteric debate that took place in the first phase of our research stemmed from a global kick-off workshop that took place during the First International Conference on Mobile Business (held in Athens in July 2002), where key stakeholders of mBusiness research and development from around the globe were present. The aim of the workshop was to bring together a limited number of acclaimed experts on mBusiness research from around the globe. They would then debate the future of mBusiness applications and services in small work groups during an intensive session, jumpstarting the process of the roadmap development.

In total, 25 researchers representing ten countries from around the world participated in the workshop. Workshop participants were presented with a list of seven domains perceived to collectively represent the factors that will primarily shape the future of mBusiness applications and services provision (*Technology Development, Market Adoption/Assimilation, Privacy and Security, Value Web/Network, Business Models, Channel Integration, and Business Alliances*). The underlying hypothesis behind this approach is that a holistic view of the area is required to capture the dynamics of the field and envisage its future. Unless all confounding factors are taken into account when debating the future of mBusiness, one risks the danger of getting trapped into a myopic outlook and a biased analysis that might limit the validity of the conclusions drawn. Having this guiding framework and hypothesis in mind, the experts were then asked to work in small groups to develop scenarios for the future of mBusiness using scenario planning techniques.

The group work outcomes, which illustrated a high degree of consensus and common understanding about the main challenges and uncertainties facing the future of mBusiness, were then synthesised into a three-tier architecture of mBusiness research challenges:

- At the basic level, the issue of *infrastructure access* consists of all those challenges and uncertainties related to the deployment of next-generation networks (e.g., third-generation mobile telephony and beyond) and the proliferation of alternative access technologies (e.g., WiFi) that will collectively provide the underlying infrastructure on which innovative mobile and wireless applications will be developed.
- Next, the core issue of *service delivery* is concerned with the issues related to the identification, understanding, classification and investigation of value-added mobile and wireless applications that will define the realm of mBusiness.
- Finally, at the higher level of value-adding potential, the issue of *intelligence* encompasses the potential of seamlessly integrating and effortlessly using innovative mobile and wireless applications in everyday life. This issue sets out challenges that transcend the scope of mobility *per se* and requires synergistic developments with other fields such as next-generation interfaces and device designs, universal access to services, dynamic content reconfiguration, and so on.

2.2 Preliminary research phase

Following the results of the kick-off workshop, the draft roadmap categories were then populated and elaborated through a detailed academic and industrial literature review, as well as through an internal web survey among the members of the 28 research groups who participated in the roadmap development effort:

- *Literature review*

The members of the participating research groups were asked to reflect on the results produced by the kick-off workshop. They were then asked to complement these findings by providing their perspective on the issues raised and by drawing on available literature stemming from academic and industrial sources. Each project partners was also asked to reflect on his area of expertise and come up with an initial suggestion regarding the thematic categories to be covered by the roadmap.

- *Internal survey*

A questionnaire was prepared and distributed to all project partners and members of the project. The questionnaire aimed at gathering the project partners' input and expertise in a structured way in order to analyse the feedback gained from the previous step. A total of 37 completed questionnaires were gathered.

The survey responses, along with the results of the previous steps, were then synthesised to produce the draft roadmap, which would form the basis in choosing which external input from the global mBusiness constituency would then be sought. The draft roadmap contained detailed thematic categories and atomic research challenges. Due to space limitations, these cannot be included here. However, the interested reader can find more details in MB-net (2003a).

2.3 Main research phase

The release of the draft roadmap is a very important milestone as it allowed us to move from the preliminary esoteric type of work (*i.e.*, the work only within the project members) to the main exoteric phase of the project (*i.e.*, seeking feedback from the global research constituency to develop the final version of the roadmap). In order to make the transition from the preliminary to the main phase of the project, the draft roadmap was heavily publicised through a systematic process, which aims at gathering and analysing feedback that would allow the production of the final roadmap. The most important phases of this process are analysed in the following:

- *Research constituency networking*

A networking session on Mobile Applications and Services was organised during the IST Conference that took place in Copenhagen in November 2002. The session was extremely successful in terms of attendance, since it attracted more than 180 participants from around the world. The draft roadmap served as the kick-off presentation of the session and acted as a starting point and an overall umbrella embracing the various aspects of the discussions and presentations that followed. The network that was developed became the core of the Special Interest Group that was then set up.

- *Special Interest Group (SIG) setup*

The SIG was established during the First International Conference on Mobile Business and was intensified after the publication of the draft roadmap. Near the end of the project, the SIG members included more than 350 researchers from 31 countries around the world.

- *External web survey*

A significant vehicle for gathering feedback on the draft roadmap from all over the world was the development of a detailed questionnaire outlining all thematic categories and research challenges identified in the draft roadmap. The questionnaire was placed on the Mobiforum portal (<http://www.mobiforum.org>) and was heavily publicised through the Networking Session, the SIG and partner direct contacts. The web survey aimed at validating and prioritising the elements contained in the draft roadmap so that the path to its final version could be paved. The survey attracted more than 100 responses, which were analysed to validate and update the contents of the draft roadmap. The results of the analysis can be found in MB-net (2003a).

