Mobile Information Systems and Mobile Learning

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Abstract

The development of new devices for mobile communication has constantly influenced the development of mobile information and communication services.. These numerous technical developments raise the question of new applications and application areas. It is important for the acceptance of new technologies, that new applications create additional values, use the advantages of basic technologies and are adapted to the needs of the user.

This paper investigates example mobile information systems for the Greek peninsula Peloponnesus, the "Pergamon Museum" and the Berlin museum of modern art "Berlinische Galerie". This work has been jointly developed as part of an interdisciplinary project by the departments of Applied Computer Sciences and Museum Science at the FHTW Berlin.

The second part of the article describes the usage and added value of integrating mobile information systems into an educational environment by using podcast and mobile devices for mobile learning.

Keywords: mobile information systems, mobile learning, podcast

1. Introduction

The development of mobile devices in the last 25 years has continually affected the creation of new mobile applications based on emergent technologies. While newly developed device types, with different technical specifications, have surrounded us in our everyday life and private environment, new base technologies have also been established step-by-step. Industrial standards and paradigms tremendously affect inventions and developments in the mobile sector nowadays starting in the field of ergonomic hardware design for the mobile market and ending with common patterns for highly effective software engineering. By combining the advantages of established technologies with these new approaches and furthermore adapting those criteria to the different user needs and application scenarios we are able to extend existing applications with new mobile components and services. Furthermore highly innovative concepts can be realised and integrated in the users environment.

2. Impact of mobile devices on mobile information systems

By looking more closely at the development of common network technologies in the consumer market those effects can be examined regarding the acceptance of miniaturised mobile devices. After starting with the idea of using mobile devices mainly for managing contacts we use those network enabled multimedia gadgets today for much more. The capability of permanent communication, almost independent from the user's current time and location, let people create scenarios not only for transmitting speech but also increasingly more pure data.

Among these constantly improved aspects in the field of network connections some other enhanced key features influenced the acceptance of mobile devices at a very high rate. These include:

- The display's colour spectrum and resolution
- The processor's power consumption and performance
- The memory size
- The type and convenience of the integrated interaction concept.

With regard to these points, there are currently a plethora of devices on the world market such as personal digital assistants, smartphones and UMTS mobile phones, going further to internet tablets or mobile navigation systems and finally video-enabled MP3 players with lifestyle character. Even though most of them show differences concerning their technical aspects engineering departments however are increasingly asked to develop mobile applications that cover all existing device types.

Particularly those services and systems that are created for the usage in a mobile environment by integrating new technologies must offer a significant additional value to the user's life to be generally accepted and resold. At this point meeting the users expectations and demands is as important as constantly offering new features and services with easy-to-use interfaces.

Since using the term of "third generation mobile technology" for addressing the universal mobile telecommunication system (UMTS) both the name and the demand for location-based services have arisen.

Applications and concepts, which follow these demands and concepts begin to take the user's mobility and her device into consideration, in order to evaluate and integrate the permanently changing parameters as well as the aspects of a restricted runtime environment into the application itself. As a result information is distributed in a memory- and bandwidth efficient way, depending on the users location and her environment. Using this technology not only makes it possible to offer basic information in a wide field of topics but it also uses information in a more detailed way which brings the additional value to the user. Instead of always giving access to the entire application the system generates single views with highly specialised content.

With regard to this range of functions a second aspect becomes increasingly important to the development of new mobile applications. For a vast array of different devices with an equally large range of different parameters not only does location dependent information play a significant role but also the reuse and adoption of a constantly growing and updated central database. For that reason it is not the goal for software developers to create several highly customised services for single platforms but to generate and distribute an optimized version of an application with respect to the device of interest.

In the following subsections will present three applications which were jointly developed at the University of Applied Sciences (FHTW) Berlin, Germany, as part of interdisciplinary projects by the departments of Applied Computer Sciences and Museum Sciences. In the project results the mechanisms of both the location-based information presentation and the multiple content transformation are discussed. The projects are integrated into a tourist environment as this is a main area of the research team (q.v. [1]).

