Abstract—Storytelling is a natural and effective approach to human communication. The enrichment of stories using multimedia technologies has been established in knowledge sharing for professional communities since long ago. However, mobile multimedia production and consumption for storytelling raises several issues for mobile data management. We start with a requirements analysis for various application scenarios ranging from business to common life with mobile multimedia storytelling. A mobile multimedia data management model is proposed based on the presented scenarios. A test bed for the measurement of mobile multimedia community information system success is briefly described for the evaluation of our approach.

I. INTRODUCTION

At this year’s Web 2.0 Summit Morgan Stanley Internet analyst Mary Meeker stated that mobile computing is going to continue to ramp up considerably. Mobile consumers will focus mainly on aspects such as car electronics GPS, mobile video, games, wireless home appliances, kindle, MP3 etc. Moreover, data integration becomes a challenge with these mobile consumers [1]. All of these aspects raise challenges for mobile multimedia management.

Digital multimedia management has become a commodity in the Web 2.0 [2]. People use platforms such as like YouTube, Flickr, and Vimeo as low-cost solutions for archiving and sharing huge amounts of user-generated multimedia. Commercial platforms allow downloading or streaming of professional multimedia content such as Hollywood blockbusters, TV series and popular music on demand [3]. The need for multimedia management and the growing availability of broadband access to the Internet is related. Mobile multimedia management is even more challenging, because of multiple capacity and interoperability limitations. Still today, mobile devices introduce limitations in terms of display size, battery life, computing power, storage capacity, etc. Interoperability has ever been a serious problem due to incompatible data formats, applications platforms and devices, and in the mobile world, this problem is even more serious due to an ever growing emergence of highly heterogeneous mobile device types. Especially for mobile multimedia storytelling, where individual multimedia items are recombined from multiple distributed sources and possibly have to be adapted for consumption on mobile devices, a suitable mobile multimedia management approach becomes inevitable.

Storytelling is a natural knowledge creation and sharing process. Storytelling can be seen as an approach to developing learning histories [4] by creating knowledge hyper stories [5]. Consequently, storytelling is an important aspect for knowledge sharing and learning in Communities of Practice (CoP) [6]. Therefore, telling, sharing and consuming stories are common ways for knowledge creation and transfer in CoP. The Web 2.0 enables every Internet user to tell stories easily with a couple of mouse clicks, which significantly lowers the barriers of media or art production, access, and management. Storytelling in any media helps spot trends and foresee impending problems via narratives of actions and reactions [7]. In practice, digital storytelling is an intuitive and effective approach to communicating with people using multimedia. However, mobile forms of storytelling introduce new possibilities, but at the same time raise requirements to multimedia management.

In this paper we propose a framework for mobile multimedia management in order to realize multiple mobile storytelling scenarios in business and common life. We analyze the requirements for mobile data management including tasks and goals. A data model is proposed regarding to a set of multimedia operations for mobile storytelling. The mobile multimedia management tasks are monitored on a mobile multimedia test bed. In the test bed various multimedia community related information is collected, including mobile multimedia creation information, multimedia access information by communities, and multimedia storytelling information.

The rest of this paper is organized as follows. A selection of use case scenarios for mobile storytelling are illustrated for requirements analysis to mobile multimedia management in Section II. The theoretical knowledge on storytelling for multimedia management and a survey of existing storytelling approaches are discussed in Section III. We propose our approach to multimedia management for mobile storytelling in Section IV. In Section V we discuss the evaluation steps on a test bed. Section VI gives conclusions and our future work.

II. MOBILE STORYTELLING SCENARIOS

Mobile storytelling is often motivated in traveling scenarios. People can use mobile storytelling to share traveling expe-
periences or get information en route. However, it is easy to identify a plethora of further mobile scenarios ranging from daily life to crisis management, where storytelling is applied, but often not explicitly recognized.

But who is actually telling the stories? While news media were produced by professional reporters not too long ago, nowadays agencies recognize the multimedia-augmented news bits contributed by mobile amateur reporters. While not too long ago, only media professionals could use traditional broadcasting channels such as TV or Cinema, nowadays everybody can raise wide media attention using low-cost hardware and Web 2.0 technologies.