- *Thematic workshops*

Perhaps the most important vehicle in the process of developing the final roadmap is the organisation of eight thematic workshops that took place in Vienna (Austria), St. Gallen (Switzerland), London (UK), Berlin (Germany), Nicosia (Cyprus), Athens (Greece), Turin (Italy) and Leiden (The Netherlands). The workshops, which took place between November 2002 and May 2003, concentrated on various aspects of the draft roadmap depending on local profiles and the expertise of the organising partners. Each workshop produced a detailed report that provided input to the production of the final roadmap. An analysis of the workshop outcomes is provided in MB-net (2003a).

All the aforementioned steps resulted in the development and publication of the final roadmap on mobile business research. The roadmap identifies specific research challenges for future research in mBusiness, and these are classified into four *research dimensions* and nine *thematic categories*. In what follows, we will outline the main contents of the roadmap. A more comprehensive analysis is included in MB-net (2003a).

3 Strategic research challenges for mobile business

The individual research challenges discussed in the remainder of the paper have been grouped into nine thematic categories, each of which belongs into one of four research dimensions, as depicted in Figure 2:

- *Research dimension 1*

Technology addresses those components of mobile business research that deal with the underlying technical progresses, which render mobile business applications possible. Technology is further split into two thematic categories: *Infrastructure* and *Devices*. The first deals with the mobile and wireless networking infrastructure domain, while the second addresses challenges associated with end-user access devices such as mobile phones, PDAs and WLAN-equipped notebooks. Further issues are discussed in MB-net (2003b).

- *Research dimension 2*

Service is concerned with the mobile business applications and services themselves. It is further decomposed into three thematic categories: *Emerging Applications*, *Multimedia Content*, and *Payment and Billing*. The first category addresses the various types of business and consumer applications that collectively define the mBusiness realm; the second is concerned with the generation, assimilation and delivery of content through mobile and wireless channels; while the third deals with the increasingly important challenges surrounding the implementation of appropriate payment and billing mechanisms that will render mobile commerce applications a reality.

- *Research dimension 3*

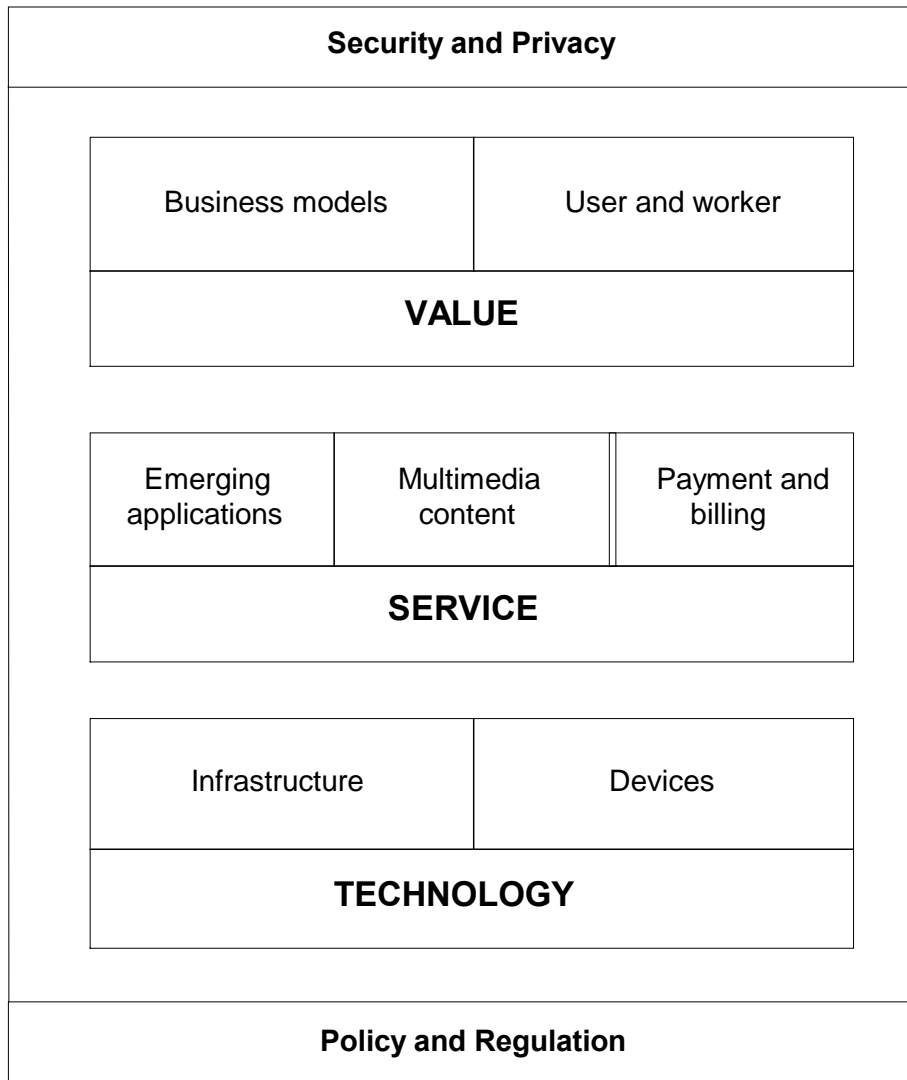
Value is concerned with how applications can be translated in marketable services and products. It is split into two thematic categories: *Business Models* and *User and Worker*. The first encompasses the development of innovative business models for mBusiness, while the second brings into perspective the requirements of the final recipient of mobile business services (*i.e.*, the end user).