2.1. The Dimo Enkyklopedia project – A multimedia tourist information system for the Greek peninsula Peloponnesus

In contrast to common applications in the field of museum guides the Dimo Enkyklopedia project does not contain information and media assets for a spatially restricted exhibition area. This project rather follows the concept of treating a whole geographical region as an open-air museum where the surrounding landscape is more or less the new museum's walls. With many detailed, widely-researched subsections – like small villages, geographical characteristics and nearby museums – the system offers a convenient way for visitors to receive information or look just around. For this purpose all historical, archaeological, geographical and cultural data were collected and listed into a content management system. This enables a better management and final presentation through a database integrating internet platform for different user devices (figure 1) (q.v [2]).

Experts as well as generally interested users can access this information collection not only through their private desktop computer but via a specially customized flexible view on the system, optimised for the device they use. This means, that besides notebook computers also personal digital assistants and mobile phones are supported as well as other mobile devices. Additionally users can also use the system to produce a printable format like PDF.

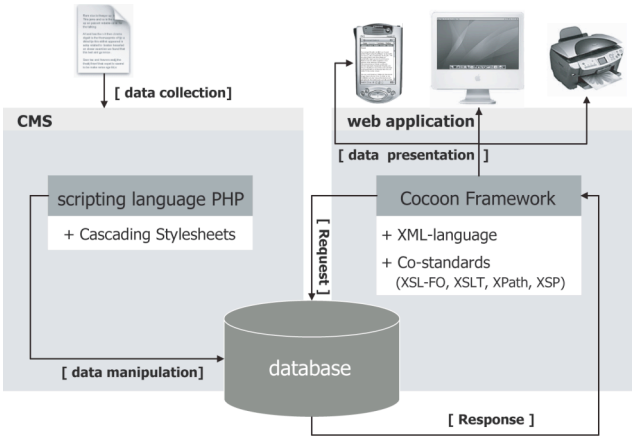

Figure 1. Data handling and presentation in the Dimo Enkyklopedia project.

For presenting the multimedia content assets the application offers access to a multitude of images, videos and 360° panorama scenes. Even the usage of these assets undergoes a special treatment for only distributing media sections in an optimised form and thus keeping the additional value for the user through multiple channels.

The system described is based on the Cocoon Framework (as described in [3]) of the Apache Software Foundation in combination with some major XML language dialects (XSL-FO, XSLT, XPath, XSP). This enables the application to keep the most flexible mechanisms for customising and extending, even in a sophisticated scenario with multiple new mobile device types. XML serves as a data format which is independent of any used media asset and therefore offers a convenient way of storing and processing any kind of data. Particularly the constantly growing database and direct accessibility for users, allow the advantages of an adaptive data transformation and presentation become increasingly important.

The continuing project is focused on integrating location-based services for marketing a complete mobile museum's guide application for personal digital assistants. In this situation the user and her position is constantly being tracked in a well-defined environment. After comparing this with data sets of known objects or places we can obtain a prediction of whether the user is in the close environment of a predefined object or place. In case of a positive match the system will present information and data in a proactive way, addressing exactly the current object. This feature obtains a highly important meaning especially in the field of archaeology. Imagine a system which can automatically display background information about an almost completely destroyed temple combined with some animated 3D-predictions about its previous appearance. In a common way this information would be kept secret for the user unless she investigates the topic

itself in a more detailed manner. With the detailed scenario users can get an additional value as well as experiencing long gone cultures in a very present environment.

2.2. Localisation in the context of a mobile information system for the Berlin Pergamon Museum

The previously discussed idea of location-based information distribution was considered and researched more intensively in a project, dealing with the conception and development of a museum guide for the Berlin Pergamon Museum (q.v. [4]). In contrast to the scenario described above, where the Global Positioning System might be used to track the user's position in a widely-spread area and present location-dependent information about a certain object, this concept cannot be applied to an indoor scenario with short distances due to its variation range.

