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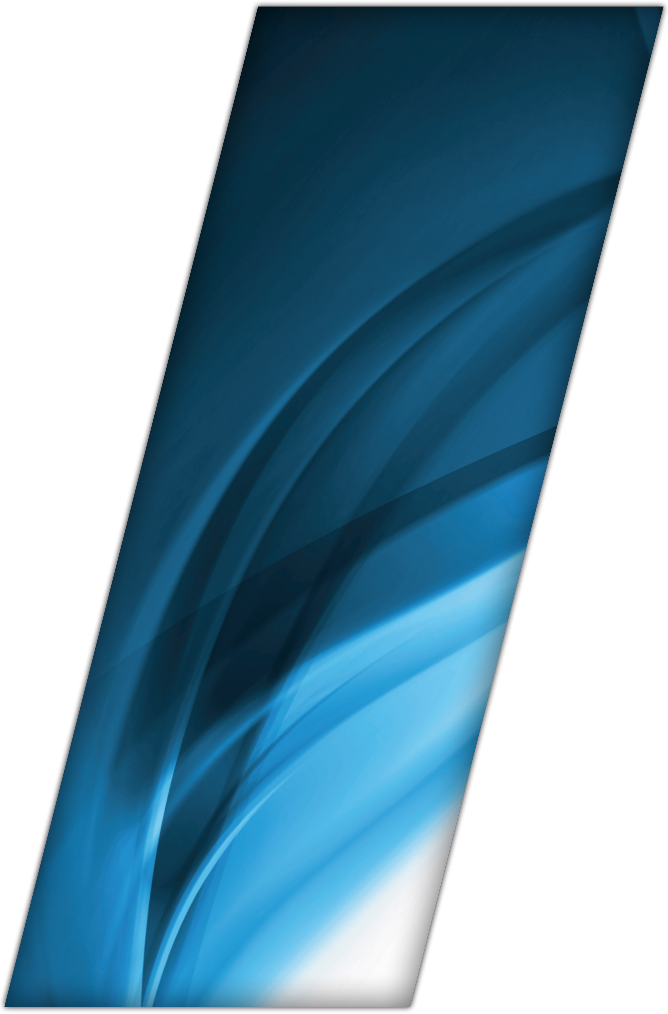

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International Relations and Security Network

MOBILE LEARNING IN SECURITY AND DEFENSE

Foundations, Technologies, Approaches and Challenges

ISN Report

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Executive Summary

Foundations

***A majority of mobile users already expects today that they can access their information from all their ICT systems**.*

For an increasing number of people around the world mobile devices are the primary if not the only opportunity to connect to data services on the Internet.

The available data indicates that mobile ICT has reached the level of a minimum socially acceptable standard for the members of security and defense organizations.

Mobility support through ICT is not limited to portable devices, but extends into device ecologies. Device ecologies form persistent information spaces across several networked devices, involving mobile phones, PCs, smart objects, etc.

Personal handheld devices play an important role in device ecologies because they are *personal connectors* that maintain persistency within or across different environments and contexts.

Today's e-learning practices are challenged by mobile technologies and by the changes and the implications these technologies have caused for information management, social interaction, and collaboration.

Mobile learning refers to technology-supported learning processes and practices that are linked to a person's contexts as well as relations and transitions between those contexts.

Content Technologies

E-books are electronic resources containing mostly linear text with pictures that are useful for the most common content format in education and training: books, manuals, articles, and essays.

In desktop environments the PDF format is the de-facto standard for e-books, but many PDF documents practically unreadable on small screens, because the documents cannot get adapted to smaller screen sizes.

The EPUB standard is an open alternative to PDF for fully accessible e-books on all major mobile and desktop platforms.

For education and training e-books provide an alternative to online information whenever learners require offline access to learning resources. Most ADL systems accept e-books as valid learning resources, but mobile use is currently constrained by the accessibility of the ADL system from mobile devices in order to download the e-books.

Novel *location-based services* can now combine location information with data from online services because current smartphones are consistently equipped with geo location sensors.

In educational settings location-based services are currently used for guiding learners in outdoor environments, but collaborative data collection and simulations are additional approaches that are currently emerging.

A special type of location-based services is referred to as "*Mobile Augmented Reality*" (mobile AR). AR embeds "virtual" information into the sensual experience of the users. Three types of mobile AR can be identified: visual AR, acoustic AR, and tactile AR.

Educational AR solutions embed information that is relevant for real-world activities, and overlay simulations with real places.

Managing Mobile Learning

ADL systems have become part of the standard educational and training practice in the security and defense sector. Many organizations maintain several ADL systems for different purposes or for different organizational branches.

In security and defense is SCORM (ADL Initiative, 2009) the de-facto standard for distributing learning material and monitoring the learning processes across environments and systems.

The primary role for ADL systems is course management, distributing learning resources, supporting student communication, and assessing the learning outcomes.

Many ADL platforms already provide optional user interfaces for mobile devices, but they are tightly coupled to the user interaction of the desktop counterparts and often they do not offer the same functionality as the desktop variant.

Current ADL systems are limited to support location-based learning because they do not allow tracking of and relating location information to learning resources and activities.

The current layout of SCORM is limited to the distribution of interactive resources, while other types of mobile learning are out of the scope of the specification, including location-based learning, contextualization, and multi-device interactions.

The next generation of SCORM will be able to track mobile learning experiences, but at this point it is not planned to provide the means for controlling or guiding mobile learners at a large scale.

Developing Mobile Learning Solutions

Mobile learning is tightly coupled to the supporting technologies, but there are no frameworks or platforms for developing interoperable educational solutions without detailed technical knowledge.

Mobile application development has been closely related to specific mobile platforms.

Each of the 9 mobile OSs is coupled to development and deployment structures (e.g., App stores). Each mobile OS uses a different primary programming language and vendor specific framework libraries.

Almost all recent mobile phones are equipped with a web-browser that is capable to display interactive and dynamic Web pages. This allows optimizing web-interfaces for interactions on mobile devices, including gesture based interactions and geo-location.

Proprietary technologies that are commonly found on the Web are not or not fully supported on mobile devices, such as Flash, Shockwave, Java, or Silverlight.

Web-based solutions for mobile face a number of limitations that are not present for native apps.

So called “hybrid mobile applications” or “hybrid apps” combine the benefits of native apps and those of mobile web-applications.

Hybrid apps provide greater flexibility regarding the supported devices while still providing the access to most device features.

Hybrid apps reduce the development costs for complex mobile applications in cases where different platforms have to be supported.

Context, Activity, Adaptation, and Learning Analytics

Sensors are an essential part of the mobile technology infrastructure. Every mobile phone comes with a range of different sensors.

Complex mobile applications cannot rely on raw sensor data but require aggregated data for providing meaningful information.

Context aware applications not only depend on aggregated sensor data but also implement analytical strategies as part of their business logic. These strategies are responsible for *adapting* the user experience.

Activity analytics refer to analytical strategies that relate aggregated sensor data to a control model of the application. *Learning analytics* refer to those are activity analytics for estimating the state of learning processes.

Learning analytics are of specific relevance in the realm of mobile learning because in many scenarios only connecting data from different sensors can identify learning actions.

Mobile learning design needs to integrate learning analytics for being able to leverage the potential of mobile learning.

Multi-device integration for mobile blended learning

The central aspect of mobile learning is the mobility of the learners. Different technologies can support this mobility, even if a device itself is not portable.

Device ecologies extend the concept of blended learning as it allows creating new forms of supporting learners through blending technologies and educational practices.

Mobile blended learning extends blended learning by integrating mobile devices as part of the teaching practice in- and outside of the classroom.

Mobile devices can provide a personal perspective for the learners, while a shared (social) screen blends these perspectives for an entire class or course.

Mobile blended learning in multi-device environments allows creating dynamic collaborative environments for course members and teams.

Challenges and Approaches for Mobile Learning in Security and Defense

The initial results from studies in security and defense organizations indicate that there is a bottom-up demand for implementing mobile. The development faces four major challenges.

- The technological challenge of providing mobile user interfaces to existing infrastructures.
- The organizational challenge of meeting the legal and regulative constraints under which security and defense organizations operate.
- The educational challenge of orchestrating novel scenarios of technology enhanced learning.
- The content challenge of creating educational learning material by educational practitioners.

While the content challenge is mainly solved by research, the other challenges require further analysis for implementing mobile solutions in security and defense.

Currently worked approaches include: e-content delivery, LMS integrated self-practicing, and mobile simulations.

Success factors and Barriers of mobile learning in Security and Defense Organizations

Five success factors for mobile learning were identified.

1. Mobile learning needs acceptance and commitment by the core stakeholders. The stakeholders include content creators, learners and trainers, as well as the organizational management.
2. Easy and efficient production of appropriate content is required.
3. Mobile learning content has to integrate seamlessly into the existing training practices.
4. Support continuity of learning through repetition and rehearsal of prior learning.
5. Measurable goals for implementing mobile learning on a large scale; and the evaluation of goal achievement.

Six barriers for mobile learning were identified.

1. Existing security regulations and security requirements
2. Cryptographic requirements
3. Mobile data connectivity
4. Devices features and interoperability
5. Device availability and financial constraints
6. Integration into existing educational practices

Recommendations for implementing mobile learning

For implementing scaling mobile learning solutions in security and defense organizations this report has identified 8 recommendations for implementing mobile learning.

1. Mobile access to information services will be main mode of interaction, but users might switch between devices of different system classes as they see fit. Therefore, updates to existing services need to consider mobile information access.
2. Mobile learning in security and defense depends organizational mobile ICT policies that need support from all stakeholders. This includes the development of new cryptographic requirements as well as the implementation of an evaluation strategy.
3. Mobile learning solutions have to be integrated with other education and training as well as HR infrastructures.
4. Reusing of existing content is key for quickly scaling solutions. For these solutions it is crucial that the mobile content is not a downsized version of previous material.
5. Applications need to support a wide range of devices from different vendors running on different operating systems. They need to be adaptable for integrating new platforms that enter the market. Hybrid applications are cost efficient for maintaining interoperability of mobile services.
6. Mobile learning needs to reflect different aspects of the mobility of the learners. This includes their connectivity state, location, and the available time.
7. Mobile learning involves social interaction and communication. Mobile services need to facilitate information access of shared information among peers, communities, or the general public.
8. Mobile learning strategies have to be prepared to integrate new educational concepts, such as scenario-based collaborative simulations; and new technologies, such as environmental sensors and activity analytics.

Introduction

Mobile technologies have been among the key facilitators of recent political and economic change around the world. Technological innovations have impacted upon how people handle information and what they perceive as knowledge. Such advances have inevitably impacted upon the activities of security and defense organizations. This in turn warrants a closer inspection of the influence that mobile technologies have on professional education and training activities in the spheres of defense, security and international relations (IR).

Every defense and security professional requires adequate training, development and evaluation to ensure that they are capable of fulfilling key tasks. Technology has made a valuable contribution to satisfying these demands for many years. Training simulators using virtual reality and computer-based training, for example, form part of the educational activities of these organizations. Yet, a host of external factors – such as overseas operations or civilian emergency planning – often mean that training and development requires more flexibility in terms of timing, accessibility and course structure. In professional contexts offering face-to-face instruction alone cannot satisfy such requirements. Just little over a decade ago the technologies of the Worldwide Web introduced flexible ways for distributing and monitoring learning opportunities that assure the timely and cost-effective diffusion of relevant organizational information and knowledge. International standards and specifications that are part of the Sharable Content Object Reference Model (SCORM) assure the interoperability of training material across systems, infrastructures, and organizations (ADL Initiative, 2009). The related technologies are typically summarized under terms such as E-learning or "Advanced Distributed Learning" (ADL).

The use of technologies in education and training has changed learning towards self-paced processes that are flexible with regard to time and location. Today's e-learning practices have adopted the concepts and principles of open and distance learning (ODL). This approach helps to ensure that learning materials remain mostly unaltered for existing handbooks and handouts. While these concepts do not touch the underpinning model of a single controlled environment for instruction and assessment, they are now challenged by mobile technologies and by the changes and the implications these technologies have caused for information management, social interaction, and collaboration.

Mobile technologies have become part of the practice of societies, communities and organizations around the world. In the past 5 years these technologies have disrupted the rules of how information is created, managed, and shared more dramatically and with greater impact than any other information technology before. It is already evident that the technological changes also influence the organizational career and talent development as a whole. While mobile learning resembles some concepts of ADL and e-learning it also has unique concepts that are uncommon to existing e-learning practice and even to institutionalized education and training. Therefore, it can be expected that the technological changes also influence the organizational career and talent development in security and defense organizations. Unlike previous information technology “revolutions” this does not necessarily imply massive investments in infrastructure because the underpinning technologies are already present in many organizations. However, the speed and scale of mobile adoption requires strategic decisions in order to meet the information demands of the target audiences in the near future.

This report focuses on the concepts and technologies of mobile learning as well as on the approaches and challenges for mobile learning in international relations, security and defense organizations. The report is structured in 4 parts. Part 1 introduces to the core anatomy of the mobile technology revolution and outlines the concepts and structure of mobile learning. Part 2 discusses present technologies that are of relevance for mobile learning. Part 3 presents the outcomes of a research inquiry on mobile learning in Europe and the United States in security and defense organizations. Part 4 analyses the success factors and barriers for introducing mobile learning into the education and training practice of security and defense organizations. The report concludes with recommendations for service providers and decision makers for defining strategies for integrating the novel requirements of a mobile information society in education and training.

Part 1: Foundations

The Mobile Technology Revolution

The technological and educational underpinnings of e-learning practices are challenged by current developments in mobile computing. Handheld technologies such as smartphones, tablet computers, and networked Personal Digital Assistants (PDA) brought the Internet literally to the fingertips of the world. Today almost all mobile phone subscriptions include some type of mobile data plan that provides mobile access to the Internet. The data provided by the International Telecommunications Union (ITU, 2012) indicates that for the majority of the Internet users access the Internet primarily through their mobiles. CISCO (2012) reports that already today almost 90% of the world's mobile data traffic originates from basic handsets. Basic handsets refer to unaltered consumer products, including both feature phones and smartphones. In developed countries more than 50% of all active mobile subscriptions include broadband data plans (ITU, 2012). This correlates with the success of modern smartphones, such as the BlackBerry or the iPhone. Within less than 5 years CISCO (2012) predicts that 25% of the world's mobile telecommunication participants will have multiple mobile devices for accessing broadband services on the Internet.

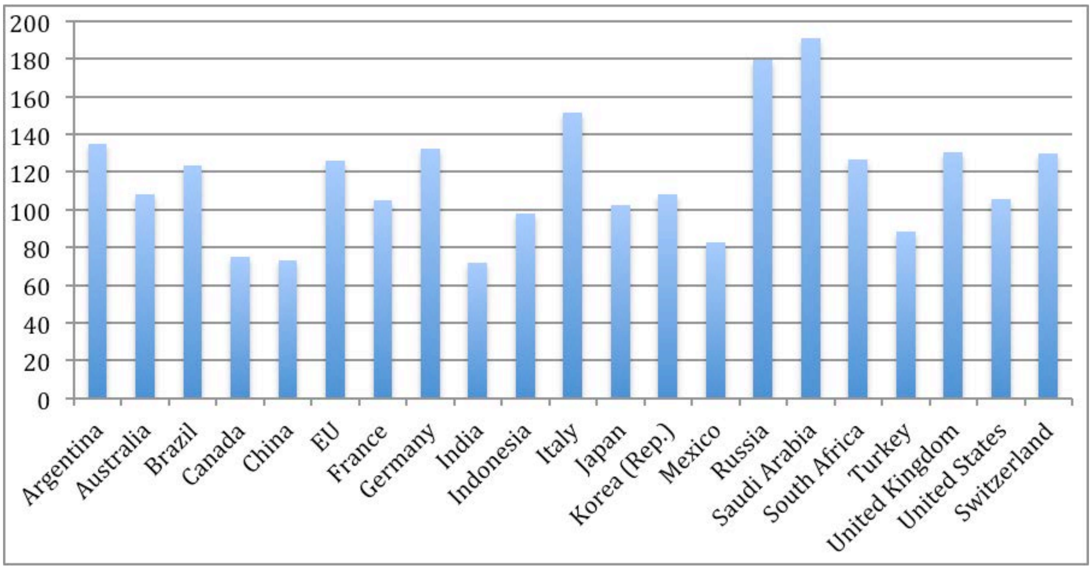

Figure 1: 2011 Mobile market penetration (%) of the G20 countries and Switzerland (Source ITU, 2012)

Indeed, subscriptions for mobile technology products in crisis zones in Central Asia, the Middle East, and Africa underline the global relevance of mobile ICT. The communication data that is reported by the ITU indicates significant differences in the use of mobile technologies in the G20 countries and other parts of the world. In the G20 countries telephony services are a main pillar for mobile telecommunication, while this is not the case elsewhere in the world. Instead, the ITU data indicates that outside the G20 countries data services are key whereas telephony services are almost irrelevant.