- *Research dimension 4*

Enablers surround the roadmap and deals with those research challenges that are, although perhaps not unique to mobile business, essential enablers for the successful deployment of a particular mBusiness application or service. It is further decomposed into two thematic categories: *Security and Privacy* and *Policy and Regulation*. The first category addresses the question of trust and respect in

potentially intrusive mobile applications, while the second ensures that the role of governments, standardisation bodies and policy makers does not go unnoticed when researching mobile business.

Figure 2 Final roadmap research dimensions



The research challenges that belong to each research dimension and thematic category are further analysed in the succeeding sections.

3.1 Research dimension 1: technology

3.1.1 Infrastructure

Mobile and wireless networking infrastructure-related research needs to be addressed within the context of current trends that aim to integrate all communication channels, including the internet, television and telephony, into an all-IP infrastructure. The aim of such infrastructure is to allow operators to deploy IP technology for delivering services, without the dependency of circuit-switched network interfaces and elements for voice services. Such infrastructure also aims to enable the provision of voice/multimedia services independent of the underlying access systems. However, the all-IP infrastructure has stimulated new research areas. In order to analyse these research areas, we should distinguish two areas that need to be addressed: *network management and control* (including the provision of Quality of Service in the core network) and *radio resource management* (supporting the Radio Access Network (RAN)).

Network management and control is a complex problem, which becomes even more difficult with the introduction of new ‘resource-hungry’ applications with stringent Quality of Service (QoS) requirements. The provision of QoS guarantees is becoming a pressing need in both wired and wireless networks to support multimedia-enabled applications in particular. Thus, this provision will require robust, possibly intelligent, control methodologies to obtain satisfactory performance (Douligeris *et al.*, 2002; Pitsillides and Sekercioglu, 2000). The research community is now directing its interest towards unified ways of looking at system design, optimisation and QoS issues in order to satisfy the requirements of next-generation mobile and wireless networks such as the Universal Mobile Telecommunication System (UMTS). The implementation of all-IP future mobile and wireless networks implies that IP QoS architectures and mechanisms need to be developed, as the existing best-effort mechanisms are unable to cope with the requirements implied by the all IP-based network architectures. In this context, research will be directed towards the investigation of issues in resource management (De Bernardi *et al.*, 2000), congestion control, connection admission control (Epstein and Schwartz, 2000) and active queue management (Hollot *et al.*, 2002) in mobile/wireless IP-based networks. Therefore, efficient and effective management and control techniques using non-linear control theory (Pitsillides *et al.*, 2001), computational intelligence (Pitsillides and Sekercioglu, 2000), and perturbation analysis of discrete-event and hybrid systems (Cassandras *et al.*, 2002; Cassandras and LaFortune, 1999) should be developed.

With regards to Radio Resource Management (RRM), specific mechanisms include power control, packet scheduling, call admission control, load control and handover. Third generation wireless systems such as UMTS are designed to support a wide variety of services like speech, video telephony, internet browsing and so on. This mixture of services produces a range of QoS requirements. These requirements are controlled in the radio interface by RRM mechanisms. In mobile communication systems based on the CDMA technique (where all users can share a common frequency), interference control is a crucial issue. This is especially important for the uplink direction, since a device that is located close to the base station and is transmitting with excessive power can easily overshoot other devices that are at the cell edge (the near-far effect). It can also block the whole cell or even cause interference to devices in neighbouring cells (inter-cell interference). In the downlink direction, system capacity is directly determined by the required code power for each connection. Therefore, it is essential to keep transmission

power at a minimum level while ensuring adequate signal quality and level at the receiving end.