The amount and size of objects, together with their mass of information, demanded new concepts when developing a mobile information application in this case. For storing and managing data at a central location, a database was established. Access to this base by a mobile device, e.g. a PDA, was given through a wireless local area network. Among several other criteria, such as calling up desired information about a particular object in a manual manner by navigating a media-enriched flash menu structure, the main goal was to automatically present relevant information as soon as the user explicitly moves towards a certain object, e.g. the world-famous Pergamon Altar or the Gate of Millet.

For guaranteeing this range of functions, the system, which follows the concept of location-based services, distributes information depending on the device's relative position to several previously registered points of the exhibition. To be able to clearly localise a user within an indoor-context, the system accesses the wireless local area network and its protocols, which are already used for communication purposes. Tracking the user's position exactly is based on the idea that every exhibition room offers an array of new information worth presenting to the user. As soon as a user and their device change position, which is equal to leaving one access point coverage and entering another, the base of relevant information changes coincidentally. This handover occurs without the loss of network connectivity.

Every client device is stored with its own Media Access Control (MAC) address into the routing tables of every access point to which it is currently connected. Those MAC addresses can be retrieved by analysing the Simple Network Management Protocol (SNMP), which is used to control and monitor networks. By adopting this information to the described use case at the Pergamon Museum, a network consisting of several access points, servers, mobile clients and alike is established, as illustrated in figure 2.

Inside of such a network a change in a client's position can most notably been detected through a lowering or heightening of the signal strength to all the access points in reach of the mobile device. In case of a user changing rooms, a logon to all new reachable access point in the new room occurs in the background.

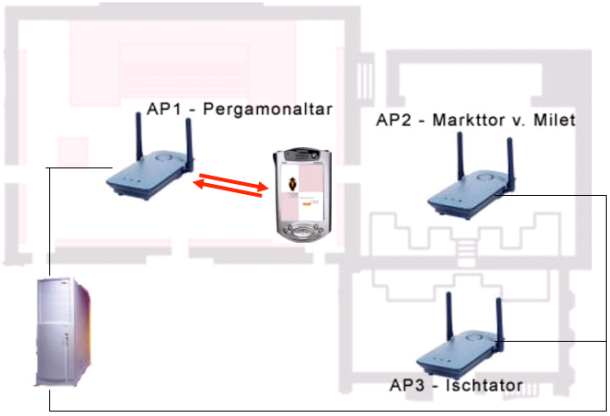

Figure 2: Network composition of the Pergamon Museum project's mobile information system

Every access point itself stores data concerning the currently and formerly logged-on clients. There, in addition to the MAC address of each device, general information of the access point itself and the network it is in are saved. According to that mechanism, every time a client device opens a connection to an access point and logs on to that component, its MAC address is permanently stored on that access point. Even if a client loses its physical connection to the access point the stored data stays accessible.

To explicitly state whether a client is still logged-on to a certain access point or not, one can analyse – in addition to the MAC address – the signal strength and try to execute a so-called link test which checks the physical availability on a single access point.

The data concerning each access point is stored locally, and is therefore lost as soon as an access point is switched off. For retrieving this kind of information and being able to process it in a given scenario a direct access through the SNMP protocol to that network device must be established. In figure 3 the scheme of how this access is realised is displayed. On the server, a permanently running PHP script collects the IP addresses of all available access points from the database. By using these IP addresses a SNMP protocol call is made to every access point in the network to obtain a list of MAC addresses of all currently or formerly logged-on mobile devices. To distinguish currently attached devices from formerly logged-on mobile devices, a second, centrally managed SNMP call is made for every access point and every attached device with a listed MAC address. As a result, a row of link tests takes place and provides exact information concerning the currently logged-on mobile devices. Only by performing this second SNMP communication call, and finally evaluating the results on the server, is a definite localisation in the given network possible.