In the following subsections we discuss four use case scenarios from different application domains, which will later on be analyzed in Section II-B for requirements valid in mobile multimedia storytelling.

A. Use Cases

1) Scenario S1: City Car Parking: Target communities are people living in cities without fixed parking slots. They have a residential parking ticket, allowing to park their cars within a certain radius around their home, but often face problems in finding a free parking slot during rush hours. Here, mobile storytelling enables people to share success and failure of parking stories on their own personal experiences in order to help others to locate free slots easily or record frequently used slots that are hardly ever available. Two modes can be applied: real-time or aftermath storytelling.

This scenario brings certain requirements for mobile storytelling. Various dimensions of mobile context - place, time and parking community - have to be included in the approach. A high diversity of mobile phones used by community members strongly requires adaptiveness. Furthermore, people not only want to share their stories with others, but also be informed about incoming information, which implies a combination of push and pull communication modes.

2) Scenario S2: Special Ops Training: Mobile storytelling is applicable in the domain of special ops training for different occupation groups such as military or fire brigades. During their missions, expert teams are equipped with mobile communication devices and additional sensors pushing rich information about their current status (e.g. position, body functions, camera vision, weapon status, etc.) to a command center and their team members in real-time. In that sense, expert squads tell a multimedia story implicitly during their missions. In aftermath sessions, recorded communication and telemetry data is analyzed to extract information about common situations, particular actions, and outcomes. This information can be used to generate training material such as multimedia stories or interactive games in order to enable apprentices to learn from success and failure of experts. In this scenario storytelling is a never ending task and needs to be adaptive to new situations, e.g. the emergence of new equipment or enemy strategies. Rich context information is indispensable for this form of mobile storytelling. A non-linearity aspect arises due to the fact that different experts are participating in the same missions. The need for reliability and security is obvious. Sending current status information requires not only all mobile context dimensions and real-time behaviour, but also high multimedia quality.

3) Scenario S3: Rallye Game: Target communities are people participating in a mobile rallye game conceptualized to familiarize new employees of a company with their colleagues and important places. Teams receive mobile devices and a certain end goal to fulfill. Objects on the campus are marked, e.g. with RFID tags. With the help of mobile devices, players locate these markers and solve accompanying tasks rewarded with a certain amount of points. Finally, the team with the highest score wins. While participating in a rallye it makes sense for a team to split in order to access more tasks in less time. However, players of a team still need to stay in touch to exchange information and their plans. For this purpose mobile collaborative storytelling presents a suitable approach. Gamers can tell a story of their game. Stories created collaboratively will consolidate all the steps team members have executed. Current mobile devices are equipped with cameras and GPS sensors for the enrichment of stories with mobile multimedia and context information, thereby reducing information uncertainty within a team.

This scenario lets us identify the need for real-time, reliable, and secure mobile multimedia storytelling. Information exchange within the groups requires data to be both pulled and pushed. Place, time and community parameters play a significant role.

4) Scenario S4: Mobile Amateur Reporting: The temptation to report or chronicle a public event as it is happening is enormous. It can provide more accurate insight of the event compared to mainstream media. Some examples include the coverage of Hurricane Katrina or the Virginia Tech shooting. People immediately share what they are witnessing by uploading multimedia on YouTube or Flickr. However, users are not able to produce complete stories on site, i.e. capture, annotate, edit multimedia, create meaningful stories and share them using their mobile phone in a seamless way. However, they can massively contribute information on an event from their own point of view.

On the opposite side, news agencies often have the story but do not have enough media from the scene. They can send requests for photos, videos or other additional information and designate the request to a particular community of subscribed mobile amateur reporters. The community can be determined e.g. by the joint interests of the members, the location or their reputations. After locating a suitable amateur reporter, the reporter collects multimedia material directly on the scene using his mobile device. Thus, amateur reporters can provide near real-time cheap multi-perspective event coverage.