Going further into the purely technical dimension, research should also focus on the business dimension of the mobile infrastructure, investigating if technological advancements are readily implemented in mobile applications and service solutions. Areas that need to be addressed include interoperability and networking technologies, test-bed evaluation, home networking and open technology platforms. The plethora of various mobile and wireless networks has generated dependencies between the telecommunication network and the application. This has resulted primarily in the implementation of 'network-specific' services, and secondly in the replication of key functions such as authentication, authorisation and security. Moreover, service roaming among various networks (for example, from a UMTS network to a WLAN) is not currently supported (at least not to a degree of full transparency to the end user). Future research should focus on the definition of a generic architecture capable of hosting 'network type independent' routing, switching and service functionality. This architecture might also imply the necessity for infrastructure sharing among network providers. Moreover, researchers should also focus on the specification of appropriate algorithms that take into account the changes in bandwidth when an end-user switches networks. This way, the quality of the presented content is automatically modified in such a way that the mobile service/application constantly provides an acceptable quality of service.

The recent examples of European UMTS network licensing, which resulted in excessive investments by mobile operators, suggest that it is essential to perform extensive network testing and evaluation with respect to service quality, conformance, interoperability and stress before deployment to commercial level. In order to verify and validate the operation and performance of their infrastructure, it is essential that research is performed in testing and evaluation methodologies as well as in platforms aiming to assist mobile network operators and infrastructure providers.

The integration of advanced wireless communication technologies (such as WLAN, Bluetooth and the forthcoming WiMAX) offer new possibilities for in-home wirelessly networked applications like access to high quality multimedia content and domestic appliance control. Research should be conducted to design strategies for more flexible environments that better meet the occupants' physical and cognitive needs. This requires research in high potential domains such as next-generation household appliances and virtual mobile entertainment applications.

3.1.2 Devices

Handsets are the means of service delivery to end-users since they carry the functionalities that allow users to access applications and services. Gonzales (2002) defines the device as the pathway to the success of mobile business applications. Langley *et al.* (2000) strongly argues that device manufacturers are the key players in the mBusiness value chain. Nordan (Nordan and Zohar, 2000) goes even further to state that they (*i.e.*, device manufacturers) actually shape mBusiness by implementing new functionalities to support new and innovative applications and services. Irrespective of their specific roles, devices are the user's means of identification in mobile business, thus tending to become part of the user's personality. Users may fail to appreciate the complexities associated with the development of mobile devices, but at the same time

they may appreciate their usage simplicity to a point that it can be taken for granted. Our analysis shows that the preservation of this 'easy-to-use' approach, while providing additional functionalities, should be the main thrust of research activities in this domain.

More specific research issues identified within this thematic category include battery duration and processing power, since devices are currently supporting a set of new functionalities and tools such as digital video cameras, Global Positioning System (GPS) receivers, storage cards and music players. Moreover, the improvement of display and video features of devices are expected to become crucial issues. Lastly, research should also be oriented towards improving the device size and weight. Although we recognise that handset manufacturers are familiar with research challenges in this domain, it is essential that research efforts are directed into matching the user requirements and expectations with appropriate technological development (Fouskas *et al.*, 2002). This is especially important if we take into account the plurality and diversity of modern mobile handsets such as intelligent appliances, bio-sensors and wearable devices, or even everyday life objects that incorporate sufficient computing capabilities.

3.2 *Research dimension 2: service*

3.2.1 *Emerging applications*

The future and sustainable success of mobile business will depend on the development of appropriate organisational and commercial applications. Without them, operators will not be able to provide users with innovative and revenue-generating services. As argued by Olderog and Skiera (2000), there is a need for multiple (bundled) services supported by the necessary applications tailored to the requirements of the user. Currently, many commercial efforts in the area of mobile business are based on the attempt to transfer internet-based applications and services to the mobile world. However, our analysis indicates that a more innovative and structured approach is needed in order to create genuine mobile applications and to mobilise existing internet-based ones.

Steering for innovation, it is important to remember that investments should not be directed exclusively to solving technological problems. Instead, particular attention should be given to the development of advanced methodologies in order to assess user interests and appreciation towards mobile applications, and more importantly, their willingness to devote additional funds to exploit users functionalities. Emerging applications that will play key role include privacy-enabling technologies, location-based services, seamless roaming, and pervasive applications and services:

- Privacy-enabling technologies are pivotal to allow users to manage their personal identity while interacting with mobile devices. This is extremely important since one of the most innovative aspects of mobile business is device personalisation. In this context, users may anticipate the fact that a non-authorised person may uncover personal data and information about them or may even contact them directly, in a very negative fashion, without their permission. The research community has encountered similar challenges (with limited solutions) while dealing with electronic commerce and the internet in general. It is possible to draw some research lessons from these failures (for example, the need to assess how much users are prepared to pay for having an access to privacy applications, or if they expect that these applications are provided for free by the mobile operator or the handset producer).