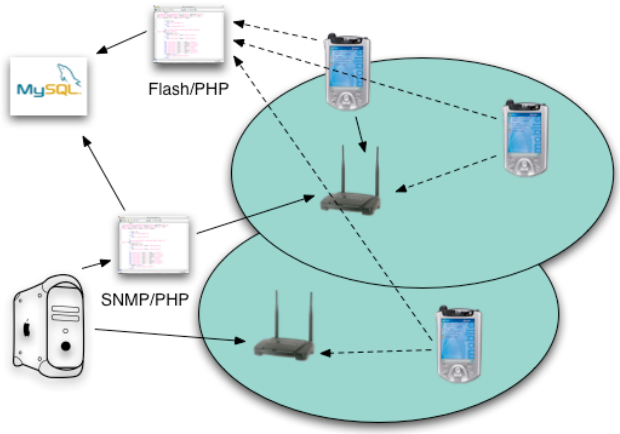

Figure 3: Scheme of retrieving a device's position in the network environment

Based on the information retrieved concerning the user's position in the Pergamon Museum's exhibition rooms, the relevant contents can be transferred to the mobile device and be displayed. The user interface and runtime environment on the mobile device is based on Macromedia Flash and contains text information as well as multimedia animations, images, video streams and interactive gaming components (q.v. figure 4).

Figure 4: Multimedia content displayed in a Flash-built user interface

2.3. Using new ways of distributing content in mobile information systems – The Zissou Project

The complexity and method of presentation of multimedia content on a mobile device in a museum information system scenario is strongly dependent on the basic parameters of the museum's concept itself, as described above. As the Dimo Enkyklopedia project's widely-spread outdoor area mainly effects the range of technologies used to generically transform and offer content, the Pergamon Museum project was based on an exhibition with fixed objects. This results in completely different opportunities of localising a user and their mobile device as well as modelling an application itself. In contrast to this, the appearance, conception and image of the Berlin Museum of Modern Art (Berlinische Galerie, Museum fuer moderne Kunst, Architektur und Fotografie) is completely different. Instead of realising a permanent and fixed object's placement, every exhibit presented undergoes a frequent change in arrangement and composition amongst others. For developing a mobile information system meeting this Museum's demands, the conceptual model needed to take two facts into consideration: firstly, the management of the vast amount of information regarding a constantly growing exhibit base with only an extract to be presented; secondly, the possibility to frequently rearrange objects depending on a certain topic.

By using a network based platform, which guides users according to previously created topic-specific tours, only fractions of any voluminous database needs to be displayed. At the same time, a location-based distribution of data according to one's relative position to a fixed network component, like WLAN access points, can be omitted. Complex tours are offered to the user, which can be chosen manually and cover several exhibition topics. Through this method, a wide range of bonus material can be presented to a consumer, only considering the objects of the currently chosen tour. However, this form of inflexible guidance, may prevent a user from fully appreciating the exhibition scenery. Therefore, users are able to start, stop and continue a selected tour at any point of interest.

As the runtime environment and principal platform for mobile usage, PDAs were addressed since these devices currently offer multiple methods of network connections, as well as the best compromise regarding display quality, media content support and physical appearance. Through addressing these devices, the chance of usage barriers appearing is minimised due to interaction similarities compared to desktop personal computers. In addition, a remarkable surplus value can be experienced by consumers. Complex museum contents can be visualised and explained in place by offering multiple multimedia-enriched contents, which reminds a user of commonly experienced human-guided museum tours.

Going further, this experience is not only restricted to the Museum's visit itself. For preparing a visit, as well as for subsequent research, the system gives access to two key features.

On the one hand, there is a way of subscribing to a list of updated tour contents from a home personal computer. By utilising the RSS (Really Simple Syndication) technology, tour contents are offered as freely available podcasts with the capability to manually control the replay of combined image and audio data. The additional value – besides the mobile usage of museum contents – can be seen in an extremely data-reduced way of distributing a combination of image and audio assets, which can be user-controlled. After synchronising an iPod with a personal computer of choice, the transferred contents can be brought into the Museum environment on a private mobile device, and finally be consumed in a similar way to PDAs. Here, an array of additional aspects positively influences the

experience for users, especially concerning the degree of freedom and flexibility: the novel interaction concept integrated in iPods as well as larger resources in the fields of storage and battery operating time.

