ITERATIVE PROCESS MODELS FOR MOBILE APPLICATION SYSTEMS: A FRAMEWORK

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Abstract

The development of mobile application systems is usually realized on the basis of iterative process models of which there are many different variants. The selection of an appropriate process model is a crucial issue for the success of every system development project, particularly for systems in a highly volatile environment such as mobile application systems. This article is devoted to the idea of selecting and applying alternative iterative process models in a project-specific way.

As a first step, an analysis of five predominant groups of mobile application systems has been conducted. On the basis of the results of this analysis, a three-dimensional classification scheme is developed. Applying this, we illustrate that mobile application systems can be classified, characterized, and differentiated over three dimensions: degree of innovation, speed of development, and risk. Based on these three dimensions, technical and organizational-personnel criteria are deduced and a typology of mobile application systems is developed. This framework allows the typification for a planned mobile application system according to eight defined types. Thus, recommendations concerning technical and organizational-personnel requirements can be generated and integrated into a specification in order to enable systems development teams to select an appropriate iterative process model.

Keywords: Process models, systems development, mobile application systems, mobile commerce

1 MOBILE APPLICATION SYSTEMS: DEFINITIONS AND PERSPECTIVES

The international concentration process in the telecommunications industry has been continuously increasing in recent years. While alliances predominated until the mid-1990s, more aggressive acquisition strategies are now evident. The controversial and intensively discussed takeover of Mannesmann by Vodafone in the Spring of 2000 is an important example of a trend that—due to the involvement of that large, well-established and nationally-recognized company—provided a graphic illustration of the process to the German public for the first time.

The astronomically large sums paid in takeovers cannot be justified solely on the basis of scale effects achieved through optimizing the core business: mobile telephony. They can, however, be attributed to a phenomenon of *mobile commerce* (m-commerce), which is perceived by the telecommunications industry to offer a high potential for increasing turnover and, ultimately, average revenue per user. The allocation of UMTS-licences in Germany that yielded record returns of 98 billion DM for the German government starkly illustrates this phenomenon, although many skeptics regard the licence fees as exorbitant. Following Great Britain, the generated proceeds for the German distribution of UMTS licences has been, per capita, the second highest, and they are significantly higher than the European average.

A general definition for the emerging research field of mobile commerce has not yet been developed. What is generally accepted is that m-commerce has many parallel characteristics to fixed-line electronic commerce and represents the mobile variant of commercial Internet usage. However, to assume on the basis of this aspect that mobile commerce is simply the "cellular-centered" variant of fixed-line e-commerce would be to miss the point (for details about success factors, see Schreiber 2000, p. 77; for high quality of content as a key determinant for the success, see Chae and Kim 2001.). There are several reasons for this. First, apart from the currently common cellular phone, a variety of different and flexible devices will be available for different purposes that can be synchronized through standardized radio interfaces (e.g., Bluetooth technology). In this context, smart phones, personal digital assistants (PDAs), organizer and sub-notebooks are of particular note (see Arnold et al. 2001, p. 108; Rischpater 2000, p. 47). Second, mobile services hold the potential for innovative features that can be seen as unique selling points for mobile commerce; namely, *ubiquity*, *localization*, and a direct connection to the net called *Always-on*.

- Ubiquity in this context means a largely unrestricted continuous use independent from location and the implied advantages of location-independent accessibility irrespective of service availability.

- Due to the localization possibilities of mobile devices, m-commerce opens up the scope for a series of location-based services that generate a substantial added value for customers.

- The third unique characteristic, Always-on, denotes the functionality of mobile devices to establish an immediate net-connection without dial-up or boot processes being necessary, while being fundamental for situational use of services.

As shown in Figure 1, existing m-commerce services do not yet offer all of these characteristics. Current GSM-based WAP services, for example, are largely perceived by customers to provide merely an inconvenient access to a restricted Web functionality.

However, since innovative technologies like GPRS, HSCSD, UMTS and Bluetooth (Biala 1996, p. 57; Häckelmann et al. 2000, p. 324; Tarasewich et al. 2001; Walke 2000, p. 7) are increasingly achieving readiness for market, it is assumed that, in the near future, more and more mobile applications will be developed that provide services complementary and comparable to fixed-line e-commerce (Lamprecht 2001, p. 33).

Considering that up to now substantial know-how about these systems could not be developed either in practice or theory, the following question should be posed: **What methods and process models are appropriate for the development of these novel applications?**

This article focuses on this question and provides insights into this under-explored field. The main objective is to develop a generic framework that allows a classification of every kind of mobile application and enables a linkage to appropriate process models on the basis of its characteristics.