Multimedia quality is significantly important for any kind of reporting. Mobile storytelling must be real-time enabled and enhanced with information on place, time and community. Data transmission must be secure and reliable. As amateur reporters have no special equipment, storytelling must be adaptive to any sort of mobile devices.
B. Requirements Analysis

An analysis of the above scenarios resulted in a list of key requirements to be presented in this section. The first observation was that all scenarios involve a cardinality relationship of n:m between story tellers and listeners, i.e. multiple story tellers contribute to the production of stories that are consumed by multiple story listeners, which are mostly organized in communities. In the next step, we extracted 12 functional and non-functional requirements, mostly shared by all scenarios. These include generic requirements (e.g. security, reliability), mobile context aspects (e.g. place, time, community) and also different modes of communication semantics (pull, push). The diagram in Figure 1 depicts our results.

C. Challenges in Mobile Multimedia Management

With the wide availability of media creation and processing as well as accessibility to Web-based services for media sharing on mobile devices, the necessity for an efficient multimedia data management arises due to the vast amount of multimedia items to be stored and indexed for an efficient retrieval and transmission to consumers. Especially with regard to mobile multimedia storytelling, a management approach must furthermore take into account the limitations of mobile devices as well as the specific processes and operations required for story creation and consumption.

Sources of mobile multimedia are heterogeneous. Storage locations of mobile multimedia are scattered. Multimedia databases, streaming servers, or Web servers can host diverse multimedia contents in various formats and transport them using different protocols, e.g. RTSP, FTP and HTTP. Further problems to be addressed are large amounts of multimedia content, inappropriate versions to be adapted to mobile devices, and the emergence of different levels of mobile multimedia uncertainty issues[8] (cf. Figure 2). An efficient form of mobile multimedia management is furthermore required to support a set of typical operations used during story creation.

- Decomposition: In many cases, only a part of a medium is needed as element in a multimedia story. Several decomposition types are imaginable. Temporal decompositions are usable with media including a temporal extent, e.g. videos or audio files. Spatial decompositions are applicable to media with a spatial extent, e.g. 3D models or images. Spatio-temporal decompositions are applicable to media with both temporal and spatial extents, e.g. videos or 3D animations. Decompositions are either physical, resulting in partial copies of the original or virtual, i.e. defined as metadata in addition to the original. In particular with regard to mobile device limitations, it is necessary to consider multimedia delivery techniques such as downloading or streaming.
- Synthesis: A central operation in story creation is the recombination of individual multimedia items. Synthesis is the main means for defining story structure. In the case of linear stories, synthesis consists of sequencing multimedia items. In the case of non-linear stories, synthesis requires the ability to define story graphs.
- Contextualization: This operation is more related to individual multimedia items. Storytelling approaches should enable multimedia items to connect to each other within a certain context. For example, a multimedia file can be mapped to a problem or to a solution. A story is even more expressive if a problem statement lies under the complete story plot.
- Semantization: Multimedia express certain semantics that should be either extracted automatically or explicitly specified by humans. Semantization tries to bridge the gap between machine processibility and human understandability.
- Analysis: Story analysis can be conducted on story content, structure or on the multimedia in use. Examples for the application of story analysis are the extraction of similarities, popularity of certain multimedia, often recurring patterns reusable for the generation of story templates, etc.
III. RELATED WORK

A. The Narrative Concepts

The grand narrative concept stressed by Boje [9] aims to problematize any linear complex stories by replacing it with an open polysemous series of little stories, inspired by Lyotard’s idea about strong expressiveness of small stories or story pieces [10]. He also conducted intertextual analysis for stories, researching on collaborative authors, actors and readers and dynamic story textual production, distribution and consumption. He featured story context in two fields [9]:

- **Global social contexts** consist of social identities, decision on characters in the story, identification of storytellers and story listeners.
- **Local contexts** mean texts in use for the stories. When extended to multimedia narrativity, local context should also include any multimedia type including texts.

Boje provides a good description for narratives. Mobility is reflected in the dynamic aspects of storytelling. One is that storytellers or story listeners are involved in the stories with changing roles. The other is non-linearity and dynamic development of story plots. However, Boje mainly focused on the textual constitution of stories, the essence of the stories with their narrativity.