Regardless of the market characteristics in national states, for an increasing number of people around the world mobile devices are the primary if not the only opportunity to connect to data services on the Internet. While previous initiatives thought about how to provide educational services through desktop computing environments to different communities (e.g. One Laptop Per Child), it showed in the past years that mobile technologies have a larger community outreach and impact than any other ICT before: after 6 years the *worldwide* relative adoption of mobile broadband technologies have exceeded the relative adoption rate of Internet connected desktop computing in the *industrialized countries* after almost 2 decades. Therefore, *it is crucial to consider mobile data access concepts before desktop support when developing new or updating existing data services.*

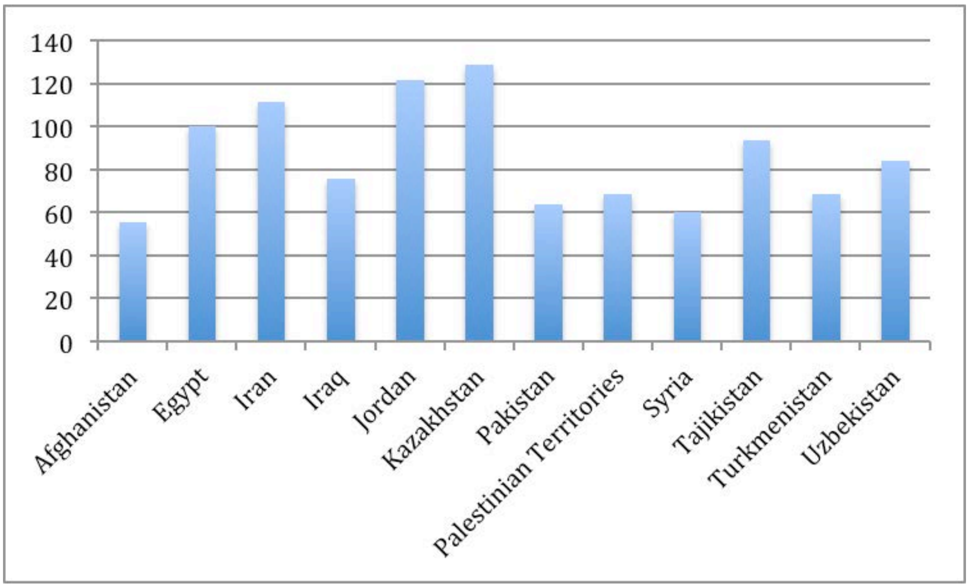

Figure 2: 2011 Mobile market penetration (%) of Afghanistan and Iraq and selected neighboring markets (Source GSMA, 2012)

A recent survey of the ISN on the technology adoption in the Swiss armed forces (VBS) indicated that in a representative sample of their staff the adoption of mobile ICT was significantly higher than the national average (Ipsos, 2012). The data refers to the individual adoption of mobile ICT without considering the ownership of multiple mobile devices or subscriptions. The results indicate that the adoption of mobile ICT is further developed in the context of defense organizations that in other parts of the society. Figure 3 shows that 89% of the sample owned a smartphone, compared to 71% who owned a laptop or netbook. The data further revealed that this distribution will further increase by approximately 5% because about half of the feature phone owners indicated that they intend to replace their feature phone with a smartphone within the coming 12 months. While the available data is only representatives for Switzerland, on the grounds of national market data it is expected to find similar adoption rates in other national or international organizations.

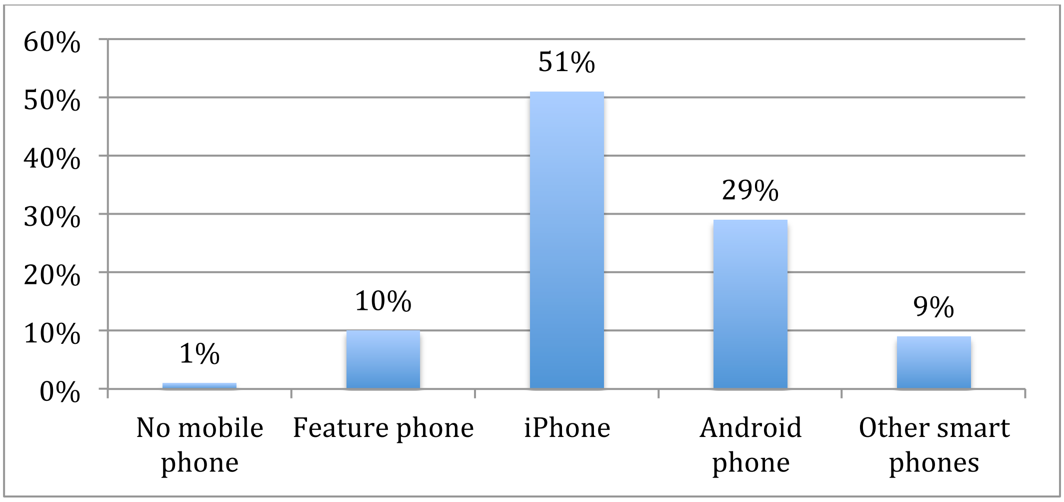

Figure 3: 2012 mobile phone adoption in the Swiss armed forces (Source ISN)

The relevance of this adoption rate becomes clearer in the context when it is related to technology adoption models. Among the most widely cited models is Roger's (1962) model of diffusion of innovation. The model describes the level of adoption of innovative technologies by a target audience (also referred as "market share"). Rogers separates the target audience into 5 distinct groups that follow different decision making patterns for adopting new technologies: Innovators or technology enthusiasts (about 2.5% of a population), who like to have access to the latest technology available; early adopters (about 16.5% of a population), who seek for new ways of improving their performance through new technologies and who are often opinion leaders; the early majority (about 34% of the population), who accept technologies that has been proven to work; the late majority (about 34% of the population), who accepts only "established" technologies; and the laggards or technology pessimists (about 16% of a population), who only adopt new technologies if other (older) alternatives are no longer available or acceptable. Very high adoption levels above 84% can be considered as minimum standard within a population, which is coupled to expectations of availability and applicability of that technology. Figure 4 relates the data from the Swiss mobile readiness study to Rogers' innovation diffusion model.

The available data indicates that mobile ICT has reached the level of a minimum socially acceptable standard both, within industrialized societies as well as within their security and defense organizations. This implies that solutions that do not or no longer meet these standards are more likely to get refused by the target audiences.

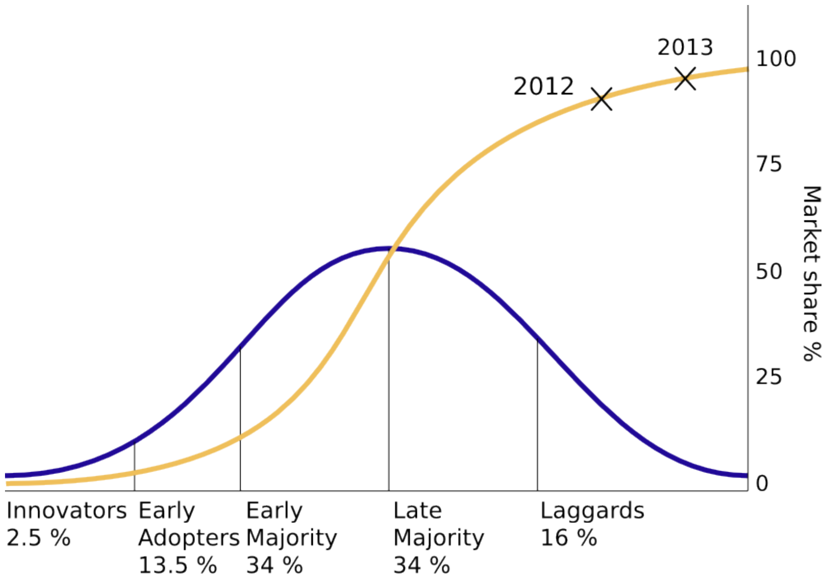

Figure 4: Smartphone adoption by Swiss defense staff in the context of Roger's model of technology adoption

Characteristics of Mobile Services

More recently, mobile phones and connected Internet-services have also demonstrated how they help shape social and political change. Not only does this technology support “flash mobs” or “Facebook parties”, it has also mobilized supporters of the “Occupy” movement and the Arab Spring. Accordingly, mobile technologies help facilitate the complex task of coordinating a large number of actors towards joint actions. Seven characteristics of mobile ICT are reflecting how entire societies change in perceiving and managing information and actions:

1. Instantaneous access to information
2. Integration of data sources
3. Continuity
4. Collaboration
5. Contextualization

6. Personal relevance

7. Situational awareness

The Arab Spring, the Occupy movement and flash mobs share that they are *collaborative activities* of peers that rely on the relatively *continuous availability* of communication and information channels, through which references to information can be *immediately accessed*. This enables movements to adapt their plans on the fly. Peer communication creates *personal relevance* and facilitates the *contextualizing* of abstract or incomplete information that comes through *multiple* information channels. Location and navigation services such as Global Positioning Systems (GPS) and Google maps help actors to find the location of a venue easily and on time. Finally, mobile technology can support *situational awareness* on others, e.g., through the camera and microphone that are built into almost every mobile phone today, or support the situational awareness of the owner by warning about road blocks or the presence of obstacles.

These characteristics are not only present in the action of political movements, but can be identified in almost every activity in which mobile ICT is used. Organizations that need to operate effectively in crisis can benefit from considering these characteristics for improving the developing a mobile information strategy.

Device Ecologies and new Types of Software

Mobile devices are only the tip of the iceberg of the mobile-technology revolution. Current developments in ICT point towards networked *device ecologies* consisting of mobile phones and desktop computers, ambient information screens (Wisneski, Ishii, Dahley et al., 1998), embedded systems (Marwedel, 2011), sensor grids (Lim, Yong, Mukherjee et al. 2005) and -networks (Akyildiz, Su, Sankarasubramaniam, & Cayirici, 2002), and smart objects (Siegemund, 2005). Interconnected ICT devices that can be used simultaneously by users characterize device ecologies. The concept extends connectivity from the level of data exchange and synchronization to the interaction level: Interactions with one device have an impact on the behavior of other devices. This way, device ecologies create data and information overlays to the physical environments, in which the devices are set up.

These technologies already influenced the development of “future soldier” concepts, as presented by the US Army (Natick, 2000), or German Armed Forces (Rheinmetall Defense, 2008). Today such concepts are no longer visionary and the technologies have been integrated into surveillance systems, traffic management, defense technologies, building automation, automotive solutions, and home entertainment. These solutions are no longer isolated but integrate into larger networks and systems. An example for such networked infrastructure in defense is the German “Gladius” System that integrates infantry and vehicle based weapon systems (Heeresamt, 2012). Further development towards “network-enabled” combat systems is in the process (Rheinmetall Defense, 2012)

Variable arrangements of devices and interfaces characterize these device ecologies, while the interacting person perceives a persistent information and communication environment. The data in such device ecologies is *automatically* updated and synchronized between present devices. Nevertheless, personal handheld devices play an important role because they are personal connectors that maintain persistency within or across different environments and contexts.

Today’s device ecologies include devices that can be structured into four generic groups.

1. Personal stationary systems;
2. Personal portable systems;
3. Social stationary systems; and
4. Social portable systems.

Personal stationary systems are typically provided by conventional desktop computing systems; such as PCs. Personal portable systems are highly personalized devices that can be carried with the user. This class includes handheld devices as well as laptop. Social stationary devices refer to systems that make information easily accessible for several users at the same time. These systems include Smart Boards, Information Billboards, or interactive tables. Social portable systems allow creating shared information spaces while on the go. This category is currently getting increased attention through reconfigured tablet and laptop computers or integrated micro-projectors. However, hands-free extensions that are built into all contemporary smartphones are the simplest form of social portable systems.

This categorization follows along two dimensions of system interaction. The first dimension is personal and social systems. Personal refers to systems that are primarily used by and customized to a single person. Social refers to systems that allow several users to access and interact with information at the same time. The second dimension is portable vs. stationary systems. Portable devices are devices that are easy to transport and are usable while they are in transport. Stationary systems are "fixed" in terms that they require certain infrastructure to operate. Laptops indicate that the transitions along these dimensions are fluid and that the same device could be reconfigured to operate in a different setting. In the laptop example, connecting the computer to a wall-mounted video beamer and start a social "clicker app" can turn an otherwise personal portable system into a stationary social system.

A majority of mobile users already expects today that they can have access to their information on all ICT systems they access. Therefore, mobile services face the increasing demand to run on several devices and platforms. This creates new requirements for software and service solutions than in the past for personal computing software. There can be several ways for handing information or communicating with peers, and the software needs to adapt information more frequently to the context in which it is used and has to perform flexibly under different or changing environmental conditions. These requirements and the new technical possibilities of mobile devices created space for new types of software and information management experiences, such as location-based services, navigation systems, gesture-based and haptic systems, mobile Augmented Reality, and anchored information services.

	Personal	**Social**
Stationary	Desktop PCs and workstations	Information billboards and interactive tables
Portable	Mobile phones, PDAs, Laptops	Micro-projectors, Smart objects

Figure 5: Relations and examples of system classes in device ecologies

What is mobile learning?

Mobile learning refers to technology-supported learning processes and practices that take benefit of mobility of people and consider learning opportunities that are created by a person's contexts as well as the relations and transitions between those contexts.

This definition does not directly refer to mobile technologies. The recent developments of networked ICT systems allow creating persistent user experiences across individual devices. Therefore, the term “mobile learning” is widely considered as a short form for "mobile and ubiquitous learning". This expanded notion takes into account that people interact with data and information services in device ecologies.

Given the special features of mobile devices, it is not surprising that early definitions of mobile learning focused almost entirely on personal portable technologies. For example, O’Malley et al. (2003) define mobile learning as “learning that happens when the learner takes advantage of learning opportunities offered by mobile technologies”. This definition does not distinguish between personal handheld devices and personal portable devices. While the former are practically always on and can actively trigger activities, e.g., through incoming messages or telephone calls, it necessary to activate personal portable devices before they can be used. Examples for personal handheld devices are mobile and smartphones, PDA, or portable multimedia players (e.g., Apple iPod touch). Examples for personal portable devices are Laptop and Notebook PCs. In the following the term "mobile devices" is used as a synonym for "portable handheld devices".

In order to distinguish mobile learning from web-based learning on Laptops, the ADL Initiative defines mobile learning as "the use of handheld computing devices to provide access to learning content and information resources." (Brown & Haag, 2011). This definition is then further restricted to the following characteristics: “Mobile learning has been called bitesize, handy learning, ubiquitous, portable, pocketable, learning on the go, my learning, untethered, informal, opportunistic, personal, private, situational, unstructured, learning in the moment, snack-learning, courselets, "bus stop" learning, a learning nugget or even a learning pill. Much of microlearning, reinforcement, and performance support are delivered on mobile devices as small chunks.” (Brown & Haag, 2011, 7)

Traxler (2007) highlights that several perspectives on mobile learning exist in contemporary research. These perspectives include, technology centered, miniature and portable e-learning, connected classroom learning, situated and personal learning, mobile learning for performance support, and mobile technologies for remote, rural or development regions. Traxler further highlights that mobile learning “is emerging as an entirely new and distinct concept alongside the 'mobile workforce' and the 'connected society.'” Mobile devices create not only new forms of knowledge and new ways of accessing it, but also create new forms of art and performance, and new ways of accessing them.” (Traxler, 2007, 5). Concerning these new forms, Traxler distinguishes mobile learning as *zero-latency task-oriented and bite-sized approaches* to learning compared to low-latency and *system-tethered approaches* that are characteristic for desktop-centered e-learning solutions.

The available definitions relate to the “always on” and “always connected” characteristics of personal handheld devices, particularly of contemporary smart-phones, although this is only implicit in the context of the definition provided by the ADL Initiative. Recent research stressed that the benefits of mobile learning are beyond improving the access to learning resources (Börner et al., 2011; Glahn & Specht, 2010; Spikol & Milrad, 2008; Looi, Seow, Zhang et al., 2010). As information becomes increasingly available on-demand the focus of learning shifts from learning facts to learning procedural skills and to the development of competences. Moreover, mobile learning opens technological support for learning to the psychomotor-domain by using sensors to capturing and integrating data from a range of sensors automatically into the learning experience, such as movements or voice levels.

The current definition of mobile learning emphasizes that mobile learning is by no means centered on one-to-one interaction (one learner to one teacher/book/device). Like the ICT systems for the future soldier, today’s technologies are connected through wireless networks and the transfer of data between individual devices becomes increasingly transparent. This creates information environments that are persistent across individual devices and that can respond to simultaneous interactions through different channels (Specht, 2009). Consequently, mobile learning refers to educational concepts and pedagogies that consider the variable features of the learners' environments and contexts.