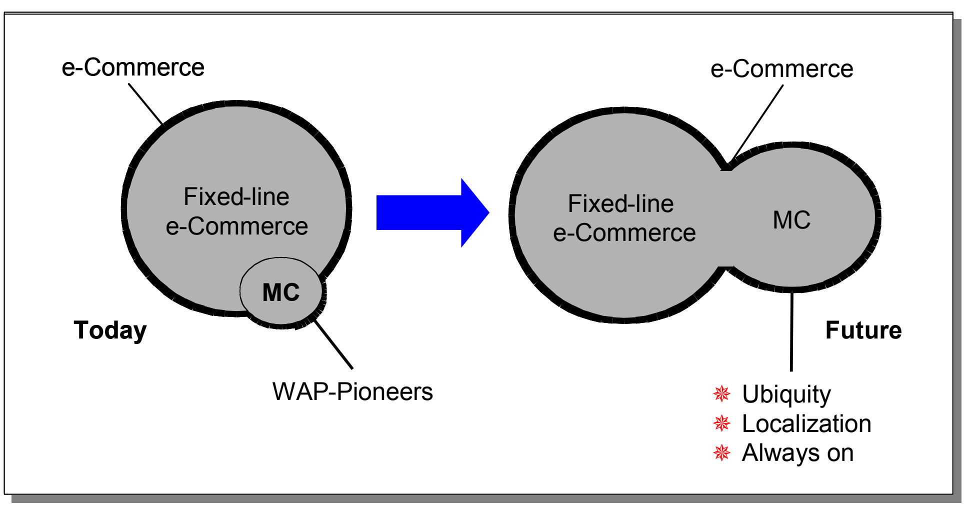

Figure 1. E-Commerce in Flux

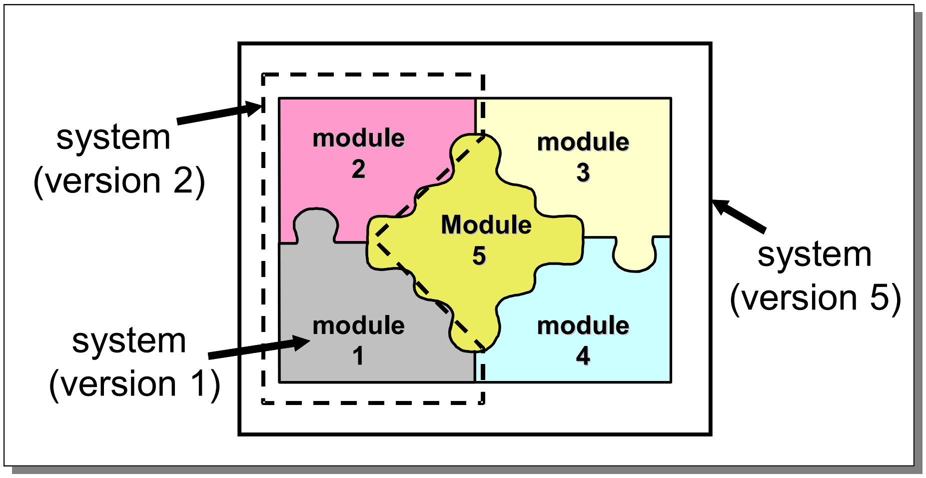

Figure 2. Modular Development in Iterative Process Models (see Balzert 2000, p. 56)

2 FRAMEWORK

2.1 Iterative Process Models: Evolutionary, Semi-Structured, and Incremental Variants

It is generally accepted that classical, sequential process models are not appropriate for the development of modern, market-oriented information systems. A temporal separation between phases of development and subsequent phases of operation and maintenance proves not to be useful. This is because an entirely new system is only comprehensible and realizable through repeated feedback loops. Alternative models for complex and dynamic systems in recent years were often captured under the term *iterative process model* (Kemper 1999). Iterative process models are characterized by repeated development blocks and a consequential utilization of prototypical methods. A fundamental goal of utilizing these iterative models is to develop and operate a planned system successively, i.e., module by module. Figure 2 illustrates that procedure.

The basic idea of iterative systems development thus lies in the reversal of the strict separation between development phases on the one hand, and the phases of operation and maintenance on the other.

Repeated cycles encompassing design, realization, and evaluation blocks (Schwarze 1995, p. 60), each resulting in a new version of the system, supersede the common sequential structure of phases. In other words, iterative systems development comprises several separate development subprocesses in which the precursor system is revised, bugs are fixed, obsolete features are removed, and new features are included as new modules according to current requirements. Dependent on the degree to which requirements can be specified in advance, this procedure, often also called *versioning* (Gluchowski et al. 1997, p. 133), can be differentiated into several variants lying on a continuum. The two extrema of this continuum are represented by *evolutionary models* on one side and *incremental models* on the other. The variants in between the two extrema are in the following called *semi-structured models* (see Figure 3).

- **Evolutionary models** as one extremum take high uncertainty concerning system requirements and technologies into account. Thus, in these models, only the most important and urgent requirements of the customer represent the initial point of the development process. On this basis the first module is developed and will be revised and upgraded later with new modules according to new requirements or due to changes of technology. This approach has clear advantages, including a quick implementation of executable modules and increased flexibility and adaptability to changing general conditions, but also implies a substantial disadvantage. Applying an evolutionary procedure bears the risk that when developing a new module, the modules already developed have to be remodelled and extensively altered because they are incompatible with the new module. Since basic architecture changes are less feasible with ongoing systems development, suboptimal structures are likely to be established so that the system in the long run is operated as a persistent provisional solution (Budde et al. 1997, p. 332; Sommerville 1992, p. 103).