B. Storytelling Approaches

In fact, with the same multimedia content a story can be told in totally different ways. First, sequences of the multimedia content can be organized in diverse ways. Second, the same multimedia content can be shared by different stories. However, the currently prevailing platforms or social networking sites lack approaches to flexible authoring and recombination of multimedia content. The existing technologies enable production of a great amount of user-generated content, but with no certain connected purpose. Storytelling is an effective and entertaining approach to pass and embed certain meaning and purposes to multimedia content. It expresses that media semantics only exist in presence of a certain context.

**Linear vs. Non-linear** represents whether a story can represent linear sequences of actions. In a linear story, the author does not have to worry about the choices and actions of the characters, since he controls the result of their actions [11]. Obviously, for the modern application of storytelling linearity is restricted [12]. Non-linearity is introduced in order to tell more complex stories. Different points of view could affect the normal flow of a story. For this kind of stories there are several versions with potentially different endings.

**Interactive Storytelling** is the ability of the consumer to actively determine the further course of history by his decisions. The consumer is also the protagonist of the story. Dynamic narratives are created with which the user can interact in a game-like manner, helping players to be more immersed in a story and enjoy it to a greater extent [13].

**Adaptive Storytelling** is required, when consumers have the opportunity to interact. Some concepts of digital storytelling unfold that with increasing interactivity the narrative component is simultaneously decreasing. Narration is taken away by the recipient. For this reason the Adaptive Digital Storytelling technique [14] is used.

**Collaborative Storytelling** combines classic multimedia production environments for non-linear stories with Web 2.0 collaborative environments for user generated content. The bridge between both worlds is built by integrated user models, profile-based story search and retrieval, Web 2.0 feedback and rating mechanisms [15].

C. A Survey of (Mobile) Multimedia Systems

Mobile multimedia information systems are realized by diverse service developments, which are in line with **Service Oriented Architecture** and **Software as a Service** paradigms. A selection of mobile multimedia storytelling systems is presented in the following.

**YouTell** is a Web 2.0 application for collaborative storytelling and expert-finding [15]. Besides the storytelling board, an additional user model is conceptualized to assign different media operation rights to users with different roles. Web 2.0 features such as tagging and ranking are also employed. Story search algorithms are developed including a profile-based algorithm. In addition, experts with certain knowledge can be identified in communities of practice.

**InStory** ([http://img.di.fct.unl.pt/InStory/](http://img.di.fct.unl.pt/InStory/)) aims to support narratives with a spatial navigator in Portugal for mobile storytelling, information access, and gaming activities. The stories are built on a set of story threads and narratives for the purpose of the exploration of physical spaces. Spatial navigation and exploration takes both the perspective of sharing information among users and historic location context. [16].

**SofiaTraffic** ([http://sofiatraffic.info/](http://sofiatraffic.info/)) is designed for mobile users. The purpose of the system is to make users familiar with the traffic conditions in Sofia, Bulgaria. Mobile users can be alarmed with the traffic jams on streets and intersections. It is also possible to vote which street has few problems to drive on it.

**Twitter** has developed the idea to a storytelling tool recently. They intend to make good use of the 140-character tweets to compose non-linear narratives. YouTube has also been a channel for online users to share stories which are shot by numerous “amateur” film producers besides film trailers and music videos.

IV. MOBILE STORYTELLING MODEL

Storytelling focuses on the research of contextualizing and re-contextualizing multimedia content with Web 2.0 approaches such as content tagging, rating, and giving feedback.

A. Requirements of Mobile Multimedia Management for Storytelling

Based on the scenarios discussed in Section II, we employed i* [17] for requirements modeling as depicted in Fig. 3. The agents also include a set of story and user management services besides storytellers and story listeners. Both story tellers...
and listeners are dependent on user management, storytelling and story management services. Tasks consist of different operations on stories such as to get multimedia resources, to compose and view multimedia stories, etc. The goal of achieving high quality multimedia stories can be adjusted by soft goals such as mobility, reliability and interoperability.