On the other hand, a secondly created additional value for users can be experienced while visiting the exhibition. There, a user can generate their own exhibition catalogue on the fly and gradually add objects of interest to it while visiting the museum. At the end, an email is sent to the user's address of choice, containing the generated catalogue attached in a printable format.

For collecting both the user's contact datasets and composing and managing the different exhibits, a custom Content Management System (as illustrated in figure 5) was developed. This application holds the information base, integrates media assets and provides the opportunity to generate new tours or manage existing ones according to arbitrary parameters.

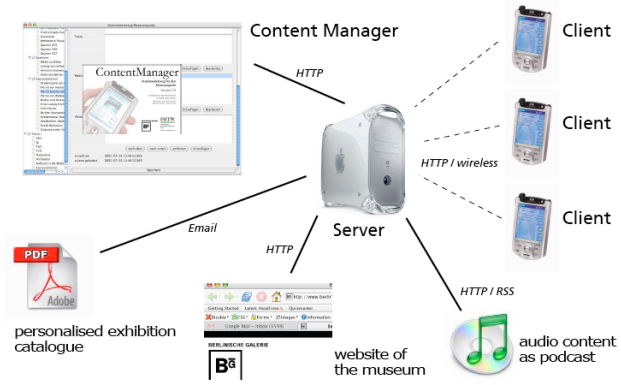

Figure 5: System architecture of the Zissou project for the Berlin Museum of Modern Art (Berlinische Galerie)

3. Mobile Learning – Using mobile information systems in the field of education

The results and conclusions received by the above projects in the field of mobile information systems are analysed on the tourist and cultural field by the FHTW Berlin within the scope of research activities. A technological adoption and conceptual transfer of mobile information systems in the area of educational aspects is constantly pushed. The guideline of creating compact and easily accessible content packages is as important as to address newly developed distribution channels and mobile devices. With regard to these specifications, podcasts were used for the first time during the winter semester in 2005/2006 as a convenient way to present eLearning contents. The goal was to completely cover a lecture in the course of Applied Computer Science with lecture-accompanying material.

2.1. Starting base and previously available contents at the FHTW Berlin

At present, eLearning content at the FHTW Berlin is available in two predominant ways. By using a Learning Management System (LMS) students are able to book lectures through a centrally offered mechanism and are supplied with static teaching material. Additionally, for better understanding, a range of customised web-based tests can be offered, and homework or projects can be published and submitted using this platform. Beyond this LMS, ways of integrating video content into further educational environments are currently examined in a third-party-funded project.

As a second way of accessing lecture material, students have the opportunity to download some content from websites, driven by several lecturers independently from the previously described platform.

2.2. Concept and Development of a new offering

As part of such a personal offering, the initiative to transform the idea of eLearning coverage to mobile devices and mobile information systems was growing just before the winter semester in 2005/2006. Thus the term mLearning (mobile learning) was shaped. It was necessary to provide a convenient way to access audio content from the lecture combined with additional visual information. The technology of choice had to simultaneously keep an eye on the principles of simplicity, comprehensiveness and ease-to-use both on the creator and consumer side.

As a result lectures were recorded by using portable hard disk recorders and afterwards, image data was extracted from the lectures. The retrieved data assets were combined in a mediacontainer format and finally published on the internet using a supporting base technology. Available lectures were marked at the website of the tutor through a flag. There, the user gains access to an RSS-file (q.v. [5]). This file contains both general information about the lecture itself and specific declarations concerning each episode and its provided media asset. It is possible to access this constantly enriched source after a single subscription by using a freely available aggregator software (e.g. Apple iTunes 4.9 or higher). New episodes will be downloaded regularly and automatically, while the user has the capability to configure the intervals of choice. Finally, the data pool will be transmitted from the home system to the portable media player as soon as it is connected and properly set up. With the described FHTW scenario, an Apple iPod photo device is used for this purpose. These devices have a storage capacity of 30 GB and are able to display menu structures for navigation as well as visual content through an integrated colour display of 220 x 176 pixels.