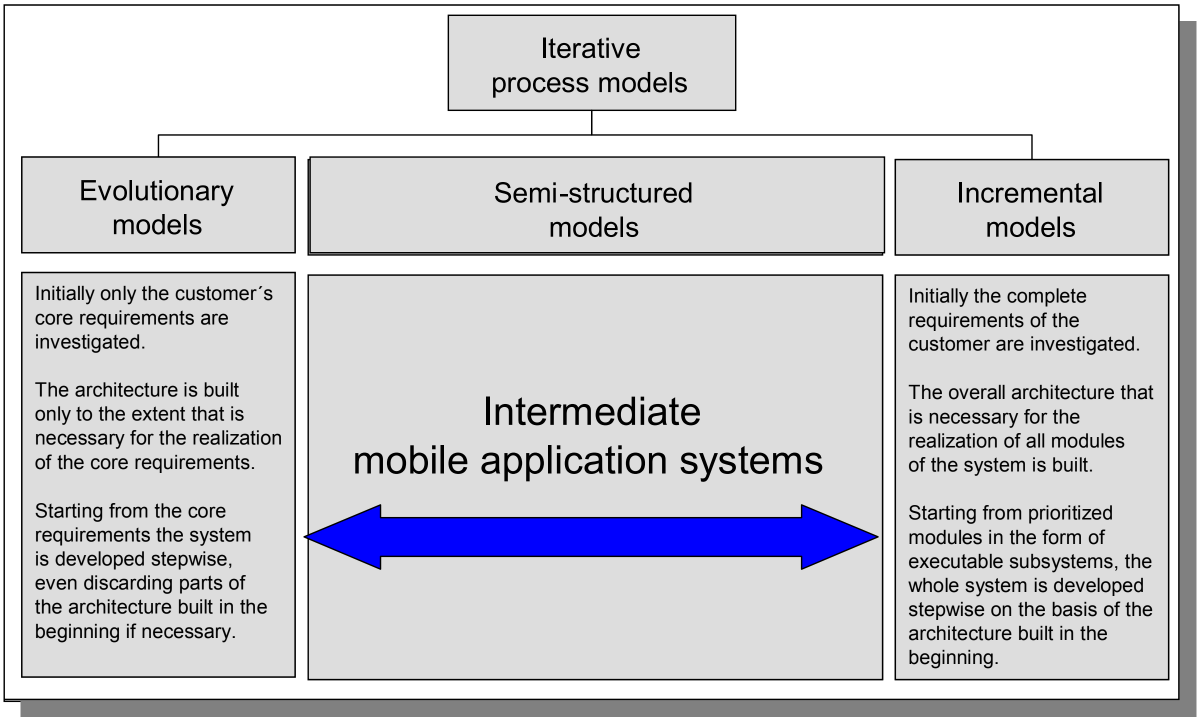

Figure 3. Variants of Iterative Process Models

- **Incremental models** represent the other extremum on the continuum of iterative models. They are based on the underlying assumption that potential user requirements, future technologies, and use cases for a planned system can be sufficiently anticipated. Correspondingly, in contrast to the evolutionary models, they imply an assessment of the complete requirements for the whole system at an early stage of the development. Based on that requirements specification, the complete architecture for the successive development of all of the system modules is generated in advance.

- **Semi-structured models** are useful for developments between the two extrema. For instance, the user requirement specifications have to be at least partly predictable at the beginning of the development. Starting from these incomplete specifications, several potential architecture variants for the whole system have to be designed. In most cases, specifications at every stage of development can be detailed only for the modules providing the most important functionality. When developing these models, the compatibility of the plans with the overall architecture always needs to be checked, and appropriate migration strategies generated. In that field, several of the models that have been developed since the 1980s include rapid application development (Martin 1991), DSDM (Stapleton 1997), adaptive development (Highsmith 2000), and extreme programming (Beck 2000). These approaches support an iterative procedure of systems development that aim at a reduction in time-to-market but by no means do they represent the entire spectrum of semi-structured models.

For the majority of mobile application systems, a variant of semi-structured models would outline the most appropriate procedure because a full design of the overall architecture in advance, as required by incremental models, is often not possible and the planned system is often too complex for applying evolutionary models. Mobile application systems are heterogenuous and differ widely in their technical complexity, user requirements, and functionality. Our analysis of a broad variety of mobile application systems revealed that the differences are system-specific as well as dependent on a company's internal and the market situation (see Appendix). Due to the fact that the indicators are all dynamic, our analysis can only provide tendentious estimation: the indicators need to be evaluated situationally for each decision to develop and implement a new mobile application system. These differences render a selection of a useful and applicable model particularly difficult. Thus, static information services such as news differ substantially from, for instance, location-based services in the area of mobile travel services and hence demand different process models for their development.

2.2 Mobile Application Systems: A Multidimensional Classification Scheme

The prerequisite for the selection of an appropriate semi-structured process model is the specification of the planned mobile application system. Therefore, as a first step, the characteristics of five predominant groups of mobile application systems are analyzed (see Appendix, Table A1):

- mobile information
- mobile transaction
- mobile communication
- mobile entertainment
- mobile services for special purposes like health, environmental, and security services

The different characteristics of these mobile application systems turned out to be primarily subsumable under three dimensions (see Appendix, Table A2, final column). Thus, as a second step, a classification scheme is developed that allows the differentiation of mobile application systems on the basis of different values on three dimensions: *degree of innovation*, *speed of development*, and *risk*.

In the context of this classification scheme, it is sufficient that the different characteristics of the analyzed application systems are primarily subsumable under these dimensions; they are not required to be disjoint.

Indicators for the values on these dimensions are depicted in Figure 4 (further examples are provided in the Appendix, Table A2, first column).