The role of context for the instructional design can be best understood from the viewpoint of activity theory (Engeström, 1999). The underlying concept suggests a generic system model for describing activities based on seven elements. The relations between the elements are illustrated in Figure 6.

1. The subjects or actors of an activity;
2. The objects or resources that are used during an activity;
3. The instruments and tools that are required to perform an activity;
4. A set tasks that are performed during an activity;
5. Rules and conditions that define procedures and restrictions;
6. The context in which an activity takes place; and

7. The activity’s outcomes or results.

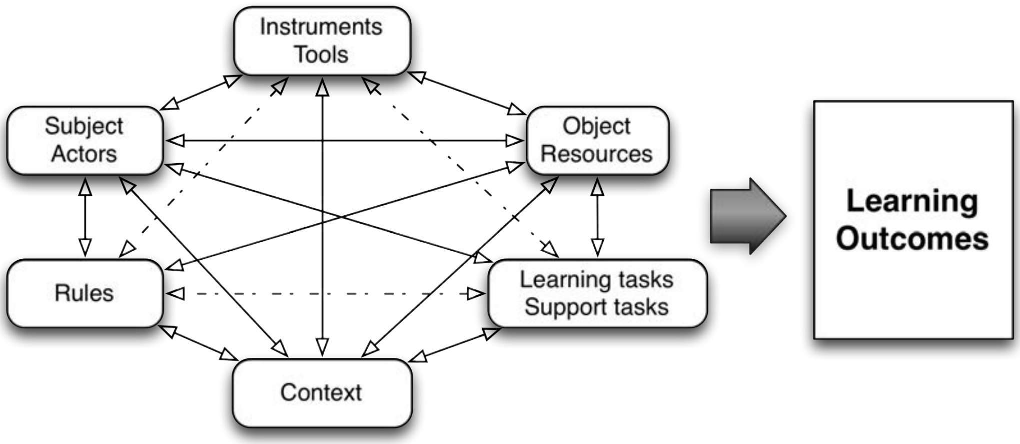

Figure 6: Activity System Model derived from Engeström (1999) with extensions by Glahn (2013, in press).

These elements are sufficiently describing different kinds of activities and can be also identified in the literature on instructional design research (Reigeluth, 2009; Dick, Carey, & Carey, 2009). In ADL the context element is typically considered as invariant during a learning activity. This notion is also reflected by the present learning technology standards that either do not consider context at all (Norton & Panar, 2003), or define context as a passive container (Koper, Olivier, & Anderson, 2003). Mobile learning changes this setting by emphasizing that the contexts of learning activities are dynamically influencing learning processes (Glahn, 2013, in press).

Despite characterizing mobile learning it is necessary to understand the educational challenges for mobile learning that require further research and development. Recently, Börner et al. (2010) identified in an expert study seven groups of educational challenges that are related to mobile learning. The groups are listed below in the order of the perceived relevance (see Figure 7):

1. *Access* to learning
2. Contextual *influences* on learning processes
3. *Context-sensitive orchestration* of learning
4. *Personalization* of learning
5. *Collaborative learning*

6. Impact of mobile technology on *organizations*
7. Using and integrating *technologies* into the educational practice

Of these key challenge types are three challenges specific to the field of mobile learning and are unlikely to get solved without considering the mobility of the stakeholders. These core challenges include the contextual influences on the learning process, the access to learning opportunities, and the context-sensitive orchestration of learning processes. These challenges highlight that technological learning support is increasingly embedded into other activities, related to locations, connected to social practices. The challenges further highlight the qualitative difference to conventional approaches to ADL.

Within the grand challenges for mobile learning concrete problems continuously emerge as practice adopts mobile technologies. This partially related to the limited maturity of available commercial products. The numbers of mobile learning related research publications is indicative for the early stage of mobile learning research and practice: before 2007 mobile learning was primarily a highly specialized niche that has been covered by a very small group of researches and institutions. Until 2009 solutions were tightly coupled to provided and prototype infrastructure in which PDAs were the prime technology for mobile content delivery and interaction. 2009 indicated a major paradigm shift in mobile learning research as in that year alone more research results on the topic were published than in the entire preceding decade. Staring in 2010 mobile and smartphone technologies were reflected in major research publications. Among the published research the majority of the publications considered either technological concepts or the user acceptance of mobile learning solutions. Most mobile learning research in the past 6 years targeted small scale or highly specific case studies. Prior research hardly considered the influence of the specific characteristics of the mobile technology on learning processes, on educational practices, or on organizational policies at a large scale. This creates a dilemma because many factors of integrating mobile technologies into organizational learning are yet to be studied.

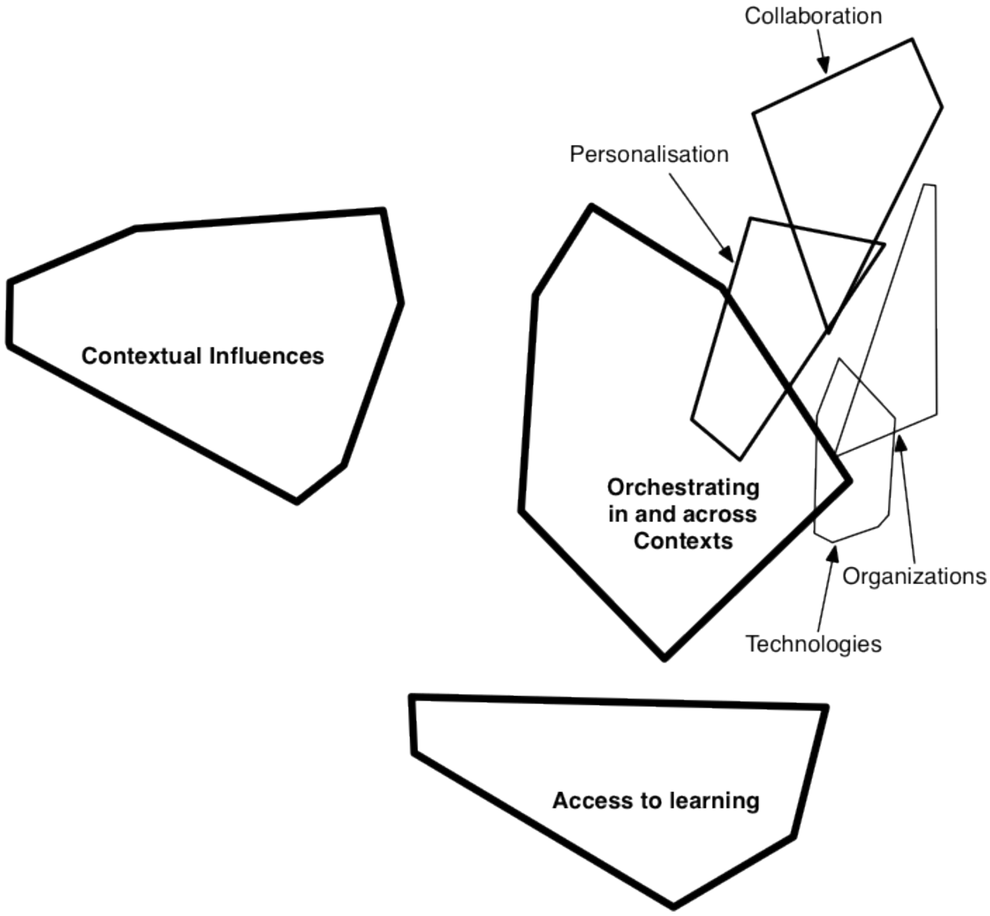

Figure 7: Mapping of Mobile Learning Challenges

Similarly, until 2010 most commercial virtual learning environments (VLE) and learning management systems (LMS) offered no support for the access from mobile devices, especially for the market leading platforms. Starting from 2011, all major players in the VLE/LMS market have at least an explicit strategy for providing system access from mobile devices or offer initial solutions (Glahn, 2010). Presently, the support for mobile devices by VLE and LMS solutions does provide at the best the same feature sets as their web or desktop-based counterparts and the prime focus for most mobile solutions is to enable the access to key features from mobile devices. This does not mean that mobile learning solutions do not exist, but they are typically isolated technological islands or vendor bound solutions that do not integrate with existing organizational infrastructures for education and training. The technical challenge of mobile learning refers to integrating mobile learning with other educational infrastructure.

Present research clearly shows that supporting mobile learning cannot get reduced to a technical problem. Instead educational technologies the findings of Börner et al. (2010) suggest that the core challenges for mobile learning are related to the novel educational, social, or psycho-motoric conditions that are created through mobile and ubiquitous ICT. These new conditions are tightly coupled with the characteristics of mobile ICT. Table 1 illustrates the relation between the challenges for mobile learning research and development and the characteristics of mobile services. The challenges for mobile learning are not only related to addressing the characteristics of mobile technologies but are also related to the consequences of their simultaneous presence on learning processes.

Table 1: Mobile Characteristics and Mobile Learning Challenges

	Access to learning	Contextual *influences*	Context sensitive Orches-tration	Personali-zation	Collabora-tion
Instantaneous access	X				
Integration of data	X	X			
Contextualizati on		X	X		
Continuity	X		X		
Personal relevance		X		X	
Collaboration			X		X

Part 2: Technologies

Like any form of technology-enhanced learning, mobile learning is dependent on technologies. However, mobile learning does not only depend on new technologies. It also requires adapted content and procedures that are suited to the technologies. Therefore, it is important to understand the interplay of different technologies and content in order to be able to create integrated and attractive mobile learning solutions.

This part analyzes mobile learning technologies from two angles. Firstly, it analyzes content and content management approaches. Secondly, it focuses on system development and infrastructures. Across the different technological approaches it appears that web-technologies are a common denominator. This includes HTML and XML as front-end technologies and web-services in the background.

Content Technologies for Mobile Learning

E-books

The most common content format in education and training are books, manuals, articles, and essays. In the context of electronic documents these resources are also referred to as e-books. Today e-books are electronic resources containing mostly linear text or pictures that can be accessed from a range of different device classes.

In desktop environments the PDF format is a de-facto standard for electronic documents. The format has its origin in print publishing. The main benefit of PDF is that it defines the exact page layout by storing the exact location of every character or picture on a page. Therefore, the content of a page and its layout are inseparable. This benefit for printing is the biggest drawback of PDF on mobile devices, as it renders the majority of PDF documents practically unreadable on small screens, because the documents cannot get adapted to the smaller screen sizes.

The advent of PDA systems created the need for accessing longer documents also on mobile devices, which has been (partially) satisfied by conversion software that tried to extract the content from PDF documents and transform it into a mobile friendly format. Such formats were later used for directly publishing mobile friendly versions of books and documents. One of the most popular formats was the Mobipocket format (Mobipocket, 2008). The Mobipocket format includes only the basic structure of a document (such as headings, paragraphs, side-notes, or references) but no layout information.

The Mobipocket reader applied the layout that is most appropriate to the reading device and the reader's preferences. This approach allows adapting the content to a range of reading devices with varying screen sizes. E-book reading devices, such as the Amazon Kindle, B&N Nook, or the Sony PRS E-book reader, have later adopted this technology.

The main drawback of the Mobipocket format and similar formats was that it relies on proprietary technology. This became evident when Amazon gained an advantage over its competitors by acquiring the company Mobipocket in 2005. This limitation of proprietary formats has lead to the foundation of the Open eBook initiative. The initiative focuses on creating an electronic publishing format based on open technologies. The International Digital Publishing Forum (IDPF) later adopted the results and integrated them into the EPUB specification. EPUB is now available in its third version (EPUB3; Conboy et al., 2011).

The EPUB format is basically a Zip archive that contains a number of HTML documents and a table of contents (manifest file). The specification further restricts the usage of some HTML elements, particularly with respect to extensive formatting and layout as well as to references to external resources. Starting with EPUB3 it is also possible to embed animated and interactive content into e-books. Furthermore, EPUB3 allows to a limited extend the integration of online services and resources, while the readability on a wide range of devices is assured.

Apple Inc. introduced the e-book reader iBooks with its tablet computer iPad and smartphone iPhone. This e-book reader allows to access several e-book formats (including PDF and all versions of EPUB). It also serves as a publication distribution frontend for Apples e-commerce platform iTunes. In 2011 Apple Inc. released the software "iBooks Author". This software enables authors to create easily e-books for the Apple hardware and the related distribution channels. iBooks Author exports documents in the "iBook format". These e-books are basically EPUB3 documents with variations that are specific for the Apple's hard- and software. Furthermore, the iBooks format is limited to the use on the iPad, Apple's tablet computer, while EPUB3 documents are accessible on all major mobile and desktop platforms. This is particularly interesting because the iPhone version of iBooks can handle EPUB3 documents but not resources in the iBook format. Finally, the iBooks Author software provides predefined layout designs that users can adapt to a limited extend. Part of these designs is a preference for the landscape orientation. In landscape mode iBooks offers a book-like reading experience (including page flipping), while the portrait orientation it presents the e-book in a long sequential text flow. This behavior cannot be changed in iBooks Author.

For education and training e-books provide an alternative to online information whenever learners require offline access to learning resources. Given the similarities between basic SCORM packages and the EPUB format it is in principle possible to provide offline scripts of learning resources as e-books as part of a single authoring process: authors can create a the basic structure of the educational text material for both their SCORM package and for a e-book version. For authors it is important that the e-book version lacks of the tracking and sequencing functions as well as some resource formats that are part of SCORM. The missing formats are specific to interactive learning material and assessment and include most prominently the lack of IMS QTI. *Therefore, e-books are most appropriate for reference or for self-study material.*

Most ADL systems accept e-books as valid learning resources. This enables learners to download offline scripts for their courses directly to their mobile devices. However, the access is currently constrained by the accessibility of the ADL system from mobile devices.

Location-based services

Contemporary smartphones are equipped with geo-location sensors that are accessible for any app on the device. Apps that use the location of the device for filtering, selecting or contextualizing information for the user from Internet databases are called location-based services. Location-based services were the first applications that deliberately considered the mobility of their users as a resource. Early examples for location-based applications are navigation systems and Geocaching (Clough, 2010). Geocaching is a location based exploration game in which players follow hints that are associated to geo coordinates in order to find hidden “treasures”.

Novel location-based services can now combine location information with data from online services because current smartphones are consistently equipped with geo location sensors (using GPS and GLONASS). Such services include:

- Real-time traffic information,
- Local search, and
- Location-based games.

Real-time traffic information services extend navigation systems by using crowd-sourced data about the mobility of their users (Barth, 2009). This feature is already built into high-end car navigation systems as well as into mobile phones. These services take advantage that navigation systems constantly measure the location, the direction and the speed. By collecting this information and combining this information from many users allows rendering a detailed picture of the traffic situation. For example, if many navigation systems that were previously heading in the same direction report that they are no longer moving then this indicates that the owners are likely stuck in a traffic jam. This approach allows the monitoring of mobility behavior even where public sensor networks are unavailable because fixed sensor networks are commonly installed on major roads with special management requirements, such as highways or tunnels.

Figure 8 and Figure 9 compare the real time traffic information of Google maps and Bing Maps at the same time for the Zurich city center. Bing Maps (Bing Services, no date) uses the data provided by the authorities from fixed sensor networks, which provides only data for major transit routes to and from the city's motorways (Figure 9). Google Maps utilizes information that is automatically reported by mobile users and shows more detailed information for almost all major roads in the city (Figure 8).