- Location-based services allow users to relate and orient themselves with any physical environment irrespective of their knowledge about it. The possibilities for new and innovative services are endless, ranging from accessible information about restaurants to local medical data. However, as already emphasised earlier, users may not be willing to pay for all of these services. The overall objective should be to devise research methodologies aimed at uncovering which services provide true value to users. Tools and mechanisms from marketing research, ranging from focus groups and surveys to computer-based stated preferences based on statistical analysis, can be effectively brought into the mobile business research agenda.
- In terms of mobile voice telecommunications, seamless roaming has been achieved due to the success of the GSM and its partial interoperability with other standards. The situation is more complex with regard to accessing data services, since GPRS/UMTS users are not yet allowed to access mobile data and services irrespective of their location. A similar limitation applies to wireless internet services. The main limiting mobile roaming factor involves the definition of better roaming agreements between various operators. We suggest that specific research activities be directed at the development of advanced methodologies in order to anticipate similar business or regulatory risks that may hamper the delivery of effective mobile business services.
- Pervasive applications and services is the result of the recent advances that occurred in two computer science broad areas, namely distributed and mobile and wireless computing. On the one hand, the introduction of the World Wide Web and the internet interconnected computers and enabled them to share almost ubiquitous resources and capabilities over the new networks. Thus, distributed computing paved the ground towards pervasiveness by introducing seamless access to remote information resources and communication with fault tolerance, high availability and increased security (Satyanarayanan, 2001). On the other hand, mobile computing provided an 'anytime, anywhere' access support which essentially prepared the way for the pervasive applications and pervasive applications and services (*i.e.*, the all-time, everywhere vision) (Saha and Mukherjee, 2003). Since pervasive applications and services imply that information technology artifacts are smoothly integrated in the physical world, the two main research challenges should/therefore include:
 - a The specification of a common design approach that would unitarily present the general properties and requirements that, in turn, would ensure the successful implementation and deployment of a pervasive applications and/or service.
 - b The specification of an appropriate business model that would ensure the financial viability of the emerging application class.

3.2.2 Multimedia content

The future of mobile business will involve the provision of efficient content to end-users in a timely manner. This is a very complex task since the overall process for content collection, aggregation and delivery needs to be structured to provide advanced localisation and personalisation functionalities (Seager, 2003; Powell and Vu, 2001). This can only be achieved if content evolves dynamically over time and location (Schmidt *et al.*, 2001).

The provision of dynamic content over mobile devices is not an easy technical and operational task. As an example, collaborative agent-based systems may provide specific functionalities to support innovative mobile applications and services. These systems can develop an understanding of the users' needs and requirements, thus tailoring content accordingly. Still, these technological solutions may fall short of delivering the expected results due to the inherent processing and display limitations of mobile devices. However, more powerful mobile devices and further research on managing on-the-fly content adaptation may provide solutions in the future. High priority should be given to the domain of dynamic content delivery applications and services including content syndication, multilingual content and content pricing:

- *Content syndication*

Content might be impossible to be produced by a single source. Consequently, operators or mobile portals will need to syndicate content from various sources and then integrate it. However, there is a need for further research into business models that support content syndication and integration in a commercially viable fashion. Particular attention should also be directed at examining how current revenue sharing agreements (among the various actors involved in mobile business) can sustain the healthy development of mobile applications and services.

- *Multilingualism*

In mobile environments, contrary to eBusiness, the English language will not dominate. Non-English-speaking users expect to have automatic access to content that is in the same language to which they have set their devices, irrespective of their geographical location. Additional work needs to be directed into examining the cost model for providing single language, context-aware content over various geographical locations.

- *Content pricing*

Mobile business should learn from the negative experience of eBusiness with regard to content pricing. In particular, any pricing scheme requires consideration of the socio-cultural context of mobile telephony. Existing users of mobile devices are more accustomed to paying for services and tools, a condition that only marginally simplifies the overall approach towards content pricing in mobile business. Due to the personalisation of mobile devices, users are more in control of what they are willing to pay for or receive for free. For example, they may not be receptive to commercial SMS messages while travelling abroad due to high roaming charges.

3.2.3 *Payment and billing*

Mobile payments are one of the most critical applications in mBusiness, constituting a prerequisite for the take-up of mobile commerce. Payments via mobile phone have the potential to become an established payment instrument of the future due to the high penetration of mobile phones and the ability of mobile payments to cover all types of payment transactions (micro, mini and macro payments). However, mobile payment services are still in their infancy, and users practically do not have any substantial experience with them.

Research challenges in the area include simplicity and usability, interoperability, security and privacy, cross-border payments, and appropriate business models. Aside from the traditional participants of the mobile value system (network operators, application developers, mobile device manufacturers and so on), mobile payments are particularly challenging since they involve other participants as well, most notably banks and credit card agencies. For mobile payment methods to be widely adopted, they will have to satisfy the needs of consumers, merchants and financial institutions at the same time. While banks have been in control of financial transactions for a long time, mobile operators are quite new to this business. Their billing systems are primarily designed for billing customers who use solely the mobile services they provide. While this has been changing lately with the advent of data services (where content is produced and provided by third parties), a lot of research remains to be done in the direction of redesigning applications and business processes (as well as business models) to support mobile payment solutions.