While voice content of the lecture is streamed over the audio output, at the same time the user can have a look at the appropriate slide on the display. In addition, it is possible to navigate the content due to specified jump labels. This enables users to follow the content at their own speed and sequence.

This kind of technology is the so-called "podcast". The name itself comes from combing the terms "broadcasting" and "iPod", where the latter is the most popular hardware player for this. The production process of a podcast described like the one here, is presented in figure 6. At first, the audio of the auditorium is captured (①). The next

step is adding visual information and jump markers to the audio content in an authoring tool (②). Afterwards, the media file is embedded in an RSS-feed (XML file) and both parts are published on the internet (④ and ⑤). Subsequently, consumers have access to the RSS file by using the URL (⑥), they can download the attached media files (⑦) and transfer them to any connected mobile device (⑧).

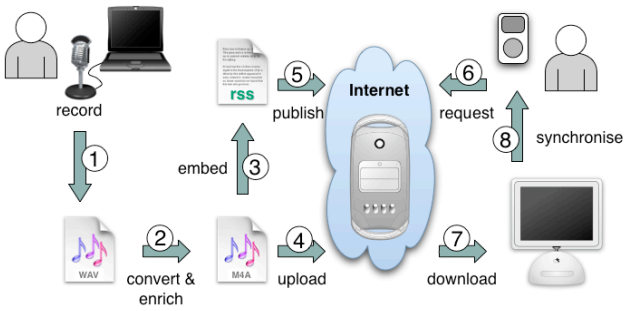

Figure 6: The podcast production process

2.3. Evaluation

Due to optimising the assets for mobile devices with colour displays and navigation input buttons, users might experience a less convenient or less enriched offering when using mobile devices or aggregator applications different from those described above. Platforms with limited specifications may discard integrated visual information or available jump markers and instead only play the main audio stream. For avoiding users being confronted with a inconvenient product for their runtime of choice, or even to give users the opportunity to subscribe to a less-enriched content range, different versions of each media set were offered and published. This ranged from a highly sophisticated version using the MPEG4 audio format combined with both jump markers and integrated images, over a file set with episodes being divided into several MP3 pieces – each representing a single lecture slide, and finally leading to a pure MP3 file representing a single lecture but holding no additions such as jump markers or image material. By giving users the choice to select one of three versions, a large number of students can be addressed, without considering their mobile device of choice or preferred environment for listening.

As the production of a single lecture, covering 90 minutes, takes up to 6 hours including media conversion, authoring and jump marker definition, an evaluation of the offering was required to gain feedback concerning acceptance facts and justification about performing the time-consuming production process.

The main background for initialising an evaluation was the prospect to continue offering mLearning contents both at the FHTW Berlin and Technical University Berlin in the summer semester 2006. There, as part of an evaluation process, statements concerning the following points of interest should be collected:

- The usage context for such a mLearning content;
- The importance of offering jump markers and visual information in addition to the audio content;
- The runtime environment of choice (both software and mobile device);
- The purpose of consuming mLearning contents.

Additionally, the evaluation forms included questions to rate the quality, structure and appearance of the published contents themselves and therefore the podcast and RSS technology used.

2.4. Results

After the evaluation took place on 6th February 2006 and all 45 students of the supported course were questioned, the following main results can be published:

(1) Almost 70% of the students rate a lecture-accompanied by offerings of the lecture's audio content to be important or very important (as seen in figure 7).

Almost 70% of the students used the published podcast contents. This is exactly the same proportion of students from the 45 participants, that evaluated such an offering as highly interesting in statement (1).