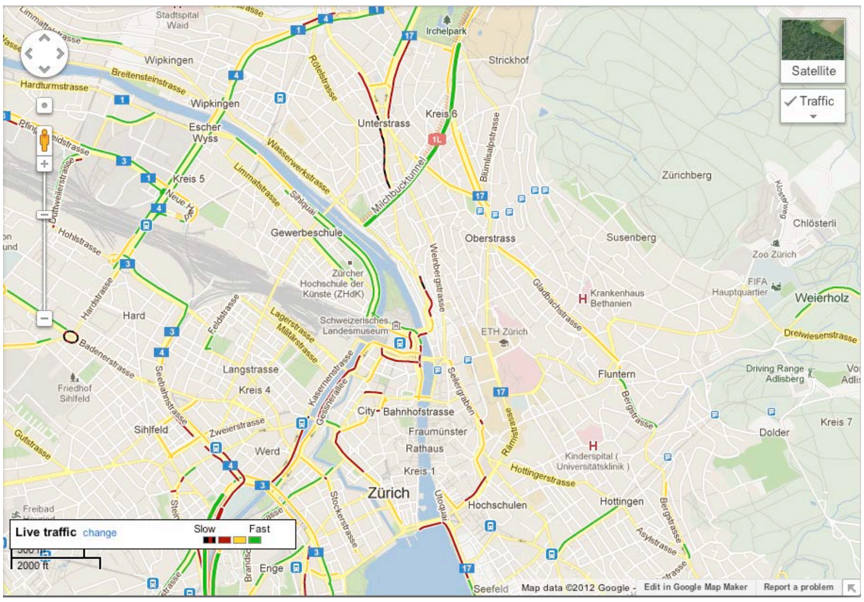

Figure 8: Real-time traffic information on Google Maps

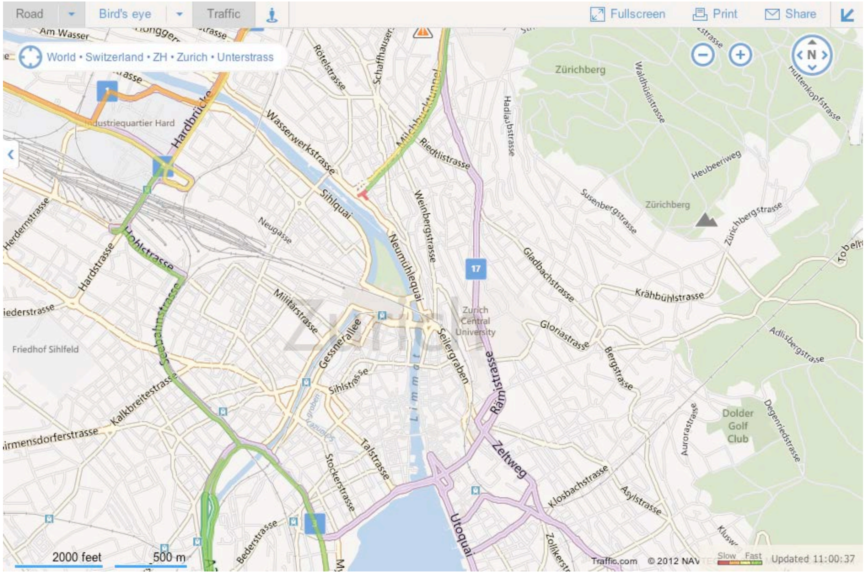

Figure 9: Real-time traffic information in Bing Maps

Location-based search (Ahlers & Boll, 2007) filters information uses geo data information of points of interests (geo location of sights or addresses of stores, public authorities, schools, etc.) for filtering information. Location-based search addresses the common need to find something nearby. In order to satisfy this need location-based search filters the results depending on their proximity to the location of the searching user. Instead of forcing the user to select appropriate results from "best matches", location-based search reduces the search results to those matches that are in the vicinity of the user. Common applications of location-based search are public transport timetables (Figure 10) or yellow pages searches (Figure 11).

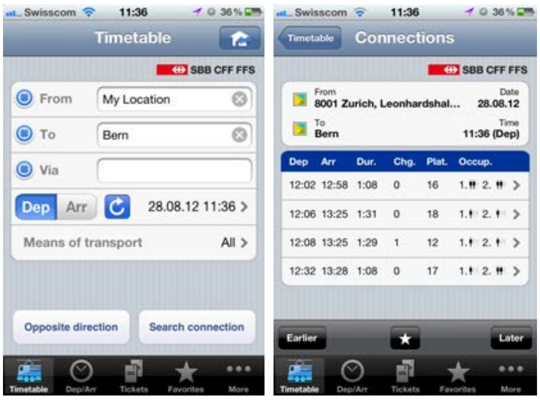

Figure 10: Location-based timetable search of the SBB on iOS

Figure 11: Location-search in the Swiss yellow pages on iOS

Location-based games are "computer games" that require real world interactions. These games integrate the location of their players into the game design. Location-based games overlay the "virtual" storyline of the game with real world locations. This is achieved by finding objects or by challenging other players. Depending on previous achievements new challenges or activities become available to the player. With this regards location-based games are very different to other types of mobile games that are played on the mobile but do not consider the location of the player.

Location-based games rely on rules and sequences that are related to locations and form the game's storylines. Often activities are connected to a location in order to reach game achievements. For example, in Foursquare (2013) the players need to check into the app in certain locations, the more often they check into the system at a given location the higher gets their score for their presence. Eventually, the players achieve location badges (by checking into many places in an area) or become a Major of a location. Further achievements can be defined for locations. For example a café can offer a free drink after checking in 10 times at their location. Other games have rules and sequences that require teams of players to set claims before they can proceed with further activities. The teams need to defend their claims against other teams or join forces in order to reach higher achievements in the game. Such game rules are found for example in games such as Gbanga (http://gbanga.com/).

In educational settings location-based services are currently used for guiding learners in outdoor environments. The guiding approach defines "points of interest" at which information becomes available. In order to access such "anchored" information, the learners need to move to the associated location (Hwang, Chu, Lin, & Tsai, 2011). In inquiry-based learning settings, learners were provided with challenges they need to solve and document using their mobile devices. In these settings, the location was automatically documented and integrated into the project documentation (Spikol & Milrad, 2008).

Augmented Reality

A special type of location-based services is referred to as “Mobile Augmented Reality” (mobile AR). AR embeds “virtual” information into the sensual experience of the users. Most frequently visual AR solutions are found on mobiles. Alternative approaches of mobile AR are acoustic and tactile AR solutions.

Visual AR creates information overlays for the visual experience (Höllerer & Feiner, 2004). This is typically achieved by embedding additional information into the picture of the mobile phone’s camera. In this case the device uses the sensors of the mobile device in order to identify the direction into which the user is pointing the device. The information overlay is generated depending on the device orientation and the location. The main drawback of visual AR is that it requires that the users actively use the device. It is expected that head mounted displays create a more casual usage experience. The Google project glass (Google, 2012) has presented a prototype of a consumer-targeted head-mounted system. However, the current prototype of the Google Glass project provides a non-interactive usage experience and is only capable to record the environment on a personal perspective but requires an auxiliary device to access the information.

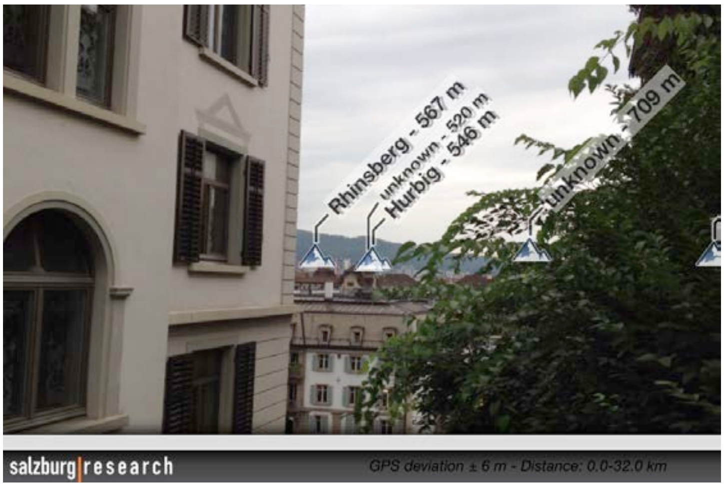

Figure 12: Information overlay of the PeakAR app on iOS by Salzburg Research

Acoustic AR uses sounds to embed information into the experience of the user (Terminer, de Vries, Börner, & Specht, 2012). Sound information related to points of interest is played depending of the user’s location. Simple sound effects can inform users that they approach a point of interest. Stereo effects help focusing the user's attention towards important aspects of the environment. Basic examples for acoustic AR are navigation systems that inform to pay attention to the traffic situation when an important waypoint will be reached or if the driver exceeds the speed limit. The benefit over visual AR is that users can use these solutions in hands- and eyes-free mode.

Figure 13: Head-mounted AR system prototype (photo by Google ProjectGlass.)

Tactile AR solutions use haptic stimuli for directing the users attention to environmental conditions (Nagel, Carl, Kringe et al., 2005). Similar to acoustic AR, tactile AR solutions may use the vibration signal when user approaches a point of interest in order to focus the users' attention. By using multiple tactile triggers, it is possible to provide directional information to the users.

Mobile AR is an interface technology for embedding educational information into real-world contexts. AR technologies are particularly useful for providing supportive information for a context or a location. As an overlay technology it is particularly important where the learners' attention be focused onto the contextual factors in which different aspects of available information is relevant.

Many technical solutions embed information that is relevant for real-world activities, and overlay simulations with real places. For example, an augmented reality game for training hostage taking created different types of information overlays (visual and acoustic) based on a simulation of the developments of hostage-taking situations in order to train communication officers at UNHCR (De Vries, Ternier, Specht, Gonzales and Specht, 2012). This training game combines audio augmentation and location-based information for different actors in a communications team. The "game logic" is embedded and linked to locations at the training site (e.g. a Hotel). The concept is discussed in greater detail in Part 3.

Managing Mobile Learning

Mobile Learning Management Systems

LMSs and VLEs are widely established in many organizations as part of the infrastructure for managing and supporting career and talent development. These ADL systems have become part of the standard educational and training practice in the security and defense sector. Many organizations maintain several ADL systems for different purposes or for different organizational branches. Data exchange formats such as SCORM allow distributing learning material and monitoring the learning processes across environments and systems. Many organizations have invested substantially into setting up and maintaining this infrastructure. Mobile learning solutions need to integrate into the existing ICT infrastructure. However, the new approaches to accessing and working with information through mobile devices challenge the functions and the design of most of the existing ADL systems as well as the underpinning concepts of SCORM.

Glahn (2013, in press) differentiates two types of ADL systems for supporting mobile learning: “mobile LMSs” and “mobile learning orchestration systems”.

LMSs are designed to support administrative tasks of educational processes. These tasks include but are not limited to the distribution of learning material and course information, online assessment, student and grade management, the collection of student assignments, and the access of educational tools (e.g. discussion forums). While LMSs traditionally emphasized the interaction context as constant from the system perspective, mobile LMS need to be more flexible and have to consider additional contextual factors. Mobile LMSs have to consider the variety of screen sizes, which make it nearly impossible to maintain a single layout for all “interaction contexts”. Moreover, mobile LMS need to be more flexible regarding the connection state of the learners’ devices. While in traditional desktop computing the network connection was mostly stable and connection disruptions were considered as negligible, mobile users are typically “randomly” online. This means that disrupted Internet connections need to be considered as the norm.

Learning orchestration systems extend the functions of LMSs by providing the means for supporting educational processes and learning models. A learning orchestration system connects learning objectives, learning activities, and learning outcomes throughout the educational processes phases. These processes do not only include learning activities, but also support activities that describe common educational interventions. Mobile learning orchestration systems range from location-based and anchored instruction systems (Chu et al., 2010, Terminer, De Vries, Börner, & Specht, 2012) via systems for simulated augmented experiences (Ternier, de Vries, Specht, & Gonsalves, 2012) to multi device environments (Glahn & Specht, 2010).

Mobile learning integration with ADL Systems

The primary role for ADL systems is course management, distributing learning resources, supporting student communication, and assessing the learning outcomes. For many organizations these systems are central hubs for course related information and student management. Furthermore, these systems facilitate course related communication between the students. An increasing number of ADL platforms provide optional user interfaces for mobile devices. However, these interfaces are tightly coupled to the user interaction of the desktop counterparts and often they do not offer the same functionality as the desktop variant.

Mobile learning management goes beyond the functions of current ADL systems. It needs to focus on the specific needs of creating and orchestrating educational programs in the mobile realm, while it must be still possible to use these systems from desktop computing platforms. Mobile learning management needs to support the learners' mobility, provide means of monitoring and intervening with the learners' activities in different locations, as well as supporting the specific ways of interacting with mobile devices. These new demands for learning management also extend the requirements for interoperable learning resources.

Four immediate challenges are present for mobile LMSs.

- Access from mobile devices
- Locating learners
- Contextualizing activities, assignments, and collaboration
- Orchestrating presentation and interaction in device ecologies

Providing access to ADL systems from mobile devices remains a key challenge. Most activities in this context are related to providing special interfaces for mobile devices and to adapting learning resources for the display on mobile devices. These activities are not considering the differences in the use of mobile and desktop systems beyond interacting with user interfaces. This includes also the mode of interaction. Almost all ADL systems are based on a pull metaphor. This means that the learners actively connect to a system and download ("pull") information from it. While most systems provide a way to send e-mail messages to the learners, this is mainly used for facilitating communication between participants but seldom it is used for stimulating the learners' attention on the relevant parts of the learning process. In contrast, many mobile applications build on top of a mixed push and pull model. In this model the users can actively engage with a system, but are automatically notified ("push") when their attention on a task is required. This mixed model extends the "anytime and anywhere" metaphor of access to learning to "whenever appropriate".

In order to support location-based training by providing anchored learning activities, ADL systems need to be able to locate learners as well as to track their activity in space. This information is needed for triggering anchored activities. Until now ADL systems use "location" information only for indicating the home or origin of a student as part of their profile. If this information is automatically updated by a client application it is possible to trigger anchored activities, however, current ADL systems do not have the means for relating location information to learning resources or activities.

Contextualizing activities, assignments and collaboration is closely related to process orchestration. Process orchestration refers to dynamically managing processes based on the process history and on external factors. This requires that ADL systems need to identify the state and the environmental conditions of learning processes and need to be able to adapt to them. This is typically achieved by orchestration rules.

In order to support multi-device integration in blended learning settings, it is necessary that ADL systems are capable to orchestrate the presentation and the interaction of learning resources in device ecologies. Contemporary ADL systems are designed for single device interactions. This design lacks of the notion that several devices can respond to the actions of a learner. Glahn & Specht (2010) describe a framework for extending VLEs for supporting interactive multi-device spaces. ADL systems for mobile learning will need to identify those devices and tools that are available to learners in a given context in order to distribute content and information across these devices when it is appropriate. This requires ADL systems to be aware of device capabilities and have access to the means of activating and orchestrating information streams to as well as between them.

Mobile learning and SCORM

Interoperable learning materials are important for many organizations in order to assure the sustainability of training and learning material across different systems. SCORM has been initiated in order to provide a guideline for interoperable learning material on different ADL Systems. SCORM provides a reference for integrating the different e-learning standards and specifications. The provided reference model has become a de facto standard in the e-learning industry. SCORM has three parts. Firstly, the specification covers content packaging or “content aggregation”. Secondly, SCORM addresses learner monitoring or the “run time environment”. Finally, the SCORM specifies the sequencing of resources and how learners may navigate through learning material.

SCORM content aggregation model defines how learning resources have to be packaged for archiving and distribution. This part of SCORM covers the structuring of course specific meta-data as well as basic sequencing of learning material and is based on the ISO/IEC 12785-1 Content Packaging standard (formerly known as IMS Content Packaging). This format is similar to the e-book standard EPUB3. The main difference is that SCORM does not define a basic content format. Instead several content formats are possible. These formats can include structured text in HTML, images in JPEG or SVG, binary formats for videos (e.g. MPEG) or documents (e.g. PDF), but also IMS QTI for assessments and testing as well as learner profile specifications and competence definitions that are used for e-portfolios. The content aggregation model can further include basic sequencing of information.

In principle this format is suitable for distributing content to mobile devices, although this requires that a special application that can open and interpret SCORM packages and that all content in a SCORM package is suitable for mobile devices. This form of distributing SCORM packages has the limitation that learner tracking is limited because the learner monitoring is bound to a run-time environment.

SCORM compliant run-time environments provide access to learning resources and monitor the learner’s activities. The learner monitoring is strictly bound to interactions with learning resources (interactive sharable content objects; SCOs) that are delivered over the Web by the run-time environment. The learner monitoring can be used for sequencing learning material within a learning unit or for individual assessment. The SCORM specification does neither consider collaboration between learners nor the mobility of learners.

The sequencing and navigation model of SCORM defines the rules for arranging the learning material in the run-time environment. The sequencing logic of SCORM is based on the IMS Simple Sequencing specification. IMS Simple Sequencing (Norton & Paran, 2003) is designed for adaptive navigation through resource structures and for basic interaction tracking. The main limitation of IMS Simple Sequencing is that it is directly tailored towards the content within SCORM package. This disallows to take learner generated content or the location of learners into account for orchestrating learning processes in SCORM. Likewise, IMS Simple Sequencing is explicitly designed for individual work with learning material, which renders unusable for collaborative learning scenarios (Norton & Panar, 2012). Furthermore, the semantic complexity of IMS Simple Sequencing makes it very hard to express and to align rules for orchestrating relatively simple contextualization patterns, not unlike the closely related IMS Learning Design specification (Gruber, Glahn, Specht, & Koper, 2010).

The current layout of SCORM is limited to the distribution of interactive resources. If these resources are designed for supporting mobile delivery platforms, these resources can be used for facilitating learning activities for users with mobile devices. Other types of mobile learning are out of the scope of SCORM. These types include location-based learning, contextualization, and multi-device interactions.

Recently, the TinCan API (ADL Initiative, 2012) has received major attention by the ADL and e-learning industry. This specification promises to overcome the current limitations of SCORM for handling novel educational scenarios. The draft specification is already discussed to be part of the next generation of SCORM.