3.3 Research dimension 3: value

3.3.1 Emerging business models

Research has long examined the complexity characterising the mobile business landscape and the multitude of actors within it (Barnes, 2002; Curwen, 2002; Li and Whalley, 2002; Olla and Patel, 2002; Sabat, 2002; Siau and Zixing, 2003; Yuan and Zhang, 2003). In order to define, develop and market robust solutions, organisations in the mobile ecosystem have to develop a plethora of core competencies in issues such as service development, user requirements capturing, customer care, pricing and billing, and more. Since this might prove to be difficult for most organisations, partnerships, cooperations and alliances are expected to be the prevalent means of providing value-added services to users. If this is already witnessed in the (much simpler) world of mobile telephony, we can only expect it to become even more so in the complicated world of mobile business. Therefore, research should focus on analysing the dynamics of the mobile market from the perspective of alternative service delivery channels, with a view to proposing appropriate business models.

Particular attention should also be devoted to examining issues like organisational capacity in order to integrate mobile applications and services within their culture and business processes, as well as in existing service portfolios. In many cases, it can be envisaged that organisations will find opportunities not to develop 'stand-alone' mobile business services, but rather to complement existing content and services by distributing them also via mobile and wireless channels. This will undoubtedly give rise to concerns regarding service complementarities, strategic positioning, potential cannibalising of service offerings, partnerships with delivery channel owners and so forth. Studies analysing such issues and suggesting best practices from innovative applications might prove especially beneficial.

3.3.2 User/worker

Essential for the success of mobile business is to direct research towards the appreciation of consumers' and workers' needs and concerns, where existing research to date has largely failed to produce spectacular results (for example, the inability to foresee the success of mobile text messaging in its first days). Improved personalisation, increased

mobility and location sensitivity are only some of the characteristics of mobile business that should be researched on (aside from their technical dimensions that were discussed earlier) from the viewpoint of examining their impact on consumer values as well as value transformations on application and service usage (Kahle, 1997). Koch *et al.* (2002), as well as Katz and Shapiro (1986), call for more research in analysing the influence of person-to-person communication and supporting services as well as the diffusion processes and network externalities of customer-to-customer relations. More work should be done in appreciating the individuals' perception of the mobile device as a personal tool, while Lindgren *et al.* (2002) calls for more work in analysing how a mobile marketplace enables consumers to transfer their behavioural patterns from the internet to a broader group of people in their specific social group. Finally, Jessup and Robey (2002) call for new forms of social interaction in terms of communication, collaboration, coordination, organisation and management, especially in the new 'ubiquitous computing era' where mobile technologies and artifacts weave in the fabric of the physical world. They propose a multidimensional analysis pertaining to the behaviour of individuals, team groups and organisations towards the acceptance and use of the emerging mobile technologies and applications. In parallel, Fano and Gershman (2002) outline that the emerging technologies will consequently redefine the business-customer relationships, establishing new communication means and feedback channels. In short, mobile technologies will eventually create new experiences for both the user and the worker (Kourouthanassis and Roussos, 2003; 2002).

In assessing the role of user/worker and in resolving the research challenges indicated, research should be primarily directed at devising and testing workable scenarios related to the use of mobile devices. These can range from the use of mobile devices while travelling to specific emergency healthcare situations. In particular, suggested research should be directed at examining the development of advanced off-line and web-based statistical methodologies and indicators in order to measure the level of awareness and satisfaction among mobile users. Research should also be aimed at the analysis of ways to easily integrate consumers' needs and expectations regarding mobile applications; the analysis of the accessibility of mobile services for users who are elderly, handicapped or technologically illiterate; and the methods and processes for the direct integration of customers into the development process of mobile services and devices.

3.4 Research dimension 4: enablers

3.4.1 Security and privacy

Security and privacy are arguably essential enablers of mobile business. They are not just add-on features because both elements are critical in fostering users' trust in mobile services and applications. As argued by Morgan and Hunt (1994), trust is a necessary base for fostering an environment where regular and repetitive transactions are undertaken.

If the future of mobile business depends on users' acceptability, a number of elements need to be considered when devising security and privacy solutions for the mobile world. Such are the user's trust in a mobile device, the continuous availability of services, and the ability of the service to manage differences and to act and inform appropriately. These three issues should then be related to the basic users' uncertainties such as control over his/her personal data, the threat of malicious attacks (for example,

viruses, denial-of-service attacks) or unsolicited intrusions into privacy (for example, spamming), the trust in charging and billing services (including the control of cost parameters), and the control of information provided to the user based on his/her choices. Protecting the end users' privacy is a critical element that should have been taken into consideration by the early design of a mobile application and/or service. It should be noted that several authors have already proposed specific principles and guidelines that should cover the design and implementation of secure and privacy-protected mobile applications (Langheinrich, 2001).