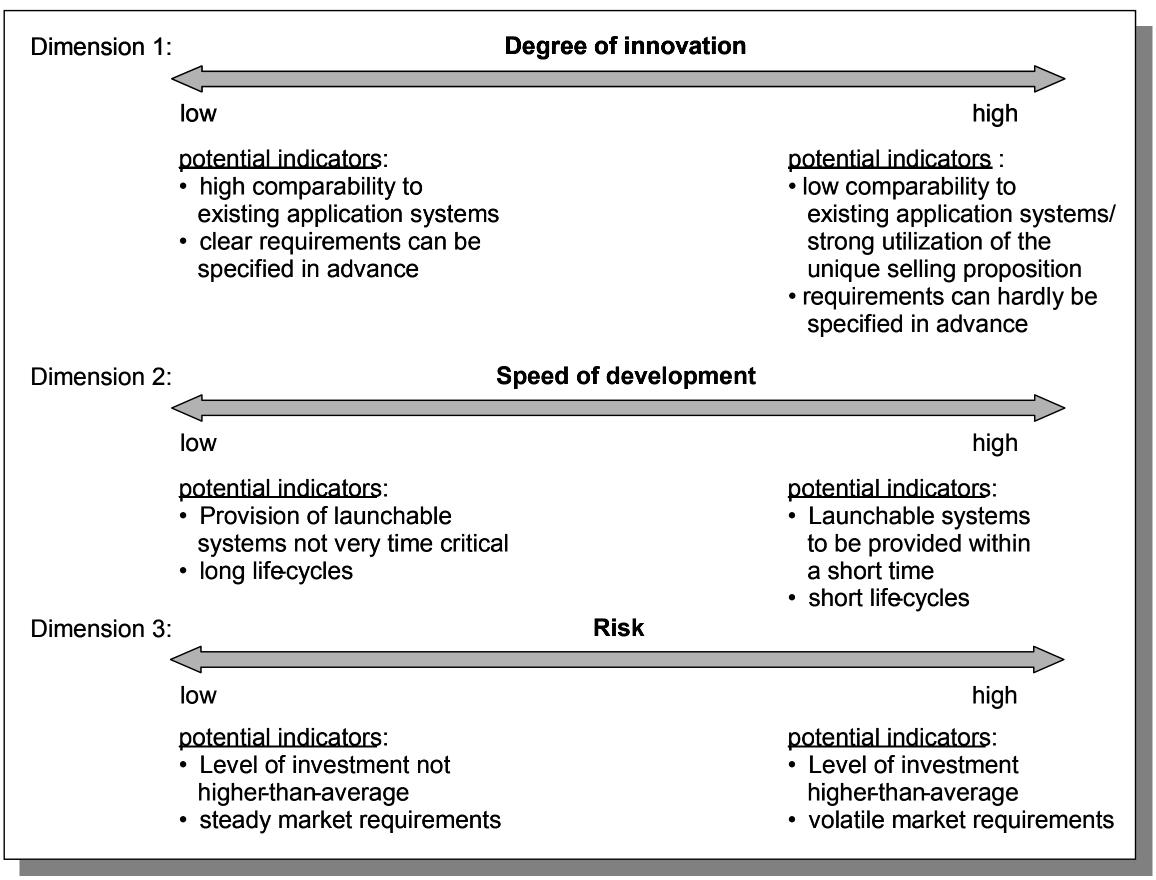

Figure 4. System Dimensions for the Classification of Mobile Applications

- **Degree of innovation**. An application's degree of innovation is determined by its novelty. Accordingly, little know-how is usually available in a company for the development of innovative mobile systems. Therefore, the requirements for a mobile application system are harder to define with an increasing degree of innovation. That is why the possibility of a complete requirements specification comes more into consideration for application systems of a lower degree of innovation. Thus, mobile services that have a counterpart in the fixed-line e-commerce field often imply a high rate of reconstructive development activities. This is true, for instance, for mobile information services that provide the content without location-reference on request of the customer.

  With highly innovative application systems, a requirements specification in advance is hardly possible. New services, whose functionality is mainly determined by unique selling propositions like ubiquity, localization, or Always-on, are more innovative and demand more creativity than reconstructive activities.

- **Speed of development**. Besides the degree of innovation dimension, the requisite speed of development is relevant for the classification of a mobile application system. Speed of development is determined by the requirements of the market, i.e., the time in which the application has to be developed and launched. A short period of time and thus a high speed of development involves short life-cycles as market pressures demand more and more rapid replacements of existing systems.

- **Risk** is characterized by the danger of financial and time losses that are especially due to feedback loops and adaptation and modification processes. As discussed earlier, these are necessary within the overall systems development process but can also be caused by incorrect decisions or highly volatile market demands during development. Volatile market demands should be met by a corresponding flexibility in the development (for factors affecting the volatility of information system in particular, see Heales 2000.).

2.3 Mobile Application Systems and Their Characteristics: Mapping Criteria

On the basis of the values of the three dimensions outlined in the previous section, a typology of mobile application systems is developed. The resulting eight types of mobile application systems are, as a next step, linked to technical (T #) and organizational-personnel (OP #) criteria derived from the dimension values. These criteria represent characteristics of development processes. However, dependent on the dimension values, their importance differs and thus they require different consideration in a development process. They constitute the set of criteria for building the framework.

- **Criteria derived from the dimension *degree of innovation*.**

  — *Iterations and frequent feedback loops (T 1)*. In cases of a high degree of innovation, the system requirements are not clear and cannot be precisely defined in advance. Therefore, such an application system can only be developed through a stepwise approach in order to check continuously if there are deviations from the desired direction of development.

  — *Modularization (T 2)*. Since the requirements cannot be defined clearly in advance, the coordination processes occur throughout the whole development period. They demand a prototypical procedure, i.e., the coordination processes have to be carried out on the basis of executable modules.

  — *Organizational implementation (OP 1)*. The completion of systems with a high innovative character is difficult to predict. At the early stage of the development, therefore, neither functionalities nor the size of modules nor the degree of probable user acceptance can be defined. Due to these imponderables, the organizational implementation of the application system warrants particular attention.

  — *Substantial know-how (OP 2)*. Due to low comparability of the planned application system with existing systems, developers cannot rely on a knowledge base that is already established in the company. In fact, the development teams need to provide substantial know-how by themselves in order to achieve an adequate transfer to the new conditions.

- **Criteria derived from the dimension *speed of development***

  — *Concurrency of development blocks (T3)*. Pressure from the market promotes quick launches of new systems. By rendering development blocks concurrent wherever possible, the critical path for the overall development of the whole system is shortened and speedy launches of executable systems are enabled.

— *Precise specifications of interfaces (T4).* A high concurrency of development blocks implies that the specification for interfaces is even more crucial for the executability of the systems which has to be done with considerable care and precision.

— *Horizontal communication (OP 3).* The more time-critical a systems development is, the more direct ways of communication are required. This is why horizontal communication processes are considerably more important than for less time-critical developments.

— *Team-oriented project-structures (OP 4).* In time-critical development processes, a team-oriented project organization is more appropriate because, in contrast to hierarchical structures, delays can be considerably reduced with informal coordination.