The TinCan API defines an exchange format for exchanging "statements of experience (typically learning experiences, but they could be anything) to be delivered to and stored securely in a Learning Record Store." (ADL Initiative, 2012) A learning record store (LRS) is typically provided by a LMS and consists of a database that collects traces of learning activities (see Glahn, 2009). Different to existing specifications and standards such as IMS Learner Information Profile (IMS LIP; Smythe, Tansey, & Robson, 2001) the TinCan API specifies not only data structures but also defines the interfaces for accessing this information in different systems. However, TinCan is not compatible with the IMS LIP information model.

Despite claims that TinCan will solve the given limitations for orchestrating complex learning scenarios it is unlikely that the specification itself can meet these claims. This is mainly due to the API's lack of interfaces for aggregating activity traces or structures for controlling the flow of learning processes. Therefore, services that are capable for contextualizing information flows (e.g. location-based services/apps) may report to a central LRS that learners have participated in learning settings but the current version of the API specification does not explain how TinCan can or will interact with existing SCORM compliant components, such as IMS Simple Sequencing.

The TinCan API does not mention the handling of mobile learning activities, explicitly. Instead the specification mentions that arbitrary data sets can be used for describing learning scenarios. Therefore, it can be assumed that the next generation of SCORM will be able to track mobile learning experiences, but at this point it is not planned to provide the means for controlling or guiding mobile learners at a large scale.

Developing Mobile Learning Solutions

Mobile learning is tightly coupled to the supporting technologies. Currently, there are no frameworks or platforms available that allow the development of innovative and interoperable mobile education and training approaches by practitioners who have no detailed technical knowledge and software development skills.

This section focuses on the development of mobile learning solutions. First it compares the three main development approaches for mobile learning, then it analyses two fundamental concepts that need to be considered for designing solutions for mobile learning: the randomly-online principle and learning analytics. Finally it discusses the costs for developing mobile applications.

One of the main challenges of mobile learning is the integration of mobile technologies into existing educational technology infrastructures for monitoring and assessment the achievements of learning goals. This integration is not fully supported by existing LMS and VLEs at this point. Furthermore, many approaches to mobile learning are not yet covered by the concepts that are implemented into the existing LMS and VLEs. These limitations require the development of solutions that leverage the potential of mobile learning.

Developing for mobile devices

Mobile application development has been closely related to specific mobile platforms. With the introduction of Smartphones, mobile phone vendors started streamlining their platforms for application delivery. This has led to mobile phone operating systems (short mobile OS). At the time of writing this report 9 different mobile OS are present at the market (see Table 3). In autumn 2012 RIM/BlackBerry and Microsoft released of their new mobile operating systems, which will be mostly incompatible to their previous versions.

Each mobile OS is coupled to development and deployment structures (e.g., App stores). Moreover, each mobile OS uses a different primary programming language and vendor specific framework libraries.

Additionally, a plethora of “feature phone” operating systems are currently deployed. The programming language Java ME (a variation of the Java programming language) is typically available on these mobile phones. However, vendors can adapt the available functions for this language, which makes it difficult to predict which features are accessible on the different platforms. Furthermore, the Java ME runs as “virtual sandbox” on the device, which is resource intensive and significantly reduces the battery duration.

Almost all recent mobile phones are equipped with a web-browser that is capable to display interactive and dynamic Web pages. The web-browsers in recent smartphones are capable to handle most Web sites that utilize standard interactive web-technologies (HTML, CSS, and JavaScript). Proprietary technologies that are commonly found on the Web are not or not fully supported on mobile devices. These technologies include particularly third party browser extensions such as Flash, Shockwave, Java, or Silverlight. A review of the web-browsers of current mobile operating systems indicates that the majority of browsers are based on the HTML5 capable web-kit engine (see Table 3). This allows optimizing web-interfaces for interactions on mobile devices, including gesture based interactions and geo-location.

Although recent mobile phone web-browsers are capable to implement user experiences that are hardly distinguishable from native applications, web-based solutions face a number of limitations. The most critical limitations are listed below.

- Limited offline capabilities
- No push notifications
- Limited access to device features
- No capability of running in the background
- Limited access to device data storage

Although the HTML5 specifications standardize the offline data storage for web-based applications, these functions are limited by the implementation of these specifications by mobile web-browsers. Typically, the offline capabilities for the mobile web are suitable for temporary offline phases, e.g., if the mobile loses the networks connection. The limitation of the offline capabilities of web-applications is grounded on the shared data storage for all web pages and web-applications on a device. If this space is used-up the web-browsers apply heuristics to free storage space. These heuristics are not or very poorly documented. Therefore, the data for offline usage can be partially or fully removed from the device without notice.

Table 2: Sensors and indicators of contemporary smartphones

Sensors	Indicators
Microphone	External speaker
Touchscreen/keyboard	Earpiece speaker/Headset
Hi-resolution camera	High resolution color display
Wireless LAN receiver	Wireless LAN sender
Multiband receiver (GSM/UMTS/HSDPA/LTE)	Multiband sender (GSM/UMTS/HSDPA/LTE)
Bluetooth receiver	Bluetooth sender
Near Field Communication (NFC) reader	Near Field Communication (NFC) sender
Accelerometer	Vibration alert
Geo location sensors (GPS/GLONASS)	Flash light
Compass	
3-Axis Gyroscope	
Proximity sensor	

Push notifications are an approach to draw the users attention to relevant information even if the device is currently not used. Push notifications are in many ways similar to SMS messages that are sent from remote services (e.g., when a new mail message has arrived), but can also be triggered directly by the device (e.g., when a location is reached). Push notifications are an essential component for efficient asynchronous data handling if user interaction is not given. The technology relies on external protocols that are bound to a user’s device and is not available for web-applications.

Today’s mobile devices provide a wide range of sensors and system features (see Table 2). Typically all sensors are accessible for native applications. Web-applications do not have access to all sensors that are provided by mobile devices. Specifically, the camera and microphone interfaces are not available for web-applications across devices from different vendors. Additionally, web-applications cannot trigger actuators other than the screen or the speaker. This limits the creation of haptic interfaces that utilize the vibration alert.

Web-applications on mobile devices can run only while a user is interacting with the web-browser in the foreground. Passive applications, such as geo tracking, can therefore not be implemented as web-applications because they immediately stop if a user switches away from the web-browser or if a user accesses a different web page.

Finally, the access to the devices’ data storage on mobile devices is more restricted than in desktop environments and the accessible parts greatly vary between mobile operating systems. Particularly, data that is created by other apps is not reachable for web-applications, while native applications can typically exchange data.

In order to combine the benefits of native apps and those of mobile web-applications a few solutions for so called “hybrid mobile applications” or “hybrid apps” have become available. A hybrid mobile app uses web-technologies for the business logic of a mobile application but builds on a native layer rather than a web-browser in order to access device features that would not be accessible for pure web-applications. The most prominent framework for hybrid apps is the open source solutions Apache Cordova (previously PhoneGap). With Apache Cordova it is possible to develop native mobile applications for different platforms using web-technologies.

Hybrid apps are of particular interest for mobile learning because they provide greater flexibility regarding the devices that are used while still providing the access to most features of mobile technologies, including extended offline capabilities, push notifications, and full access to the device sensors and actuators. Furthermore, hybrid apps reduce the development costs for complex mobile applications in cases where different platforms have to be supported.

Table 3: commercially available smartphone operating systems by summer 2012; ordered by market share of the vendors

Vendor	Operating System	Programming Language	Web-browser
Google	Android	JAVA/C++	Web-kit based
Apple	iOS	Objective C	Web-kit based
Nokia	Symbian	C/C++	Web-kit based
RIM	Blackberry OS 6	C++	Web-kit based
RIM	Blackberry OS 7	C++/J2ME	Web-kit based
Microsoft	Windows Mobile 6	C++	Internet Explorer Mobile
Microsoft	Windows Phone 7	C#	Internet Explorer 9
Microsoft	Windows 8 Mobile	C#	Internet Explorer 10
HP	WebOS[1]	Javascript	Web-kit based
Samsung	Bada	C/C++	Web-kit based
Mozilla	Firefox OS[2]	Javascript	Gecko based

Context, Activity, Adaptation, and Learning Analytics

Sensors are an essential part of the mobile technology infrastructure. Every mobile phone comes with a range of different sensors. Minimalistic feature phones already have at least a microphone, a keyboard, a Bluetooth and a GSM receiver. Contemporary smartphones already provide a wide range of

[1] HP stopped shipping webOS on handheld devices in 2012

[2] Firefox OS has been presented at CES 2012 and has been announced for product release mid 2013.

sensors (see Table 2) that can provide data about interactions with the device, with external services or with the environment.

It has been argued that raw sensor data can get used for direct interaction such as entering text or identifying the current context of a system (Dey, 2001, Dey, Abowd, & Salber, 1999). Typically, complex mobile applications cannot rely on raw sensor data but require aggregated data for providing meaningful information to a user (Zimmermann, Specht, & Lorenz, 2005). For example navigation systems do not rely on the raw location and compass data but aggregate the data provided by the GPS receiver and the compass sensor over defined timeframes in order to determine speed and direction of the device, where the latter is often different from the compass provided device orientation.

Zimmermann, Specht, and Lorenz (2005) argue that context aware applications not only depend on aggregated sensor data but also implement analytical strategies as part of their business logic. These analytical strategies are part of *adapting* the user experience, the contextualization of information, or the adaptation of process flows. In the previous navigation system example the analytics are required for estimating the next turn or identifying a wrong turn based on the current location, speed, and direction of the device.

The term “activity analytics” refers to analytical strategies that relate aggregated sensor data to a control model of the application. The control model defines the complete set of analytical strategies of an application. Recently, the term learning analytics has emerged in the literature. “Learning analytics” refer to analytical strategies for estimating the state of learning processes. Therefore, learning analytics are tightly coupled to educational and cognitive models. These specific types of control models provide predictors for the state of learning process and suggest appropriate interventions when necessary.

Davenport, Harris, and Morison (2010) identify “information” and “insight” as the two key applications of activity analytics in the business context. These applications can be applied to past, present, and future phases of processes in order to address information needs. In the context of mobile and ubiquitous computing as well as in the context of learning processes these two applications do not address the process control. Glahn (2009) has argued that learning analytics are useful to support the three levels of reflection, namely reflection in action, reflection on action, and reflection for action. In accordance to the theories of self-regulated and of self-directed learning these types of reflection are essential for regulating learning processes. Where self-regulated and self-directed learning emphasize the role of learning analytics for supporting learner decisions (Glahn, 2009), similar concepts are applied in classroom and cohort orchestration (Bollen, Giemza, & Hoppe, 2008; Verpoorten, 2012).

Aljohani and Davis (2012) categorize three kinds of learning analytics that are relevant for mobile learning. Firstly, learner-to-learner analytics address analytics based on communication between learners. This kind of analytics includes for example the message count of messages that were sent between learners or the number off co-locations of learners in a location. Secondly, learner-to-learning-material analytics focus on the learner interactions with learning resources. This kind of analytics includes for example the number of attempts that were required to pass a test or the number of times a special document has been accessed. Thirdly, learner-to-context analytics refer to interactions of learners with their environment. These analytics include the presence of learners in a predefined environment or that a learner carries an object to a different location.

Furthermore, Aljohani and Davis (2012) differentiate between implicit and explicit actions that can be included into the analytic process. Explicit actions are typically considered in the design of learning material or educational scenarios. For example SCORM variables typically cover explicit interactions with the provided educational material. Analytics based on explicit actions would use the predefined variables to estimate the state of a learning process. Implicit actions are not part of the predesigned educational scenario but are side effects that can provide predictors for the progress and success of learning processes. Implicit actions include rhythms of accessing learning material, the number of times coming to locations, the absence in meetings, or the number of times a location has been visited. While explicit actions can be directly captured within the logic of an instructional design, implicit actions are only accessible through aggregated sensor data.

In order to utilize learning analytics for mobile learning it has been argued that learning analytics need be connected to indicators (De Jong, Specht, & Koper, 2008; Glahn, Specht, & Koper, 2007). Indicators are interfaces, through which information can get accessed. The actuator-indicator framework proposed by Zimmermann, Specht and Lorenz (2005) has been successfully applied in web-based (Glahn, 2009), mobile (De Jong, 2011), and ubiquitous learning scenarios (Glahn & Specht, 2010). The framework consists of an actuator layer, an aggregator layer, a control layer, and an indicator layer. The actuator or sensor layer manages the data collection from sensor networks. The aggregator layer manages the data aggregation of the sensor data. The control layer applies analytical strategies on the aggregated data for guiding the learning process through selecting appropriate educational strategies. The indicator layer provides access to learning material, scaffolding information, or motivators. Within this framework learning analytics are primarily applied on the control layer. However, some educational strategies allow learning facilitators and learners to scrutinize the learning analytics directly (Bull & Kay, 2005). In these scenarios the outcomes of the learning analytics are also exposed on the indicator layer.

Learning analytics are of specific relevance in the realm of mobile learning because not all mobile interactions can be expressed or can get immediately identified as explicit interactions. This is particularly the case for psycho-motoric, context-based, or complex social interactions in mobile context. In these scenarios even explicit learning actions become only identifiable by connecting data from different sensors. Therefore, mobile learning design requires that the analytical strategies and the implications of the generated information on the learning process have to be more carefully considered than it would be needed in conventional desktop-based VLEs.

Multi-device integration for mobile blended learning

While much of the discourse on mobile learning focuses around mobile and portable devices, it is often forgotten that the central aspect of mobile learning is the mobility of the learners. Different technologies can support this mobility, even if a device is not portable. Furthermore, a conversion of ICT systems can be observed. This perspective suggests mobile devices only as one part of a more complex ICT ecosystem. This development towards such ecosystems can be already identified at the level of commercial products as well as at the level of how ICT is used. From an instructional design perspective this conversion extends the concept of blended learning as it allows creating new forms of supporting learners through blending technologies and educational practices.

Blended learning integrates e-learning concepts with face-to-face teaching practice. Mobile blended learning extends this concept with respect to integrating mobile devices. While blended learning concepts are often described as sequences of alternating online and offline phases, mobile blended learning integrates mobile devices as part of the teaching practice in- and outside of the classroom. In such settings mobile devices can provide a personal perspective for the learner that are integrated by a shared (social) screen for the entire class.

Multi-screen approaches have been recently taken up in home entertainment. For example, the AirPlay feature for Apple devices enables streaming of interactive content to different devices (see Figure 14). The present technology is restricted to the devices of a single vendor and is limited to personal rather than social use. Furthermore, current solutions require the users to actively setup the connections between the devices.

Probably one of the oldest approaches to multi-device integration in blended learning are the so-called “clicker systems” (Cladwell, 2007; Lantz, 2010). A clicker system offers mass-interaction in large cohorts. Typically, a presenter poses a question or challenge with several answer options. The audience uses special clicker devices or clicker apps to provide their individual answer to the question. The incoming responses are integrated and displayed on a public screen. Typical applications for clicker apps are quizzes or votes. Traditionally, clicker systems are designed as integrated hard- and software systems that connected in a local installation. With the success of mobile devices, a number of “clicker apps” emerged that allow to connect to a clicker system directly from a mobile device.

Figure 14: Multi-device integration for home entertainment (photo: Apple Inc.)

The next step of multi device integration is a seamless integration of multiple devices, interfaces, and objects into an integrated experience for several users. The devices detect the presence of the users and identify the available interfaces in order to arrange and distribute information for the most suitable interaction mode. Glahn & Specht (2010) describe a ubiquitous interface environment for arranging and rearranging information for mobile learners who are present in locations where multi modal interaction is possible through different interfaces. This allows creating dynamic collaborative environments for course members and teams. Such environments are the foundation for blending the face-to-face trainings with mobile learning approaches. In these scenarios the learning environment supports classroom training by distributing information across the several interfaces.

Part 3: Approaches to Mobile Learning

The development and uptake of mobile technologies challenges the existing approaches to ADL and to knowledge management in the security sector. Yet, research and practice of mobile learning for supporting security and defense learning is in its infancy, scattered, and weakly connected. In order to address this limitation the “Mobile Learning in Security and Defense Organisations” (Glahn, 2012) has been organized in conjunction to the 11th World Conference on Mobile and Contextual Learning (mLearn 2012). The objective of this workshop was to connect the existing activities on mobile learning in the security and defense sector. The workshop hosted four research presentations covering ongoing research in the field. In addition to the workshop contributions this part includes the TinCan project of the ADL Co-Labs. These projects are guiding approaches for implementing mobile learning in security and defense organizations.

The contributions to the workshop range from ethical factors of innovating ADL through mobile learning technologies to new forms of simulating crisis situations. All contributions were addressing need for integrating mobile technologies into learning and organizational processes of performance support. Consequently, the provisioning of a technical framework is central to each solution. The presented solutions focus on access to content, access to learning, and scenario-based orchestration of training. The workshop results indicated that device and content interoperability are core requirements for mobile technology. This creates technical challenges not only for developing learning material but also for maintaining the continuity of learning and engaging learners. However, the contributions agree that the technical challenges are not specific for mobile learning in security and defense organizations.