In order to address these issues, a twofold approach had to be created. This approach is based on the identification of mobile-specific security and privacy challenges. It is also based on the examination of available security and privacy methodologies and processes in order to realise their applicability in countering the new kind of operational risks, which are faced by both users and service/application providers. Our analysis indicated that additional research attention should be directed at examining the security and privacy areas such as content filtering, adaptive user control profiling, identity management and data access process.

Although some interesting work may originate from the location service application developers, specific attention should be directed at examining the commercial and business implications of implementing content control mechanisms that are fully transferable over various networks and operators. Particular attention should also be directed at examining issues related to the legal/liability implications when it comes to the transfer of these controls. An analysis of the overall mobile business value web seems to indicate that the liability can involve many actors. The identification of a proper national/international regime is pivotal (this challenge is also related to the Regulation and Policy thematic category below).

The issue of content control introduces the need to develop appropriate technological and business solutions in the field of identity management. While involved in mobile transactions and activities, users should be able to enjoy the same right for anonymity and pseudonymity as in the off-line world. Technical tools providing anonymity and protection of privacy are gaining popularity. However, this is often achieved at the cost of functionality. Therefore, further research into application-specific privacy preservation as well as models for anonymity and pseudonymity is needed. More research should also aim at examining alternative approaches to identity-based authentication of entities as means of establishing their functionalities and trustworthiness. Also essential is the examination of consequential changes to traditional dependencies on authenticated identity for specific areas such as accountability, traceability and non-repudiation.

In conclusion, more research should be devoted to improving simplicity, interoperability and transparency in software development by using or developing appropriate internationally recognised standards. More research should also be directed at examining the technical and management intricacies of security architectures for every layer of service networks. Particular attention should be given to devising new trust models for future mobile communication systems and seamless security handover at the network level.

3.4.2 Regulation and policy

The mobile era poses new challenges for the traditional regulatory framework. Of critical importance is the establishment of strong relationships with key standardisation, regulatory and policy-making bodies that investigate and promote various aspects of mobile applications and services. Efforts towards providing an operational framework where effective competition (with minimal monopolistic or oligopolistic risks) exists will enable new approaches targeting mBusiness future scenarios to flourish. As an example of such coordinated actions, we can mention the European Union. It develops common directives that have to be adopted by all of its member states, therefore providing a homogeneous approach that eases the pan-European introduction of mBusiness services.