- **Criteria derived from the dimension *risk***

— *Short cycles for feedback and adaptation processes (T 5).* Development steps that have to be revised through feedback loops or adaptation processes should be kept as short as possible in order to minimize risk. Thus, short cycles and frequent but short checks are required.

— *Reusability of modules (T 6).* The higher the level of investment for the different development blocks, the more the reusability of modules gains in importance.

— *Early agreement on the architecture (T 7).* Agreement on the architecture as early as possible reduces the risk of misdirected investment in development steps that may turn out to be incompatible with the system as a whole.

— *High involvement of customers/users (OP 5).* The higher the development costs, the greater the importance of customer/user involvement in order to make sure that the solutions match their requirements and to reduce the need for changes.

— *Low utilization of resources in feedback and adaptation processes (OP 6).* A low commitment of resources, personnel and hardware for example, in feedback loops and adaptation processes contributes significantly to the minimization of risk for repeated development steps.

The development of a travel portal offering complex location-dependent functionalities could, first, imply a high value on the dimension degree of innovation; second, with respect to the current high stress of competition, a high value on the dimension speed of development; and third, due to the necessity for a high level of investment, also imply a high value on the risk dimension.

This kind of application system would, as depicted in Figure 5, be one of type 8. Mobile information systems that initially port an already-existing online-news service to mobile technology would imply a high speed of development but a lower degree of innovation, and due to a lower level of investment would also imply a low value on the risk dimension (type 2). An application system such as mobile interactive games, for example, could have a high value on the dimensions degree of innovation and speed of development but a low value on the risk dimension (type 6).

A synopsis of the typology is represented in Table 1. An integration of the criteria derived from the three dimensions described in section 2.3 complements the typology and leads to the framework outlined in Table 2.

Table 1. Typology of Semi-Structured Application Systems

Type of Application Dimension	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7	Type 8
Risk	low	low	high	high	low	low	high	high
Degree of Innovation	low	low	low	low	high	high	high	high
Speed of Development	low	high	low	high	low	high	low	high

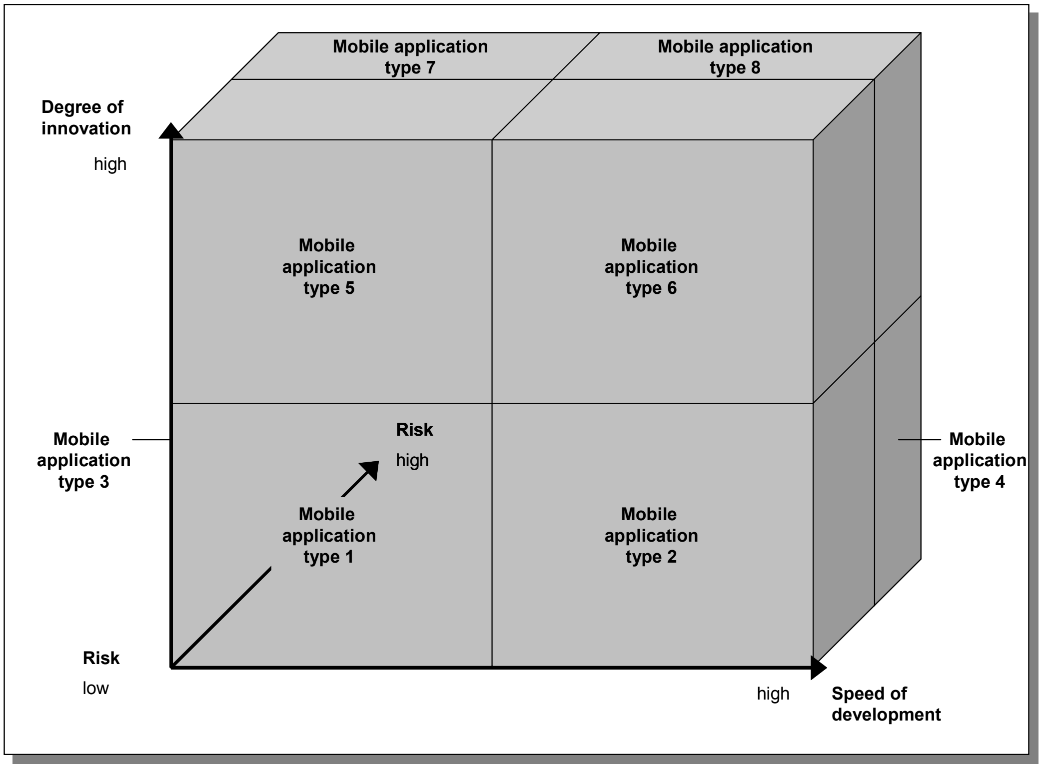

Figure 5. Types of Mobile Application Systems

Table 2. Framework for the Development of Semi-Structured Application Systems

Dimension	**Type of Application**	**Type 1**	**Type 2**	**Type 3**	**Type 4**	**Type 5**	**Type 6**	**Type 7**	**Type 8**
Risk		low	low	high	high	low	low	high	high
Degree of Innovation		low	low	low	low	high	high	high	high
Speed of Development		low	high	low	high	low	high	low	high
Technical level									
T1	Iterations and frequent feedback loops					x	x	x	x
T2	Modularization					x	x	x	x
T3	Concurrency of development blocks		x		x		x		x
T4	Precise specifications of interfaces		x		x		x		x
T5	Short cycles for feedback and adaptation processes			x	x			x	x
T6	Reusability of modules			x	x			x	x
T7	Early agreement on the architecture			x	x			x	x
Organization-Personnel Level									
OP1	Organizational implementation					x	x	x	x
OP2	Substantial know-how					x	x	x	x
OP3	Horizontal communication		x		x		x		x
OP4	Team-oriented project structures		x		x		x		x
OP5	High involvement of customer/users			x	x			x	x
OP6	Low utilization of resources in feedback and adaptation processes			x	x			x	x

3 SUMMARY AND OUTLOOK

It would be naïve to assume that mobile application systems by reason of their common quality of mobility, or due to the utilization of the same communication technology, would be similar to such an extent that a small selection of development guidelines would be sufficient for the professional development of all variants of mobile application systems.