**B. Data Model for Mobile Multimedia Story Production**

A data model design for collaborative mobile multimedia story production is proposed to meet the requirements of mobile multimedia management in the context of mobile storytelling. The strongly simplified ER-Diagram in Figure 4 depicts the model. The main entities are story, story user, and story project. A story project employs the idea of multimedia production management from a classical viewpoint. Stories can be told based on story templates serving to assist storytellers in creating story structure, organize multimedia and adapt stories by varying applied story templates. A story is composed from an arbitrary number of multimedia items. Additional story attributes facilitate versioning and the possibility to rate and review. For reasons of simplicity the depicted model does not include information on story structuring details. For this purpose, we employ a formalized version [18] of the MOD paradigm [19], introducing a recursive story graph structure composed of units with alternative begin, middle and end parts and the specification of story paths. Multimedia items and annotations are managed by using MPEG-7 [20] metadata and are uniquely addressable by an identifier or URI. Besides free text annotations, semantic information is specifiable. Additional attributes available from mobile context information include network infrastructure, device, time, location, etc. Stories are told to state problems and appropriate solutions. Problems are considered as special context attributes.

It should be noted that different degrees and forms of data uncertainty are inherent. Examples are the imprecision of location context information available from GPS sensors or semantic annotation imprecisions introduced by inefficient extraction algorithms or human annotation failure.

**C. Mobile Multimedia Operations for Storytelling**

In this section we refer to the realization of the mobile multimedia operations described in Section II-B. The technical foundation for our realization is LAS [21], a lightweight application server hosting all necessary functionality as a set of modular services.

- Decomposition: realized by an MPEG-7 multimedia content service for the definition and retrieval of multimedia decompositions. Until now, we have demonstrated spatial decompositions on images and temporal decompositions on videos.
- Synthesis: realized by a specific MOD story service for definition and retrieval of non-linear multimedia stories. The service uses MPEG-7 services for the linkage of multimedia items to story units. On top of the MOD service, a set of further services facilitates a complete story production process reflected in Figure 4.
- Analysis: experiments have been started in the form of a dedicated service on structural analysis for the identification of similarities among stories.
- Contextualization: realized by a set of methods in the MOD story service. Problems can be assigned to multimedia items occurring in a certain overall story context.
- Semantization: realized by an MPEG-7 semantic base type service facilitating the definition of semantic entities. These can be assigned to multimedia items using the MPEG-7 multimedia content service. Mobile versions of LAS connector clients (e.g. for J2ME [22] or the iPhone [23]) are enabled to transfer mobile context information available from mobile device sensors, which can then be used for automatic annotations.

**V. MOBILE MULTIMEDIA MANAGEMENT EVALUATION**

For the evaluation of our approach we will briefly sketch the applicability of MobSOS [22], an extension of LAS towards a test-bed for mobile multimedia community information systems. MobSOS is backed by a success model based on [24]
and combines qualitative and quantitative success measures. The model is fed by a monitoring module recording service usage information in conjunction with mobile context information and a user survey module enabling users to provide rich feedback.

With respect to mobile multimedia storytelling, the evaluation consists of a joint approach of analyzing monitoring log data and user survey results for the respective LAS services across all six model dimensions referring to the requirements stated in Section II-B. For example statements on reliability or scalability can be derived from service invocation error rates, service invocation request processing times, etc. available from monitoring logs, while statements on perceived multimedia quality or impact on individuals and communities can be derived from user survey results. The outcome analysis results can contribute to improve our approach.

VI. CONCLUSIONS AND FUTURE WORK

Mobile storytelling is a process of a series of operations on multimedia with regard to context and semantic information by user communities. Mobile storytelling can be widely applied for knowledge sharing among communities at real-time. It raises new challenges for mobile data management tasks. Multimedia creation is highly heterogenous by different user communities for various scenarios. The whole multimedia creation and consumption cycle requires well using context and multimedia semantic information. We summarize the goals and tasks of mobile storytelling systems in an i* model. The related data model is based on the key entities story, story project and story user with regard to community, multimedia semantic and context. How far the requirements on mobile multimedia management for mobile storytelling are fulfilled can be measured in our test bed.

At the storytelling operation level, a set of analysis can be further carried out on stories including story network analysis can be measured in our test bed.

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