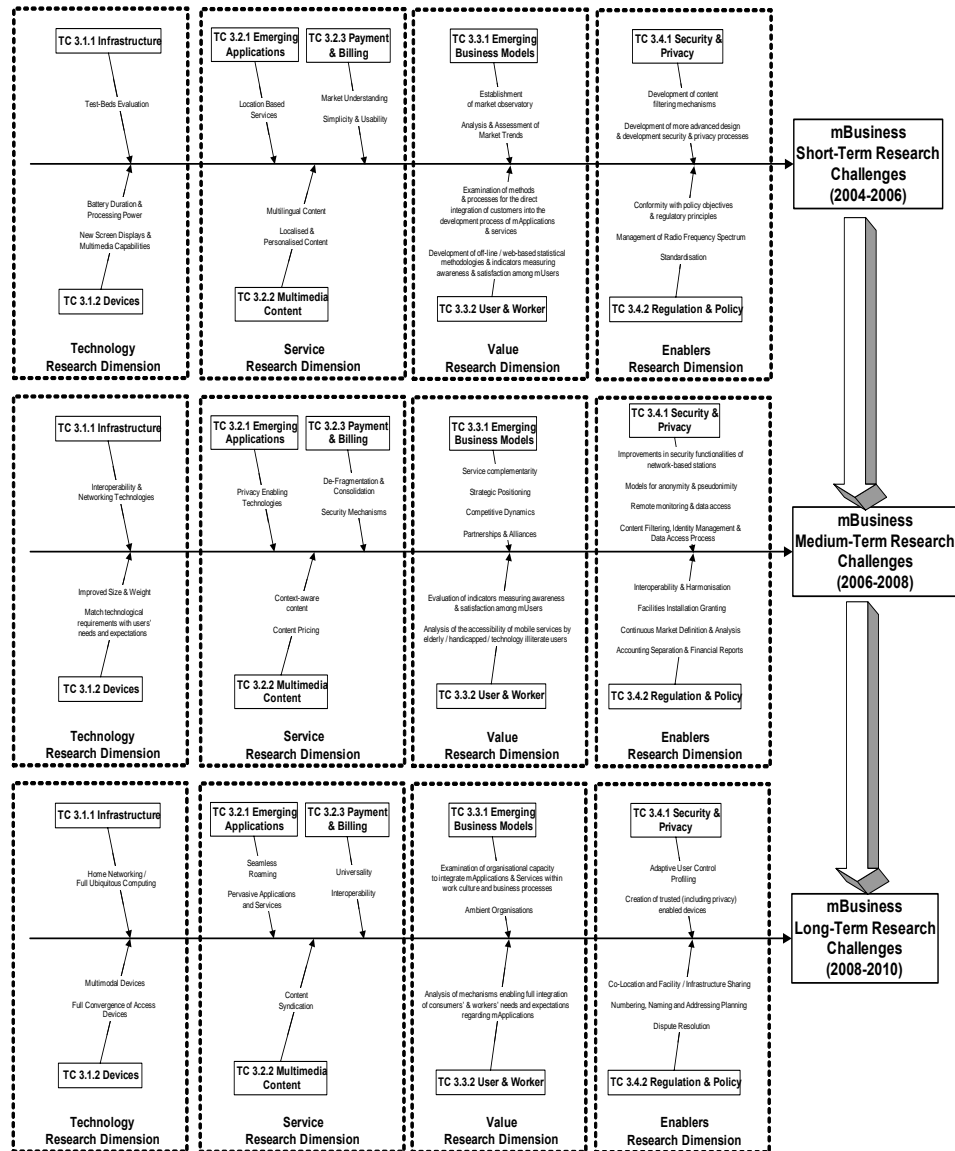
Research challenges rely on effectively identifying the right regulation and policy combination for specific domains of mBusiness applications and services, as well as on enforcing them at national and international levels. Such challenges include, among others: increased service choices for customers; accelerated infrastructure expansion to cover under-served regions and people groups; numbering, naming and addressing planning; co-location and facility/infrastructure sharing; standardisation, interoperability and spectrum licensing; uniform privacy protection mechanisms (especially with regards to location information); and dispute resolution (including the resolution of cross-border disputes). Aligning the different legislation schemes (especially in the case of the EU and USA) represents the first step towards a uniform examination of mobile applications and services. Camponovo and Cerutti (2004) have provided a comparison of the regulatory frameworks of Switzerland, the European Union and the USA, analysing their likely implications for the mobile business industry.

Competitive dynamics in recent years have led to a decreased role of the government in the direct regulation of the mBusiness market (with the possible exception of some Asian countries). Self-regulation has therefore arisen as a mechanism dealing with challenges in the mBusiness domain. In the future, considerable effort also has to be invested into dealing with self-regulation and policy challenges, balancing them with centralised regulation and market monitoring.

3.5 Synthesis: a roadmap for mBusiness research

In order to develop a prioritised research roadmap based on the research method described earlier, researchers participating in the web survey and the thematic workshops were asked to interlink the research challenges identified, prioritising them into short-, medium- and long-term research objectives. As a result, the roadmap challenges have been grouped and classified into two axes: *Research Dimension* and *Priority* (illustrated in Figure 3). The roadmap is meant to serve as a guiding vehicle for researchers to place their own work within a wider context so that knowledge is incrementally and systematically developed in the area. Of course, the roadmap is not meant to provide an exhaustive enumeration of research challenges (this would be impossible in a fast-moving area like mBusiness), but rather, it provides an indication of open issues to allow researchers to generate questions, identify interdependencies with the works of others, and gradually build their research agenda in a coordinated fashion.

Figure 3 A roadmap for mBusiness research



4 Conclusion

We have outlined the processes and findings of developing a roadmap for research on mobile business. We started by outlining the methodological framework employed for the production of the roadmap, which focused on providing a robust and comprehensive plan enabling the global research constituency to voice their opinion and contribute their expertise and priorities into the roadmap production.

The final roadmap describes the main challenges of the emerging mobile business landscape and identifies the issues that collectively define its current and future boundaries. Challenges are classified into nine thematic categories, which themselves belong into four research dimensions. The roadmap does not only further defines the research topics that should be investigated within each thematic category, but it also, and perhaps more importantly, highlights the necessity to engage in interdisciplinary research that spans across the categories in order to surface an integrated development of mBusiness (technology-, business- and policy-oriented at the same time). Emerging mobile technologies pose new research challenges not only on technological but also on business issues as well. Early identification of and research on successful tackling of these challenges will not only free the future mobile applications and services from the current obstacles, but it will also allow these applications and services to evolve and serve the mobile user better – in commercial (if feasible) (Mylonakis, 2004) or other forms.

It must be stressed that the short-, medium- and long-term research challenges contained in the roadmap reflect the existing research and market situation at the time of the roadmap production. The area of mobile business is extremely volatile, and this has to be kept in mind when examining the roadmap. Moreover, due to their largely indicative nature, the challenges contained herein need to be constantly updated so that a timely research agenda is maintained.

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