In fact, it is true that mobile application systems, like other modern market-oriented application systems, are best developed on the basis of iterative process models; however, their variety proves to be exceptionally wide as our analysis has shown (see Appendix). Thus, their development requires particularly project-specific procedures. For a professional development process, it is crucial to identify the planned system first in the context of the variety of potential classes of applications. On this basis, concrete guidelines for the development process can be generated.

This article contributes significantly to the solution of this problem. An analysis of five predominant groups of mobile application systems was conducted. A three-dimensional classification scheme was developed for use in identifying and characterizing mobile applications on the dimensions *degree of innovation*, *speed of development,* and *risk*. On the basis of the values on these three dimensions, criteria concerning the technical and the organizational-personnel level were derived and a general typology of mobile application systems was subsequently developed.

With this framework, it is possible to allocate planned mobile application systems to the eight different types and hence generate initial guidelines and instructions for their development. These guidelines on the technical and the organizational-personnel level can be leveraged by development teams as a first set of requirements in order to select appropriate iterative process models for the development of the particular system. Thus, project management at any level (management committees, project commissions, project managers, members of development teams, hardware specialists, software architects and designers, programmers, data modeling specialists, software ergonomists, pilot users, etc.) of a company that plans to develop a mobile application system can benefit from our framework.

Indeed this aspect of selecting an appropriate iterative process model for the development of a particular system also represents the current dilemma in theory and practice. In the field of iterative systems development, practicable process models in the field of semi-structured solutions are few. Mere evolutionary models that in practice often resemble a "quick-and-dirty" procedure, or incremental models that need the total specification of the whole system architecture in advance, are not sufficient for the development of mobile systems. Therefore, as the next research step, we plan to evaluate empirically the development processes of mobile applications and to synthesize a classification of existing development processes. This is necessary as a basis for conceptualizing and optimizing new flexible variants of iterative process models in order to meet the ever-increasing challenges associated with successful development of future mobile solutions.

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Appendix: Analysis of Mobile Application Systems

Table A1. Groups of Mobile Application Systems as Basis for the First Analysis

Basis of Analysis: Mobile Applications	**Examples: Mobile…**
Mobile Information	A. News B. Reference Content (dictionaries, phone books, ZIP code lists etc.) C. Travel and tourist information D. Location/Navigation Guidance (self location, object location, hotel/taxi/restaurant/ATM finder, person navigation, vehicle navigation, etc.) also within facilities (fairs, exhibitions, shopping malls, etc.) E. Access to cultural heritage F. Learning G. Traffic telematics (traffic news, vehicle systems information and faults diagnosis, vehicle security, vehicle tracking, etc.) possibly in combination with location/navigation guidance (petrol station finder, service station finder, etc.) and alarm/vehicle rescue service H. Delivery or asset tracking, fleet management I. Remote diagnostics and maintenance (for commercial vehicles, distributed machinery and plants, etc.)
Mobile Transaction	A. Banking B. Brokerage/stock trading C. Travel booking D. Ticketing/reservations E. Shopping, trading, mobile auctions F. Government services G. Payment/billing H. Automated tolling (road tolling, car parking payment, public transport payment, etc.) I. Second signature/digital signature
Mobile Communication	A. Location-based quick-dials (taxi/hotel/restaurant chains, etc.) B. Location-based call control (in airplanes, hospitals, theaters, etc.) C. Advertising/coupons D. Messaging (SMS, MMS) E. Military and defense communication F. Access to corporate intranets and office applications (sales force automation etc.)
Mobile Entertainment	A. Audio (mp3, streaming audio) B. Video (mpeg, streaming video) C. Games and gambling (local games, lottery, betting, multi-user location-based games, wireless casino games, etc.) D. Communities of special interests (leisure activities, flirt lines, etc.) E. Books F. Events (sport scores/results, etc.)
Health, Environment and Security	A. Access for emergency services to mobile user location (injured persons, etc.) B. Emergency service finder C. Alarm (car alarm, automated fire alarm, elderly or ill people call for help, etc.) D. Vehicle rescue service E. Child tracking (location-based) F. Critical health monitoring (for people with pace makers or artificial kidneys, epileptics, diabetics, etc.) G. Environmental monitoring (pollution/contamination/radioactivity monitoring, flood/storm/fire control, volcano impact monitoring, etc.), energy management (heat loss monitoring, etc.), water management (water presence detection in regions of water scarcity), precision farming H. Mobile insurance I. Terrain analysis (for areas under exceptional and/or quickly changing conditions, like military battlefields, etc.)