Challenges and approaches

The initial results from the Swiss study that was presented in Part 1 indicate that there is a bottom-up demand for implementing mobile learning in security and defense organizations. However, it remains a challenge to satisfy this demand and meet organizational requirements and training objectives at the same time. The contributions to this workshop analyzed four aspects of mobile learning in security and defense organizations.

1. The technological challenge of providing mobile user interfaces to existing infrastructures.

2. The organizational challenge of meeting the legal and regulative constraints under which security and defense organizations operate.
3. The educational challenge of orchestrating novel scenarios of technology enhanced learning.
4. The content challenge of enabling trainers and educators to create educational learning material for the new medium.

The first challenge emphasizes that educational technologies are not new to the security and defense sector and that mobile devices are likely to be used together with traditional web-based systems. The contributions suggested two approaches to this challenge. The first approach is to provide alternative interfaces for mobile devices. Alternate interface enable learners and teachers to access all functions of ADL systems from mobile devices. These interfaces are designed for meeting the specific constraint of the small screen estate of mobile devices. While the screen resolutions of contemporary smartphones would be sufficient to display most types of web-content, it is the constraints of the human body that require special attention for enabling learners and trainers to interact with this content. The second approach is to provide complementary learning opportunities based on the available learning material through mobile devices. This approach considers mobile devices not as an alternative way for accessing the same functions as with desktop computers. Instead, mobile devices offer new affordances that can be utilized for alternative learning experiences. For example, it is possible to improve the continuity of learning through casual exercises that are mediated through mobile devices.

The second challenge addresses the legal frameworks and operational regulations of security and defense organizations. For this purpose it is necessary to understand the legal frameworks and the security needs to which mobile learning solutions relate. This is of particular relevance for innovating ADL solutions across organizations. In order to meet the legal and operational requirements of different organizations common denominators for the use of mobile technologies in related organizations. A first analysis on the research ethics for testing mobile learning solutions in defense organizations indicates a great variation of regulations between organizations and nations that influence how research ethics can and have to be applied for studying mobile learning.

The third challenge refers to the practical implications of applying mobile learning into the educational practice. The affordances of mobile technologies create new ways of supporting learning processes such as more authentic and situated learning. The contributions discussed trainer monitoring and intervention as well as rewarding mechanisms for approaching this challenge. This creates new opportunities for mobile scenario-based simulations for team training. Depending on the learners' performance the trainer can decide to change parameters of the simulation script in order to escalate or ease the challenge for the learners. Mobile dashboards for the learners combine performance-based and effort-based metrics for self-assessment and formative evaluation. This enables the learners to monitor their learning progress. Furthermore, these metrics are synchronized with the ADL system so trainers can analyze learner statistics and provide support where needed.

Finally, the fourth challenge addresses the need for mobile learning content. Content authors need empowerment for supporting new delivery modes. The learning material in security and defense organizations is often tailored to the special requirements and training procedures of the organization. The very trainers who use these resources often also create them. Therefore, it is necessary to provide easy to learn and to handle tools for creating appropriate material for mobile learning. The SCORM specification provides a widely accepted and used framework for creating and exchanging learning resources. The contributions suggest reusing the available authoring environments for the creation of learning material, while the learners access full or partial learning units from their mobiles.

Key Results

From the contributions it appears that the core technological concepts are well understood and are ready for mobile learning applications. The workshop indicated three key areas for future mobile learning research in security and defense organizations.

- Organizational regulations.
- Mobile Interfaces for existing infrastructures
- Novel instructional designs

The influence of laws and organizational regulations cannot be underestimated in the security and defense sector. For bringing mobile learning solutions from prototypes to practice it is necessary to understand the context in which mobile learning will be applied. Specifically defense organizations have strict rules for how and where to use mobile devices. These rules go clearly beyond the level of research ethics. Therefore, it is necessary to develop a better knowledge about the influence of organizational, national and even international regulations on implementing mobile learning in this sector.

Integrating mobile learning with existing infrastructures remains one of the main practical challenges on the way of scaling up the use of mobile devices for education and training. This includes not only the user interfaces of these environments, but also touches the communication between the mobile devices and the main ADL system. Concepts such as extended offline periods or push messages are typically not well supported by existing ADL infrastructure. Furthermore, it is necessary to revisit the data-traffic footprint of ADL systems for communicating with their mobile clients.

Finally, it became evident that mobile learning also requires revisiting the concepts of instructional designs for ADL. This is not only required for novel concepts such as mobile team simulations, but also for more conventional concepts such as formative tests and content delivery. Although existing learning material remains accessible if appropriate interfaces are available, its attractiveness and usefulness appears to change with the move from desktop computing environments to mobile devices. Therefore, it is necessary to develop a better understanding about the relation between mobile technologies and micro-level instructional design patterns.

Research Ethics in the MoLE m-learning program

Contributors: Jacob Hodges and Geoff Stead

Challenges:

- Complying to varying legal frameworks for using mobile technologies
- Integrating with existing infrastructures and procedures

The Mobile Learning Environment (MoLE) Project was based on a requirement by the Commander, U.S. Naval Forces Europe (CNE)/Commander, Naval Forces Africa (CNA)/Commander, SIXTH Fleet (C6F) to effectively operate in the largest maritime area of operations (AOR) where the most difficult challenge is the ability to train and communicate. The basic concept of the MoLE Project aims to leverage the global cellular network infrastructure, mobile technologies and emerging mobile application/service models to build a mobile learning (m-Learning) capability that integrated into the Deputy Director, Joint Staff (J-7) for Joint and Coalition Warfighting (DD J7 JCW) Joint Knowledge On-Line (JKO) portal to facilitate the sharing of educational content between US and multi-national partners. It would provide the foundation for conducting a proof of concept for evaluating a mobile learning (m-Learning) and mobile collaboration (m-Collaboration).

Initially, MoLE focused on currently available mobile devices in order to assess which mobile platforms and solutions ‘best’ meet the operational needs and requirements since not every participant in this proof of concept has a state-of-the- art mobile device. This approach proved to be a very cost-effective approach since a majority of mobile devices (e.g., GSM, 3G and 4G capabilities) are accessible worldwide. Therefore, the proof of concept, which would involve 22 nations, ensured time and financial resources were focused on identifying and developing an effective operational capability rather than the procurement of specific types of mobile technologies.

One of the areas that was particularly challenging was agreeing a common frame of reference for research ethics, given the wide range of stakeholders, and the mix of educators and medical practitioners. Medics have their own set of stringent guidelines for any trials. The EU has a secondary set. The US Government has it’s own guidelines too. The partners needed to define a subset of these three and seek approval via the appropriate channels, to agree an appropriate protocol.

The MoLE project primarily focused on research and development related regulations for the protection of personal data. The authors reported a wide range of regulations concerning the protection of the individual as well as the protection of the organizational interests. These regulations co-exist partially at national and multinational level and provide an ethical framework for conducting research and development in security and defense organizations. For projects that conduct studies concurrently in different organizations it is therefore important to know and implement these regulations accordingly. The key challenge for evaluating mobile learning solutions in international network of organizations is to identify the common denominator for an ethical framework.

The MoLE project developed a mobile learning solution for providing field practitioners with exercises and self-study material in the area of health-care and disaster relief. The demonstrator solution primarily focused on practice related self-studying. The MoLE demonstrator is based on a hybrid smartphone app that includes the learning and reference material. This material includes multi-media training guides for physical exercises (in the form of video, diagrams, photos and text), health care reference material for diagnosis, reporting guidelines and checklists, as well as self-study material in the form of quizzes that complement the reference material. The approach of the MoLE project integrates with existing procedures and processes by replacing static and non-interactive handbooks with interactive resources for smartphones. The system exchanges data with a backend system only for research purposes in order to exchange usage information.

Supporting crisis simulations with the ARLearn toolkit for mobile serious games

Contributors: Stefaan Ternier, Bernardo Tabuenca, Fred de Vries, Atish Gonsalves, and Marcus Specht

Challenges:

- Meeting security needs of learners and organizations
- Developing and exchanging subject matter resources

The contribution focuses on a pilot case study of using mobile tools for crisis simulations at the Office of the United Nations High Commissioner for Refugees (UNHCR). As UNHCR is frequently active in crisis zones it is regularly confronted with kidnappings and hostage-takings of their co-workers. Therefore, the organization needs to train their employees for being able to handle such situations. As these trainings are also required for staff members in missions, travelling to on-site trainings puts these employees additionally at risk. In order to reduce this exposure, UNHCR seeks for more flexible solutions for training their staff while reducing their exposure to risk.

Conventional ADL approaches are not very suitable for such trainings because they relate to complex situations that involve many organizational, social and communicative decisions. Simulations and games are commonly used for this purpose but PC based simulations lack authenticity that is required for the needed skills. In order to expose the employees to more authentic scenarios an ARLearn “decision making” game was designed in order to engage participants in a real-time simulation of hostage-taking situations.

ARLearn is a framework for using advanced capabilities of mobile devices for learning. Originally, the Centre of Learning Sciences and Technologies of the Open University in The Netherlands develop ARLearn a system for collaborative visual augmented reality for learning. Soon it has been recognized that visual augmented reality limits many education and training scenarios by placing device interactions in between otherwise authentic activities. The framework uses scripts for orchestrating learning processes. Different to many web-based orchestration systems, ARLearn allows contexts (such a location) to trigger “actuators” that relate to learning activities. “Actuators” refer to mechanisms in which a device becomes active even though its user is not interacting with it. A common actuator on smartphones is the app notification. App notifications inform the device owner if a service has important updates that might require attention.

The game presents the participants a real-time simulation of a hostage-taking situation. The game script was created taking into account several roles (Head of Office, Security Official and Staff Welfare). Depending on the role, participants receive different tasks and information. For instance, the head of office receives calls from journalists, while staff welfare receives a call from a distressed hostage’s family member. Therefore different educational scenarios and collaborative scripts have been implemented in ARLearn to simulate complex hostage taking scenarios and their management with different roles.

ARLearn Toolkit

ARLearn, originally a tool for audio augmented reality, has grown into a full-fledged mixed reality application platform taking into account field-trips, serious gaming, augmented virtuality and a notification system (Ternier, 2012). In order to support the creation of simulations, ARLearn builds on two important concepts:

- A game is a blueprint for a simulation and defines the game artifacts, user roles and the logic that combines these artifacts.

- A run defines users grouped in teams. With a run, the actions of these users, their responses and progress are tracked. For a game, an arbitrary amount of runs can be created.

ARLearn implements a simple data model that enables the definition of several message types including multiple choice messages, video messages, audio messages, etc. Messages can be bound to a location and/or a timestamp in the game. Furthermore a flexible dependency mechanism enables the author to define the game logic. For instance, an author can define through this framework that 60 seconds after all players have read the introduction message, a video message will become available.

UNHCR Hostage Taking Pilot

The Office of the United Nations High Commissioner for Refugees (UNHCR) leads and co-ordinates international action to protect refugees and resolve refugee problems worldwide. As this organization is sometimes confronted with kidnappings of their co-workers, employees need training for dealing with such situations. An ARLearn "decision making" game was designed in order to present the participants a real-time simulation of a hostage-taking situation. The game script was created taking into account several roles (Head of Office, Security Official and Staff Welfare). Depending on the role, participants receive different tasks and information. For instance, the head of office receives calls from journalists, while staff welfare receives a call from a distressed hostage's family member. Therefore different scenarios and collaborative scripts have been implemented in ARLearn for simulating complex hostage taking scenarios and their management within different organizational roles.

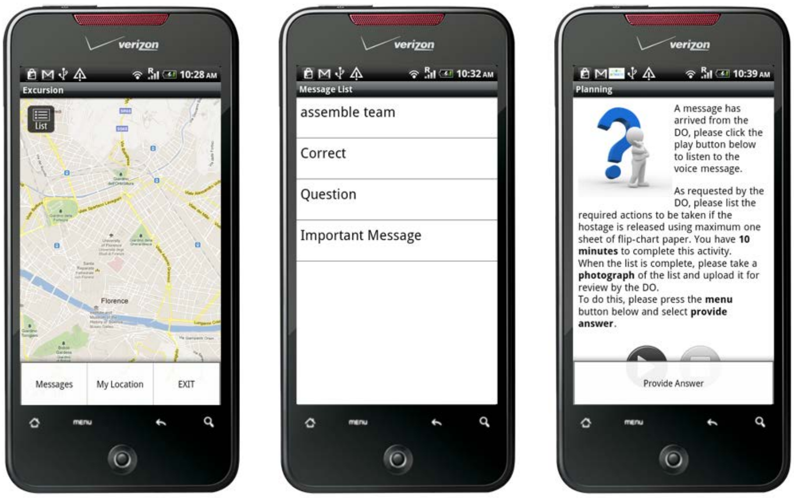

Figure 15: UNHCR Screenshots: map view (a), message view (b), example assignment (c)

UNHCR aimed at giving their trainees an authentic learning experience. An incoming video message with a plea for help from the hostage created a sense of immersion. Through overloading the participants with many messages and tasks, the game designers wanted to create a level of stress that is common to such situations. For this purpose the possibility to trigger notifications automatically, was extended with the possibility for a game operator to trigger them manually. This way, the operator can better estimate when a message (with additional work) should be dispatched.

This game script was implemented in two phases. In November 2011, a dry-run was organized in Budapest with staff members of the organizations. In

December 2011, the actual pilot was organized in Entebbe, Uganda. Here, 3 rounds of the game were ran at the same time featuring 3 roles per run.

Although no summative and quantitative evaluation was organized for this pilot, the game organizer provided the following formative feedback.

- Being able to run the game on Android devices has many advantages. Although this was not the case for the UNHCR pilot, ARLearn games can be ran on personal devices, implementing a “bring your own device” (BYOD) strategy. Leverage a widespread operating system, makes the solution much cheaper compared to AR solutions that need special hardware. In this particular case however, learners had to become familiar with the device (touchscreen, Android OS, etc.). Therefore it was suggested to create a demo run to enable participants to get accustomed to the device.
- The script was implemented with both manual and automatic triggers for items to appear. Although manual triggers offer some degree of flexibility, future pilots should have more automatic triggers and fewer dependencies on a network connection. The unreliable network results sometimes in manual triggers not arriving at a device. Automatic triggers have the advantage that they are cached on the mobile device and they lower the workload for the operator.
- Lowering the dependency on Internet connection will make the game easier to port to other countries, not having to acquire many sim cards or deal with wireless settings.

Using Mobile Technology to enhance eLearning in CAROL I National Defence University

Contributors: Daniel Beligan, Ion Roceanu and Dragos Barbieru

Challenges:

- Developing and exchanging subject matter resources
- Integrating with existing infrastructures and procedures

Currently, there is a wide variety of smartphones that can access and surf on the Web through installed browsers, offering a wide range of applications. This variety can be seen from both perspective, also as a good thing but sometimes as something that causes difficulties in adaptation for users. From here results the necessity of using standards, but in the domain of mobile technology standards are still developing.

One of the great problems of compatibility of the content of educational content in classical and electronic platforms and on mobile devices are the display size and multimedia characteristics. Content for desktop computers is not automatically compatible with mobile devices display screens. Creating different content for mobile and for desktop platforms on the same subject is expensive. On the other hand, the users of eLearning are most out of time and usually in motion. Providing access to educational content independently from the users' location is an objective for future proof eLearning solutions. The technology is evolving very rapidly and there is a very close competition between developers to create apps and to offer many features and applications to end-users. Mobile devices involve unique requirements and challenges. They are usually limited in terms of processing power, battery life and user interfaces.

Dedicated mobile educational content can take many forms depending on the capabilities of the targeted mobile device. Modern mobile devices contain an advanced Web browser with support for several multimedia formats and dynamic interaction. The educational content could have the same complexity and form like in the standard educational content for desktop systems. For mobile devices that do not support a modern browser, the content must be reduced in its complexity.

Research regarding the development of such applications for mobile terminals is still confronted with essential questions such as: is it more preferable to have a web-based application or a standalone app?

To cover the widest possible range of mobile devices and provide a consistent experience with mobile device capabilities, educational content packages must include two forms of educational content, one with a low-level format quality and functionality and one with interactive format with high quality and interactive functionality. Both formats should be wrapped and stored in the same content repository. The formats will be selected depending on the capabilities of the device either by selection or by automatic detection capabilities.

All these aspects were considered in 2008 when the “CAROL I” National Defence University started the development of a scientific research project to identify opportunities for expansion of educational and training system for lifelong learning segment using high technology components for desktop and mobile communications.

The proposed model, named “Mobile learning – net centric based on knowledge access – Access to knowledge and learning database using mobile technologies” aimed at the integration of the latest technologies in the field of computers, wireless communication, educational and knowledge management advanced software. The most important aspect of this enterprise is to find the solution to access knowledge databases on different types of wireless devices (PDA, SmartPhone, iPod, UltraMobile PC, handheld military radio stations etc.) that are connected through different communication networks and use different specifications and communication protocols.