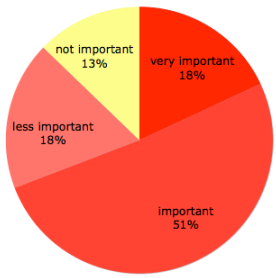

Figure 7: Ratings of the importance of the described offering

(2) For consuming the contents via a mobile device a certain range of device types was used, split in the following manner: mobile phones reach 64% coverage and are the dominantly used device. With 62%, MP3 players and iPods combined almost achieve the same percentage.

(3) Single lectures published as a podcast episode were consumed up to 3 times. There, users listened to audio lectures in general for 6 hours on average (by offering more than 16 hours of material overall). A single lecture was consumed for 1 hour on average without interruption.

(4) 68% of the students used the lecture podcasts in a mobile context, either mobile at home, mobile at the university, or through a laptop or other mobile consumer device on the go.

(5) The main purposes for listening to lecture podcasts were to prepare for examinations (86%) and reworking lectures (54%) (see figure 8).

Users experienced a completely new quality which results in them wanting to re-listen to the contents rather than re-reading them. The additional value is guaranteed through rapid publishing with the RSS technology and the provision to consume the contents in a mobile environment.

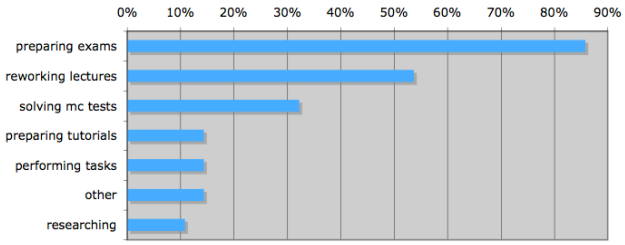

Figure 8: Purposes for using lecture podcasts

(6) The podcasts were rated to be helpful for all questioned purposes (preparing examinations, reworking lectures, solving web tests, preparing tutorials, performing tasks, researching, other).

(7) Among all others, particularly the quality of the audio contents (61%) and general appearance (54%) were rated positive.

(8) At questions regarding the different versions offered, with differences in the included information range (visual content and jump markers), 71% of the questioned people suggested additional visual content was required. 61% also prefer jump markers for navigation (see figure 9).

(9) When asking for any negative effects on the attendance in lectures which offer a simultaneous podcast, 68% of the students – which is clearly the majority – stated this has no influence on their attendance (see figure 9).

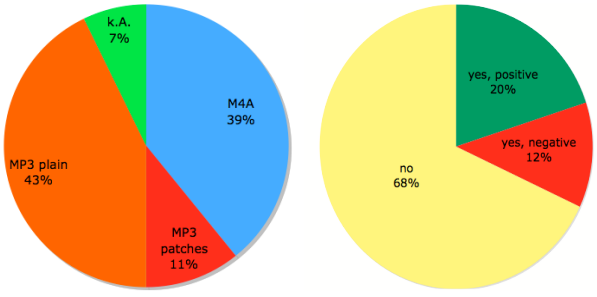

Figure 9: Preferred data formats (left side) and effects of lecture podcasts on the student's attendance in a lecture

2.5. Conclusions

With regard to the results described above, several conclusions can be drawn concerning the integration of lecture-accompanying podcasts in an educational environment. Even if the currently available podcast contents are overwhelmingly rated as helpful and positve, some starting points for additional changes were identified. Withholding the current standard regarding the quality of audio content, future work should also be focused on reducing the amount of data, and its data rates, for better supporting the mobile usage and more mobile device types. Additionally, instructions on how to use these contents, subscribe to them and the required technological base should be published for encouraging even more students to take part.

2.6. Outlook

For serving the demands of several different data format versions, each with different enrichment levels regarding addition contents, future work must cover the aim of reducing the current time-consuming production process. There, the current offered time slots after each lecture shall be minimised as well as the amount of integrated software and hardware tools. For offering a platform independent system to allow each lecturer to decide if, and how many of, their lectures should be recorded, a possible single-user solution is researched for private use on every personal computer. Here, the main focus lies on the generic editing and composition of contents via XML language dialects (as described in [6]).

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