Table A2. Analysis of the Characteristics of Predominant Mobile Application Systems

Mobile Application Systems/ Aspects	Mobile Information	Mobile Transaction	Mobile Communication	Mobile Entertainment	Health, Environment and Security
Comparability to existing application systems	Higher for A, B, C, F if there is already an online version of the service. Lower for D, E, G, H, I because these services imply localization as one of the unique selling propositions of mobile application systems.	Higher for A, B, C, D, E, F, G if there is already an online version of the service and if not integrated with an overall CRM data base. Lower for H because of localization as one of the unique selling propositions and for I if there are few experiences with the technological and security implications of digital signatures.	Higher for D because that service is already well established, for C if not location-based and for F if there is already an online version of the service. Lower for A, B because of localization as one of the unique selling propositions and for E because of special security requirements.	Higher for A, B if established coding/ compression technologies and transfer protocols can be applied, for C if local and for E. Lower for C, D if location-based and for F if based on real time data.	Higher for H if there is already an online version of the service and if not integrated with an overall CRM data base. Lower for A, B, D, E, G, I because these services imply localization as one of the unique selling propositions of mobile application systems.
Extent to which requirements can be specified in advance	Higher for functionalities of A, B, C, F that are realized in an online version or substitutes of the service. Lower for D, E, G, H, I because functionalities of localization based services are not yet well explored.	Higher for functionalities of A - G that are realized in an online version or substitutes of the service and if not to be integrated with an overall CRM data base. Lower for H because functionalities of localization based services are not yet well explored and for I if there are few experiences with the realization of digital signatures.	Higher for D because these functionalities are already well known, for C if not to be integrated with an overall CRM data base, for E because processes are well defined and regulated and for functionalities of F that are already realized in an online version or substitutes of the service. Lower for A, B because location-based functionalities are not yet well known.	Higher for A, B, E, F because these functionalities are already well known from other technical realizations. Lower for C, D if functionalities are location-based.	Higher for functionalities of H that are realized in an online version or substitutes of the service and if not to be integrated with an overall CRM data base. Lower for A, B, D, E, G, I because these services imply localization as one of the unique selling propositions of mobile application systems.
Increased complexity/ new interfaces/ technical challenges	Higher for A, C, F with complex interfaces with content data bases and its display and for the implementation of localization of D, E, G, H. Lower for B.	Higher for the integration with back office systems of A - H and for the implementation of security requirements of I.	Higher for C if location-based, for the implementation of localization of A, B for the realization of security requirements of E and for the realization of the interfaces to corporate systems of F. Lower for D.	Higher for the coding/ compression of A, B and the real time data transfer of A, B, C and F, for the display of B . Lower for E.	Higher for the implementation of localization of A, B, D, E, G, I for new interfaces of C and F and for the integration of geo-information into G, I. Lower for H if not to be integrated with an overall CRM data base.
Relative advantage for customers, potential for process improvement, added value (cost-saving, time-saving, increasing convenience/ reducing inconvenience, prestige enhancing,	Higher for A - I providing useful information on demand at any location just in time and for e facilitating lifelong learning. Lower whenever extensive content is required because of display restrictions.	Higher for A - I enabling transactions just in time without physical presence at the transaction partner's location. Lower whenever higher data transfer is required because of Lower transfer rates.	Higher for A saving time, for B improving security, for C if the content is highly specific to the customers, for E saving time and human resources, for F saving time and costs and increasing convenience. Lower for D in situations where calls are equally or more appropriate and for C if comparable to spamming.	Higher for C, D facilitating interactions with new people, for A, B, C, D, F enabling entertainment always and everywhere and for F saving time to get the information. Lower for E because of display restrictions and little difference to taking physical books.	Higher for A, B, C, D, E, F increasing personal safety and convenience, for G, I increasing environmental safety. Lower for H if not providing all customer-specific data and enabling all transactions including to effect insurances (also ad-hoc for situations of extreme risk) and to cancel policies.
Specialty of know-how required for development	Higher for the implementation of localization of D, E, G, H, I. Lower for A, B, C, Fif an online versions exist and the know-how can be transferred.	Higher for security of A, B, F, G, for H because of new interfaces and the implementation of localization and for I because of the decelerated development of standards. Lower for general features of A - G if an online versions exist and the know-how can be transferred.	Higher for C if location-based, for the implementation of localization of A, B, for the security of E and for the realization of the interfaces to corporate systems of F. Lower for D because the service is well established.	Higher for the coding/ compression and streaming/ real time data transfer of A, B, F, for the multi user interactivity of C and for the display of B . Lower for E.	Higher for the implementation of localization of A, B, D, E, G, I for the interfaces of C and F and for the integration of geo-information into G, I. Lower for H if not to be integrated with an overall CRM data base.
Requirements for compatibility with the existing infrastructure	Higher for content data bases of A, C, D, F, for interfaces with vehicle systems of G, for H with interfaces with an ERP system and for I with interfaces with machinery and automation systems of plants. Lower for content data bases of B, E because the content is less dynamic.	Higher for the back office systems of A - G, for the automation systems of H and for the encryption/decryption of the checksum of I.	Higher for B if calls are not blocked but routed through a central desk, for the integration of C into an overall CRM system, for the integration of E into an overall secure infrastructure, for the integration of F into the corporate legacy systems. Lower for A, D.	Higher for the compatibility of A, B with the audio/ video data servers, for the compatibility of the systems of all players of C and all community members of D, for the connectivity with the real time data base of F. Lower for E.	Higher for the compatibility of A, B with the central systems of the emergency services and of D with central systems of the vehicle rescue service, for the compatibility of the interfaces of F with health systems, for the compatibility of G, I with the automation systems (sensors), for H with the insurances back office systems. Lower for C, E.