The project resulted in an experimental model for an integrated mobile learning system that allows access for different users, from formal educational systems or from professional system, to knowledge bases and real time learning, according with “anywhere and anytime” principle. The integration aims to cover two major directions of interest: access to education (mobile LMS- mLMS) and access to knowledge resources (mobile Knowledge Management System - mKMS) together with a study conducted about the role of these new technologies in a knowledge society in relation with market opportunities to adopt such solutions.

The purpose of this paper is to share information about the main results of the project: mLMS and mKMS.

The mLMS product runs digital content in various formats, including SCORM, which was really something new in domain. The mLMS eLearning application is a web application (presentation, application and data tiers) that builds mostly on top of open source technologies. It is database independent. The application is divided in two different parts: the content repository server and the LMS. The content repository is a lightweight content management system customized for the eLearning activities. It stores lessons, tests, and documents, and offers different features which exist in a document management system like storing information in a files and folders structure, versioning operations, clipboard like features (copy, cut, and paste) and archiving. The LMS offers features that make easy the interaction between a trainer and a trainee in a remote environment, like: authoring tools (HTML editor, editors for standard compliant SCORM lessons and IMS QTI tests), managing learning activities in both synchronous (virtual classroom module) and asynchronous modes, assignment of work to other users, system notifications and personal messages between users and also a reporting area.

The second product of the project, mKMS is designed for organizations with highly mobile staff, which need permanent connections to a knowledge portal for problem solving.

The general concept of the second product is not new as such. Its novelty is given by access to 3G networks and the possibility of adding events and new procedures in real time. Thus, the knowledge base is accessed as a living organism that grows with each step made by the users.

Both systems were tested with several types of mobile devices, from simple phones with Internet access, to smartphones and tablets. Depending on the operating system of each device, the responses were primarily positive

The mobile LMS and mobile Knowledge Management System solutions open new opportunities for learning environment corresponding to the skills of the future generations and the requirements of a dynamic organizational environment.

Supporting learner mobility in SCORM compliant learning environments with ISN Mobler Cards.

Contributor: Christian Glahn

Challenges:

- Developing and exchanging subject matter resources
- Integrating with existing infrastructures and procedures

This contribution introduces the Mobler Cards app for LMSs (LMS). Mobler Cards is basically a variation of a flash card learning app that uses test questions for repetitive practicing on smartphones. The unique feature of Mobler Cards is that it synchronizes itself with a LMS and provides all functions even while the learners are offline. After learners installed the app on their smartphone, they connect to the LMS. After the authentication Mobler Cards identifies appropriate learning resources for the courses into which a learner is enrolled. For each of the learners' courses the app has two modes: a practicing mode and a statistics mode.

The practicing mode offers the typical flash card learning experience of a question and an answer. In order to monitor the learners' progress they have show that they are able to answer the question correctly. In addition to this question-response activity, the learners receive immediate feedback on their answer and can evaluate their answer in comparison with the correct answer. Each answer can have three levels of achievement: "excellent" if the correct answer has been provided, "partially correct" if the parts of the answer were correct, and "wrong" if the provided response were not matching the correct answer at all.

The statistics mode allows the learners to analyze their performances for the course. Four analytical measures are available for the learners: The number of questions handled during a period of 24h, the average score that has been achieved during the same period, the progress to answer all questions correctly, and the average speed for answering each questions. The difference between the average score and the progress is that the average score includes partially correct answers as well as fully correct answers, while the progress includes only fully correct responses. In addition to these performance-based learning analytics, the app offers two learning badges that are based on the effort learners using the app. The first learning badge indicates that the learner handled all available questions for a course. The second badge is awarded after the learner answered a large number of questions in one sitting. For both learning badges, the performance is irrelevant.

Figure 16: Mobler Cards main screens

Research Challenges and Solutions

The key challenge that has been addressed by the research related to this app is how to make use of SCROM compliant learning material for supporting learning and extending the continuity of learning. The objective was to identify whether the reuse of existing learning material for new learning experiences can get achieved with existing SCORM compliant resources.

Mobler Cards is designed to complement existing web-based ADL courses with exercises for repetitive practicing. Three core requirements were considered for the app. These requirements are key for scaling up mobile learning in security and defense organizations.

Firstly, the app requires full integration with the underlying LMS system. Besides avoiding the hosting and maintenance of additional systems and infrastructure, this also allows the integration of mobile learning into existing education and training programs. Furthermore, the reuse of existing infrastructure allows utilizing existing SCORM compliant learning material whenever possible without additional overhead.

Mobler Cards provides an alternative interface for accessing and using the question pools that are stored in the LMS. By doing so, the app complements web-based training but it does not build on existing interfaces of the LMS. The app reuses the LMS' components for user management and preferences, for course management, and for test objects. In order to minimize the network traffic for the mobile app, the app contains all parts of the user experience and exchanges only the relevant data with the LMS through a set of REST services.

Secondly, the app has to minimize the authoring overhead for the learning material by enabling content authors to use their knowledge about web-based courses and web-based assessment. This lowers a significant barrier for scaling mobile learning in security and defense organizations. This has been achieved reusing the authoring capabilities of the LMS. As Mobler Cards reuses the available functions provided by the LMS it allows the immediate use of existing course resources for learning and inherits the user management. As a side effect this allows to repurpose components of existing SCORM packages for mobile learning.

Being able to use existing learning material for initial courses can significantly reduce the barrier for providing mobile learning offerings on a broad scale. Instead of the necessity for creating entirely new educational resources this approach relies on adapting existing material.

Finally, the app provides full flexibility for mobile learners in order to support the continuity of learning. For the learners' perspective the objective of Mobler Cards is to enable learning in suitable moments as they occur. These "learning opportunities" can vary in their duration and in their contexts. Such as waiting for a bus or commuting in the train. Also it was presumed that the Internet connectivity is not a reliable factor of the learning experience. Furthermore, it should be possible that learners still have access to the learning material during extensive offline phases. Yet, the learning activities must not be disconnected from the LMS with it features for learning support.

Mobler Cards optimizes the time frame that is available for learning by hiding most of administrative tasks from the learners. This includes authentication, data synchronization, and course navigation. Furthermore, Mobler Cards allows the learners accessing supportive features such as learning statistics at any time. This feature requires that all functions have to be implemented in the app instead on being provided by the LMS.

Proof of Concept and Demonstrators

In order to prove the concept of Mobler Cards it has been tested for delivering course material for two courses. The first course "Introduction to NATO" had no question pool available so an entirely new question pool has been created that was specifically tailored for mobile delivery. The second course “Building Defense Organizations” is an existing SCROM compliant course that has been implemented in 2008. This course included a question pool for assessing the achievement of the learning objectives. Both courses were successfully delivered on a range of test devices.

The training and learning architecture and the future of SCORM

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Challenges:

- Integrating with existing infrastructures and procedures
- Developing and exchanging subject matter resources

One of the long-standing problems of legacy ADL systems is that they do not integrate well with other organizational ICT services. This limitation is rooted in the content-centric approach of the current version of the SCORM specification. With the rise of social software and the increasing availability of mobile systems the scope of SCORM on static content-centric courses became increasingly a shortcoming for implementing state-of-the-art ADL solutions that require learner contributions, social interactions, or mobility as part of the educational rationale. Four areas of improvement of SCORM were identified in the course of preparing the specification to cover today’s and future ADL challenges: Integration of flexible experience tracking, improved learner profiles, dynamic content brokering, and comprehensive competence infrastructures.

The integration of experience tracking is one of the core tasks for leveraging mobile learning in SCORM ecosystems and for implementing learning support beyond conventional ADL concepts. The project TinCan is the first approach by the ADL Co-labs for extending the reach of educational solutions beyond web-based and content-centric LMSs. The objectives of the project are to track and access diverse learning experiences across value adding services; to homogenize the data format for describing learning trajectories; and to reduce the dependencies to centralized web-based LMSs.

The requirements for the project were defined through community outreach, feedback from help desks and the UserVoice Web-site, as well as from 1-to-1 interviews. Across these sources a consistent set of issues with the current SCORM framing was identified and has led to the development of the experience tracking specification that is the main result from project TinCan. The issues are closely related to how SCORM is currently specified. SCORM is basically a content packaging format for web-based learning material for individual learning. As such it does not consider hosted (cloud-based) learning material and relies on statistical model for predesigned assessments that offers only scores and pass-or-fail options. Furthermore, the specification does not define the access to the learner data after the learning has finished, which is why many systems do not implement this important feature for HR management. These limitations isolate ADL solutions from other ICT solutions that are part of contemporary HR management.

Talent management in lean security and defense organizations include more transparency about the competences of their members as well as documenting learning experiences that happen outside of legacy LMS. Yet, LMS contribute important functions for managing learning processes, providing access to educational and training material, and assessing the achievement of learning objectives. Figure 17 shows the context of a legacy LMS in today's talent development environments. The arrows to external entities indicate the use cases for the TinCan API.

From the perspective of the TinCan API, all learning activities are part of an activity “stream”. An activity stream is the sequence of (learning) activities that have been performed by a learner. Unlike the sequencing specification used by SCORM it is not required that the activities in an activity stream are part of the same learning sequence. This allows capturing concurrent activities or parallel activities that relate to different learning objectives and tasks. For example, this allows HR systems to request learning performance metrics from a LMS, or the LMS requests position related information that can be translated into learning objectives of associated courses.

Another use case of the TinCan API is the exchange of activity streams between interactive systems, such as LMS, simulators, social media service, and mobile devices. Connecting the activity streams across these systems can create integrated immersive environments, in which actions in one system have implications on available activities in the other systems without the need of tightly integrating these systems.

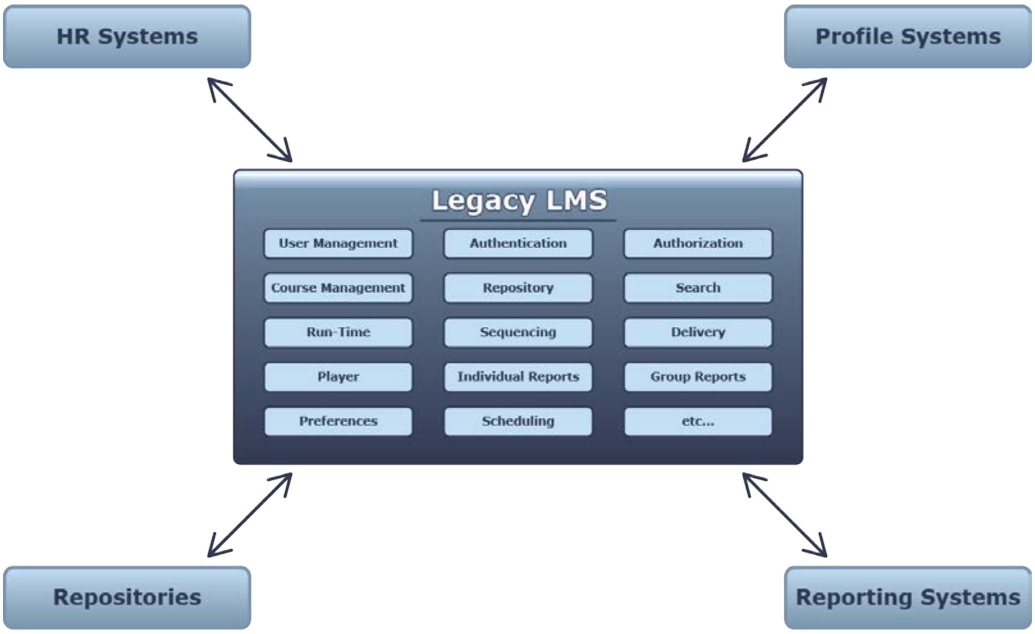

Figure 17: Legacy LMS and TinCan extensions for integrated talent development environments

Part 4: Success factors and Barriers of mobile learning in Security and Defense Organizations

At the PfP ADL working group meeting in November 2012 in Vienna, Austria, a workshop session explored the success factors and barriers for mobile learning in security and defense organizations. About 40 international ADL experts and practitioners from defense academies and training units participated in this session and discussed the different dimensions for bringing mobile learning into practice. The workshop session aimed to answer the following questions related to mobile learning in security and defense organizations.

1. What are the success factors for implementing mobile learning in security and defense organizations on a large scale?
2. What are the main barriers for mobile learning in security and defense?
3. What are appropriate topics that can be implemented through mobile learning using conventional ADL concepts?
4. What are new forms of mobile learning that have to be considered for mobile learning beyond conventional ADL solutions?

The participants included members of the ADL Co-Labs, decision makers from NATO organizations, and ADL coordinators and researchers from European defense colleges that are organized under the umbrella of the PfP Consortium. All participants had sufficient experiences with introducing ADL solutions into their organizations. This assures that this focus group has a good understanding about the conditions of implementing new technologies for innovating education and training within their organizations.

The session was organized as a pre-structured open space session in which the participants discussed the matters of mobile learning for 45 minutes. The open space format is a bottom-up approach for group discussions on different topics. This means that the participants distribute into different groups themselves by choosing the topic of their interest. The participants were free to move between discussions if they like. The open space format requires chairpersons to be responsible of leading and documenting the discussion for one topic. These participants are not allowed to switch their topic.

Given organizational constraints the workshop session implemented a variant of the open space format by pre-structuring the available topics and appointed the chairpersons for the discussion moderation. The entire session was implemented in a single large room in which four discussions tables were setup. This setup allowed the participants to easily move between the topics. In order to document the discussions the chairpersons were asked to create concept- or mind-maps. For this purpose they were provided with flipchart paper and color pens. After the discussions ended each chairperson was asked to briefly present the results of their discussion to the plenary.

Success factors

The discussion identified the five success factors for mobile learning

- Stakeholders acceptance
- Easy and efficient production of consistent content across multiple platforms
- Integration with existing education and training practice
- Continuous competence development
- Definition of organizational education and training goals and their evaluation

Most fundamental to the success of mobile learning is its acceptance by the core stakeholders in security and defense organizations. Three core stakeholder groups were identified. Firstly, content creators who have to adapt to new forms of educational material for mobile devices. Secondly, it includes the end users who will use mobile learning. This group includes trainers and learners. Finally, the organizational management has to support the use of mobile technologies for education and training, explicitly. Any successful implementation of a mobile learning solution has to be easily understood and should be easy to use by all stakeholders.

Related to first stakeholder group is the easy and efficient production of appropriate content because mobile learning changes the ways how information is accessed and used. On the one hand, this requires the rethinking of structuring and organizing content. On the other, the development of mobile learning content needs to integrate with existing processes of content creation. Therefore, efficient tools for content creation are essential for the introduction of mobile learning in security and defense on a large scale. These tools need to help authors to optimize their content for the delivery across multiple platforms and to facilitate new forms of interacting with the content. This integration of working procedures and practices is essential for “creation of consistent content” (also known as C3).

The participants emphasized that consistent content has to be independent from the learners' delivery platform because mobile learning content has to integrate seamlessly into the existing training practices. Ideally, mobile learning will extend blended learning practices. Therefore, educators and trainers need to be aware of the relation of instructional concepts for mobile learning and their practice. This implies more relevance of performance metrics not only for supporting learners but also for measuring the influence of the different educational strategies on the educational outcome in terms of formative evaluation.

According to the participants the continuous development of competences and skills is relevant for the success of mobile learning. In this context the participants mentioned explicitly the repetition and rehearsal of prior learning. This is seen as a key support for professionals in order to reach and to maintain the right levels of expertise that is required for their position in the organization. While this has the potential to minimize the rehearsal phases on courses and trainings, it creates the new need for motivators for engaging the target audience. Therefore, supporting continuity requires a balanced mix of challenges and incentives as well as easy to use interfaces for keeping learners attracted to learning.

Security and defense organizations require measurable goals for implementing mobile learning on a large scale. These goals provide a strategic guideline. Organizations can monitor their progress in supporting mobile learning by measuring the achievement of these goals. While having an evaluation strategy is not directly related to mobile learning, it is critical to monitor and control the uptake of mobile learning in the organization along predefined goals.

Barriers for mobile learning in security and defense

Although the consumer adoption of mobile technologies has taken over the adoption of desktop computers, the organizational take-up is limited. Yet, the available market data indicates an increasing demand for mobile information services rather sooner than later. Security and defense organizations will have to respond to this demand because an increasing number of young recruits will be well connected through mobile devices and expects the ubiquitous availability of mobile data services. Yet, mobile learning faces several barriers in security and defense organizations. The discussion of the participants indicated 6 distinctive areas that create barriers for introducing mobile technologies and mobile learning in these organizations.