→ Aspects can be subsumed under
"Degree of innovation"

Mobile Application Systems/ Aspects	Mobile Information	Mobile Transaction	Mobile Communication	Mobile Entertainment	Health, Environment and Security	
Time for functioning systems to be provided, time to market	Shorter for A, C, D, F, G, H, I because of wider market span and/ or higher competition. Longer for B, E.	Shorter for A, B, C, D, E, G, H, I because of wider market span and/ or higher competition. Longer for F.	Shorter for A, C, D, F because of wider market span and/ or higher competition. Longer for B, E.	Shorter for A, B, C, D, F because of wider market span and/ or higher competition. Longer for E.	Shorter for A, B, D, E, F, G, H because of wider market span and/ or higher competition. Longer for C, E, I.	→ Aspects can be subsumed under "Speed of Development"
Life-cycle of the system	Shorter for A, C, D, F, G, H, I. Longer for B, E.	Shorter for A, B, C, D, E, G, H, I. Longer for F.	Shorter for A, C, D, F. Longer for B, E.	Shorter for A, B, C, D, F. Longer for E.	Shorter for A, B, D, E, F, G, H. Longer for C, E, I.	
Availability of competitive products/ substitutes	Higher for A, C. Lower for B, D, E, F, G, H, I.	Higher for A, B, C, D, E, G. Lower for F, H.	Higher for C, D. Lower for A, B, E, F.	Higher for A, B, C if based on local files and for D, E, F. Lower for A, B if streaming is applied, for C if interactive,	Higher for H. Lower for A, B, C, D, E, F, G, I	
Potential market share	Higher for A, C, D, F, G, H, I. Lower for B, E.	Higher for A, B, C, D, E, G, H, I. Lower for F.	Higher for A, C, D, F. Lower for B, E.	Higher for A, B, C, D, F. Lower for E.	Higher for A, B, D, E, F, G, H. Lower for C, E, I.	
Customers´ switching costs	Dependent on the predominant systems of the desired target group and the company's pricing policy.	Dependent on the predominant systems of the desired target group and the company's pricing policy.	Dependent on the predominant systems of the desired target group and the company's pricing policy.	Dependent on the predominant systems of the desired target group and the company's pricing policy.	Shorter for A, B, D, E, F, G, H because of wider market span and/ or higher competition. Longer for C, E, I.	
Strategic importance of setting standards	Dependent on the corporate strategies.	Dependent on the corporate strategies.	Dependent on the corporate strategies.	Dependent on the corporate strategies.	Dependent on the corporate strategies.	
Rate of innovation of the underlying technologies	Higher for D, E, G, H, I. Lower for A, B, C, F.	Higher for A, B, F, G, H, I Lower for C, D.	Higher for A, B, C, E, F. Lower for D.	Higher for A, B, C, D, F. Lower for E.	Higher for A, B, D, E, F, G, I. Lower for C, H.	
Importance of time to mar-ket for corporate image	Dependent on the corporate strategies.	Dependent on the corporate strategies.	Dependent on the corporate strategies.	Dependent on the corporate strategies.	Dependent on the corporate strategies.	
Competition for human resources in other projects	Dependent on the company's decision situation.	Dependent on the company's decision situation.	Dependent on the company's decision situation.	Dependent on the company's decision situation.	Dependent on the company's decision situation.	
Path dependency	Dependent on the company's decision situation (knowledge base, organizational structure etc.).	Dependent on the company's decision situation (knowledge base, organizational structure etc.).	Dependent on the company's decision situation (knowledge base, organizational structure	Dependent on the company's decision situation (knowledge base, organizational structure etc.).	Dependent on the company's decision situation (knowledge base, organizational structure etc.).	
Higher-than-average level of investment	Dependent on the company's decision situation (total assets, average level of investments for the development of new application systems, relative weight of the necessary investment etc.).	Dependent on the company's decision situation (total assets, average level of investments for the development of new application systems, relative weight of the necessary investment etc.).	Dependent on the company's decision situation (total assets, average level of investments for the development of new application systems, relative weight of the necessary	Dependent on the company's decision situation (total assets, average level of investments for the development of new application systems, relative weight of the necessary investment etc.).	Dependent on the company's decision situation (total assets, average level of investments for the development of new application systems, relative weight of the necessary investment etc.).	→ Aspects can be subsumed under "Risk"
Volatile market/consumer needs	Dependent on the company's decision situation (situation on the selling market, consumers´ expectations on the background of their experiences with such services etc.).	Dependent on the company's decision situation (situation on the selling market, consumers´ expectations on the background of their experiences with such services etc.).	Dependent on the company's decision situation (situation on the selling market, consumers´ expectations on the background of their experiences with such services etc.).	Dependent on the company's decision situation (situation on the selling market, consumers´ expectations on the background of their experiences with such services etc.).	Dependent on the company's decision situation (situation on the selling market, consumers´ expectations on the background of their experiences with such services etc.).	
Sufficiency of in-house know-how	Dependent on the company's decision situation (HRM, knowledge base, organizational structure etc.).	Dependent on the company's decision situation (HRM, knowledge base, organizational structure etc.).	Dependent on the company's decision situation (HRM, knowledge base, organizational structure etc.).	Dependent on the company's decision situation (HRM, knowledge base, organizational structure etc.).	Dependent on the company's decision situation (HRM, knowledge base, organizational structure etc.).	
Availability of external know-how	Dependent on the company's decision situation (required know-how, situation on the labor market etc.).	Dependent on the company's decision situation (required know-how, situation on the labor market etc.).	Dependent on the company's decision situation (required know-how, situation on the labor market etc.).	Dependent on the company's decision situation (required know-how, situation on the labor market etc.).	Dependent on the company's decision situation (required know-how, situation on the labor market etc.).	
Strategic importance for future business	Dependent on the corporate strategies.	Dependent on the corporate strategies.	Dependent on the corporate strategies.	Dependent on the corporate strategies.	Dependent on the corporate strategies.	
Dependency on technological	Higher for D, E, G, H, I. Lower for A, B, C, F.	Higher for A, B, F, G, H, I Lower for C, D.	Higher for A, B, C, E, F. Lower for D.	Higher for A, B, C, D, F. Lower for E.	Higher for A, B, D, E, F, G, I. Lower for C, H.	
Existence of technological standards	Higher for G, H. Lower for A, B, C, D, E, F, I.	Higher for A, B, G, I. Lower for C, D, E, F, H.	Higher for D. Lower for A, B, D, E, F.	Higher for A, B. Lower for C, D, E, F,-	Higher for G, I. Lower for A, B, C, D, E, F, H.	