- Existing security regulations and security requirements
- Cryptographic requirements
- Mobile data connectivity
- Devices features and interoperability
- Device availability and financial constraints
- Integration into existing educational practices

The participants identified the biggest barrier for mobile learning in the existing *information security policy of security and defense organizations*. Mobile technologies raise a number of challenges for existing policies. These range from the carrier networks that are used for data transmissions of varying classification levels to the access to mobile information technologies within military facilities and their use for education and training. The participants indicated large differences between their organizations at the level of specific regulations, but they generally confirmed that most ICT related security policies were not designed for responding to the increasing availability of mobile handheld and personal devices. While such regulations are typically unrelated to education and training, they have direct impact for implementing mobile learning.

The second barrier has been identified by the *cryptographic requirements for data transmissions and data storage*. As mobile learning requires data exchange between mobile devices and the organizations infrastructure it raises questions regarding protecting organizational information. Given the rapid growth of mobile data communication, many security risks of mobile technologies are either unknown or the understanding of security implications is in its infancy. One prominent example for this situation was the unrestricted access of installed apps to the contacts and calendar information on devices running Android, Blackberry OS, and iOS. This function has been present in these systems at least since 2007 but it only received major attention in 2011 after it became public that many app developers “harvested” addresses and calendar schedules for customer profiling even if the respective app did not use this information. This incident indicated that this form of data exchange between applications on personal devices has not been considered as a security threat, although all affected platforms already provided strong cryptographic features for protecting application data against other forms of unprivileged access. The example illustrates that the cryptographic requirements are not limited to data transmission but extent to storing and processing data on mobile devices.

Additionally, the participants referred to *different and potentially contradicting security protocols at the level of national organizations and international alliances that are addressing mobile data communication*. In order to take full benefit of mobile learning it is necessary to analyze how these protocols can be aligned and standardized in order to enable the development of interoperable education and training services.

Another barrier for mobile learning is related to the *wireless network infrastructure in military facilities*. This infrastructure is mandatory if access to information services has to be independent from private sector partners. This barrier has two aspects: firstly, wireless network infrastructure is not available in all facilities; and secondly, where the infrastructure is available it is not clear if and how it can get used for education and training purposes. This poses a barrier for mobile learning because the related educational scenarios rely on wireless data transmission at some point.

The participants perceive the device features as another barrier. Two aspects play a role with this respect. The first aspect involves the definition of mobile devices. The second aspect refers to the operating systems that are installed on mobile devices.

Less then 10 years ago, mobile computing was mainly referring to laptop computers, while there are at least 3 major concepts for mobile ICT relevant today: smartphones, tablet computers, and laptops. In the literature "netbooks" and "PDAs" are still present and communicated as independent device classes. Each of these device classes is clearly representing aspects mobile ICT that are distinct from the other classes. Near future predictions in wearable computing indicate further diversification in this segment. Therefore, it is difficult to specify the key characteristics of mobile devices for educational purposes. This creates a barrier for mobile learning and ADL because *it is unclear if mobile learning has to be optimized for a specific type of device, or if all classes need to be supported at the same time*.

The second aspect of this barrier is related to the *limited interoperability between mobile operating systems*, which challenges the sustainability of investing in developing educational material for mobile learning. For the development of mobile ICT solutions at least 8 relevant platforms have to be considered, compared to 3 platforms in desktop computing. These platforms are tightly coupled to the devices on which they are preinstalled. Unlike the situation in desktop computing, it is typically impossible to install a different mobile operating system on a mobile device. Even updating a mobile device to a new major release of its operating system can be difficult (in the case of Android) or impossible (in the case Blackberry OS or Windows Mobile). The participants noted that the increasing success of HTML5 technologies holds the potential for overcoming this barrier. However, they also expect that their organizations will face a very diverse distribution of mobile OSes.

Related to the wireless network infrastructure in security and defense organizations is the barrier of *device availability and financial constraints of education and training departments*. In the private sector particularly smaller organizations follow a “bring your own device” (BYOD) strategy to mobile ICT. While this has the benefit of cost savings by relying on the infrastructure that is already in the hands and pockets of the staff, this path is difficult to follow for security and defense organizations due to the lack of controllability of information access. Yet, many organizations are unaware of the availability and distribution of privately owned mobile in their organization. The alternative to BYOD is to provide all members of the organization a mobile device, which will in return cause major financial investments in devices, infrastructure, and solution development. Such investments require an overarching organizational strategy because they are beyond the scope and financial capabilities of educational departments.

Finally the participants identified the *integration of new mobile learning concepts into the existing educational practice* as a major barrier for mobile learning. While mobile learning holds great potential to introduce new concepts to motivate learners, the assessment and certification remains a major challenge. Casual learning and “gamification” were discussed as ways of making learning more attractive, but the participants are not convinced that these new approaches are compliant with the legal requirements for certification and re-certification. This requires a detailed analysis of mobile learning approaches with respect the compliance national and international regulations and policies.

Content for mobile learning

The third workshop topic focused on the suitable content for mobile learning. The scope of the discussion was on the near future solutions for mobile learning. Near future solutions refer to mobile learning content could be available within 12 months. The participants approached this topic from two angles. On the one hand concrete course topics were identified and discussed, on the other hand the participants agreed that mobile learning needs integration into existing ADL practice and discussed the interoperability of content for mobile learning in the context of existing practice.

With respect to specific topics the participants highlighted that mobile learning can *supplement* existing courses. These course topics are mainly introductory courses that cover topics that are of shared interest for ADL in security and defense. These topics include “Cultural Awareness”, “Gender and Security”, “NATO basics”, “Code of Conduct”, and “International Law”. Mobile solutions could offer meaningful extensions for such courses and extent their reach.

The discussion emphasized that mobile learning can *enhance* a second type of content through unique features. The related topics include language learning, civic education and safety education. Language learning can benefit from new developments in the area of mobile picture and sound recognition. This helps learners to document and improve their competences by capturing and revisiting authentic situations. Similarly, mobile learning can support civic and safety education by relating exercises and event-driven activities to the settings in which the learners are active.

The second part of this discussion focused on the integration of mobile learning with existing ADL activities. The participants highlighted the relevance of e-books for providing educational material to mobile learners as well as approaches that lower the threshold for starting learning activities such as “micro learning” (Gassler, Hug & Glahn, 2004). Furthermore, they indicated that traditional ADL courses could distribute performance support tools, such as checklists. Such solutions need to be applicable on different devices while being engaging and simple to use.

The major challenge for mobile learning content is the interoperability with “classical e-learning” that is present in many security and defense organizations already. With this regard new educational and organizational concepts are required for reflecting the co-existence of online and offline learning activities so content authors can easily use these features for their courses.

Mobile learning beyond conventional ADL

The fourth group of participants discussed approaches to mobile learning outside the scope of conventional ADL solutions. The purpose of this part of the discussion was to identify other approaches to mobile learning are relevant for security and defense organizations. The discussion has identified 4 main areas of potential mobile learning solutions in the security and defense sector.

- Non-linear situational simulations
- Mobile social media and information sharing
- Interactive TV and virtual reality systems

- Wearable sensors and bio-feedback systems

Non-linear situational simulations are special kinds of so-called “serious games” for mobile players. While the learners interact with the simulation through their mobile devices, the simulation can be controlled though choices, the player location, or other triggers, such as QR tags. This kind of serious games creates an immersive environment in which the learners follow a non-linear so. Two types of mobile serious games were discussed by the participants: simulation that run on a mobile device but are not connected to the context of the learner and simulations that require that the learners interact with their environment in order to influence the simulation. Specifically, through prepared tags such as QR codes or RFID, organizations can prepare training games that require that the learners move between different stations in order to solve challenges and tasks.

Mobile social media and information sharing solutions responds to the increasing need for creating and exchanging information in and across security and defense teams and units. Using social media for training allows repurposing the tools that is provided by the different social media services. These services can be used for creating learner portfolios as well as for supporting collaboration and discussions. The main challenge in using these services is that none of these services were designed with learning and education in mind. Therefore, trainers have to supervise and to moderate the learning processes that utilize social media and networks.

Interactive TV and virtual reality systems can link mobile devices with other interactive technologies. The discussion mentioned the integration of mobile communications and interactive TV for setting up simulations and video-conferencing. This line of reasoning follows the convergence of mobile and ubiquitous computing technologies. The participants mentioned that technologies like the Microsoft Kinect enable learners to interact with virtual reality environments just through their body gestures. This consumer technology allows the creation of more realistic interactions for training simulators.

Finally, the participants raised the relevance of wearable computing for training. Specifically, body-area networks of wearable sensors allow considering biometric information in real-time in trainings. The participants are certain that this will expand the scope of mobile learning from learning facts towards the training of psycho-motoric skills. The discussion indicated that these developments hold the potential to create even more authentic non-linear simulations and trainings than it is possible with today’s mobile technologies.

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Glossary

Achievement	See *learning badges*
ADL	Advanced Distributed Learning; Synonym: *e-learning*
Ambient information screens	Public or room-based information displays. Ranging from TV screens, via interactive walls, to public billboards.
Anchored information service	Systems that anchor information to locations or contexts. See *location-based service*
Android	*Mobile OS* maintained and promoted by Google Inc. and used by a number of *smartphone* vendors
Apache Cordova	Open source software development framework for *hybrid apps.* Formerly known as Phonegap.
API	Application Programming Interface
App	Software that is designed for handheld devices; short form of "application"
App Store	Integrated system for selling and distributing software for mobile devices. See *AppStore*, *PlayStore*
AppStore	Apple Inc. trademark for selling and distributing software to their products.
AR	Augmented Reality

Badges	See: *learning badges*
Bluetooth	Technology for short-range wireless networks.
Broadband service	Internet connection with data transmission rates (bandwidth) above 56 kbit/s.
BYOD	Bring your own device; organizational strategy for using mobile devices in the workplace.
CEN	European Committee for Standardization.
CISCO	Telecommunication and ICT infrastructure manufacturer and solutions provider.
Crowd-sourcing	Approach to outsource tasks to a large and distributed group of people, typically involves volunteers.
CSS	Cascading Stylesheets; W3C specification
E-learning	Computer supported training and learning services. Recently, it is also referred as “technology enhance learning” or *TEL*.
Embedded system	Devices and objects that integrate software and physical processes. See *smart object*
E-portfolio	Web-service for collecting and documenting learning outcomes.
EPUB / EPUB3	Electronic publication. XML-based distribution format standard for digital publication. EPUB3 refers to the 3rd revision of the EPUB standard.

ETSI	European Telecommunications Standards Institute
Feature phone	A feature phone is mobile phone with advanced features beyond making phone calls and sending text messages, but they run a non-standardized *mobile OS*.
Flash mob	Ad-hoc group meeting in public spaces “organized” or triggered via social networks; typically involving large assemblies of people.
Facebook party	Party organized and advertised via the Facebook platform. See: *flash mob*
G20 Countries	The 19 national states with the most powerful economies in the world plus the European Union. The G20 include Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, the REPUBlic of Korea, Mexico, Russia, Saudi Arabia, South Africa, Turkey, the United Kingdom, the United States of America.
Gamification	Adding of game features to non-gaming tasks for improving motivation and engagement.
Gecko	Open source web-browser rendering engine that is used by the Firefox web-browser
Geocaching	Community-driven outdoor treasure hunts that use GPS systems for finding hidden containers.
Gesture-based system	A system that is operated through gestures of its users. Touch-gestures refer to touch screen interactions; otherwise it refers systems that recognize body movements for interaction.

GLONASS	*Globalnaya Navigatsionnaya Sputnikovaya Sistema* (Global Navigation Satellite System); Russian radio-based satellite positioning system.
GPS	Global Positioning System; US radio-based satellite positioning system.
GSM	Global System for Mobile Communications; ETSI standard
GSMA	GSM Alliance; International association of mobile telecommunication providers.
Handset	A handset refers to the piece of hardware that is designed for handheld operation; Typically this refers to mobile phones.
HR	Human Resources
HTTP	Hypertext Transfer Protocol. W3C standard.
HTML	Hypertext Markup Language. W3C standard
Hybrid app	App that has been developed by combining web-based and native development approaches.
ICT	Information and communications technologies
IDPF	International Digital Publishing Forum, international trade and standardization body for electronic publishing; see EPUB
IEEE	Institute of Electrical and Electronics Engineers. The IEEE is an association dedicated to advancing innovation and technological excellence

IEEE/LTSO PAPI	Personal and Private Information specification for exchanging learner profiles and activity tracking data. Joint specification by the IEEE and the CEN
IMS	IMS Global, international standardization body for educational technologies.
IMS CP	IMS Content Packaging specification; used by SCORM for organizing and exchanging educational material
IMS LD	IMS Learning Design specification
IMS LIP	IMS Learner Information Profile specification; for exchanging learner profiles and activity tracking data. Extended version of IEEE/LTSO PAPI.
IMS QTI	IMS Question and Testing Interoperability specification; content format for tests and assessments.
IMS SS	IMS Simple Sequencing specification; used by SCORM for describing processes.
iOS	*Mobile OS* for Apple Devices
IR	International Relations
ISN	International Relations and Security Network at the Centre for Security Studies of the ETH Zurich
ISO	International Standardization Organization
ITU	International Telecommunications Union, association of national and private

	telecommunication providers
J2ME/ JavaME	Java Micro Edition; Subset of the Java programming language specifically designed for Mobile systems.
Javascript	Programming language; mainly supported by all web-browsers. Part of the W3C HTML5 standard
JPEG	“Joint Photographic Experts Group”. Typically used as short form for digital image formats. ISO standard
Learning Analytics	Analytical procedures for processing the data of *LRS.*
Learning badges	Learning badges are visual representations of learning achievements. Typically granted based on the outcomes of assessments or *learning analytics*.
LMS	Learning Management System; System
Location-based service	*Web-service* that anchors information to locations. Users can use a (or their) location to request data from the service.
LRS	Learning Record Store; database for tracking learning activities
LTSO	Learning Technology Standardisation Observatory of the CEN
Mobile OS	Operating system for mobile devices. Required for using the device. Typically includes User Interfaces, core apps, system libraries, and a web-browser.

MPEG	“Moving Picture Experts Group”; used as a short form for the related video compression format; ISO standard
Native app	Application that is implemented for a specific mobile OS by using its “native” API
Netbook	Small and lightweight portable PC designed for working with *Web-based services*, typically made of low-cost components
NFC	Near Field Communication; referring to short-range ad-hoc data exchange protocol.
ODL	Open and Distance Learning
PC	Personal Computer; computer running a window-based desktop working environment, such as MS Windows, MAC OS, or Linux.
PDA	Personal Digital Assistant; handheld computer without mobile telephone capabilities.
PlayStore	Google Inc. trademark for selling and distributing software to their devices running Android.
PDF	Portable Document Format
QR / QR Code / QR tag	Quick Response Code. 2D matrix barcode. Often used as synonym for all kinds of 2D matrix codes.
RFID	Radio Frequency Identifyer; Passive NFC technology.
SCO	(Interactive) sharable content objects.

SCORM	Sharable Content Object Reference Model. Interoperability specification for e-learning material.
Sensor	Data input device, including non-interactive data input, such as thermometers or fire detectors.
Sensor network	Network of data collecting ICT systems. A sensor network collects and integrates data from multiple sensing devices. A sensor network relies on pre-configured network connections between.
Sensor grid	Self-organizing *sensor network* with data processing capabilities. Each sensing device in a sensor grid can initiate and manage incoming and outgoing network connections as well as process and aggregate data.
Smart object	Device with an *embedded system* that can exchange over and use data from a data network for communicating with other ICT systems. See *sensor network* and *sensor grid*
Smartphone	A smartphone is a mobile phone that includes advanced computing and connectivity functions beyond making phone calls and sending text messages. Smartphones have the capability to display photos, play videos, check and send e-mail, surf the Web, and run third-party applications.
SMS	Short Messaging System; Text messaging system for telephones. Part of the GSM standard.
SVG	Scalable Vector Graphics; digital graphic format for 2D graphics; W3C standard.
Tablet Computer	Large handheld devices that using optimized hardware for mobile and handheld use; running a

	mobile OS. Typically of the size of a sheet of paper or a paper block.
Tablet PC	Personal computer that provides finger- or pen-based interactions via a touch-sensitive screen to the underlying desktop operating system. Typically tablet PCs are based on modified Laptop Hardware.
TEL	Technology enhanced learning. See*: e-learning.*
TinCan	The TinCan project provides two-way exchange of learning activity records (or learning records) between educational systems and services.
UNHCR	The United Nations' Refugee Agency
VBS	Swiss Federal Department of Defence, Civil Protection and Sport ("Verteidigung, Bevölker–ungsschutz und Sport")
VLE	Virtual Learning Environment; See *LMS*
Web-kit	Open source web-browser rendering engine that is used by many mobile and desktop web-browsers, including Google Chrome and Safari
Web service	Software for machine-to-machine communication that relies on *HTTP* for data transmissions.
XML	eXtensible Markup Language; W3C standard