W.I.S.E.

Final Report

Viking Ship Project

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May 11, 2005

Preface

The final report is composed of two parts; the analysis and the design. The careful consideration of each part is a result of an iterative Waterfall development. Corrections to each part were therefore amended as a consequence of iteration. Although we did not manage to capture the "contents of our minds" in black and white does not mean we haven't tried. It has resulted in this very lengthy deliberation. We do not apologize for the volume of the report. On the contrary, we humbly admit that we trivialized the importance of ethnography, in all its variations and forms. Furthermore, we apologize for not keeping to the spirit of process ontology and storytelling. We had hoped to film our efforts but did materialize it due to the lack of time.

Nonetheless, we feel as if we have reinforced the importance of a holistic approach to systems development and the value of a prototype. This is because it is difficult to apprehend something of such a large scale purely with the mind. By involving our senses, we are more able to mentally grasp these concepts which are otherwise very acute.

Although we now leave the project at an infant phase, we hope we have brought into bold relief the more tacit aspects of systems development. That is, an emergent meaning and purposive processes which bound both mind and matter. Exemplified in Norway's much enriched cultural and historical heritage.

W.I.S.E.

Analysis
Part I

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May 11, 2005

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1 Ethnography

Ethnography is the branch of anthropology[1] that deals with the scientific description of specific human cultures. The origin of the word comes from Greek, *ethnos*, meaning people and *graphia*, meaning to write.

Ethnographic Methods

Ethnography may also be conceived of as a category of human computer interaction research [1]. As such, the observation of human interactions in their native social settings and activities is an adaptation from cultural anthropology. Even the workplace may be described as a culture, filled with work standards, business practices (both formal and informal) [1], as well as social relations of the employees.

The most salient reasons why ethnography is of such importance to the analysis and design of information systems are [1] [1]:

- An ethnographic study is a powerful assessment of users' needs: A crucial goal of an ethnographic study is to gain the capacity to view a system through the eyes of the user. This perspective is extremely useful in creating a user interface to fit the needs of the end-user. It uncovers the true nature of the system user's job: A goal of an ethnographic study is to uncover all tasks and relationships that combine to form a user's job. It is often the case that a user performs tasks and communicates in ways that are outside of their official job description.

- The ethnographer can play the role of the end-user: The high level of user understanding that an ethnographer can gain through his/her fieldwork can be a useful bonus. For example, the ethnographer can act as the end-user in participatory design when “real" end-users are difficult to procure.

- The open-ended and unbiased nature of ethnography allows for discovery: Other HCI research methods, such as task analysis and controlled experimentation, must formalize, categorize, and/or theorize how users interact with a system in order to yield quantitative results. The unassuming nature of ethnography can often yield unexpected revelations about how a system is used.

However, there are also disadvantages associated with ethnography. They are [1]:

- Time requirements: The rewards that come from an ethnographic study are directly related to the time investment. While external constraints often limit field

[1] In particular from ethnology, the science that analyzes and compares human cultures, as in social structure, language, religion, and technology. That is, cultural anthropology.

studies to a few days or hours, formal ethnographic studies have been known to take weeks or even months.

- Presentation of results: The highly qualitative nature of results can make them difficult to present in a manner that is usable by designers.

- Scale: Most ethnographic studies use a small number of participants and a small-scale environment. Increasing the scale can be extremely difficult as it imposes a much greater amount of cost, communication, and effort.

There are degrees of involvement in ethnography, as in other social studies.
It is generally accepted that the more involved a researcher is, the richer the understanding of the culture is revealed. Consequently, to think like or as a user results in a more appropriate user interface.

"Field study" and ethnography are synonyms in social studies. Contextual inquiry is a specific form of ethnography of asking questions. Observational study is as the term implies, purely watching, without any form of interaction. Participant observation involves the engagement of the ethnographer in user activities. All three forms of ethnographic study are instrumental in revealing the cognitively opaque nature of a user's world. It is namely these tacit aspects of user's culture which are problematic.

Most data from ethnographic studies, such as in-person observation, audio/video observation, and interviews, is highly qualitative; impressions, opinions, environment descriptions, etc. [1]. Quantitative data, such as error rates and questionnaire results are also inherent in an ethnographic study [1].

An example of such qualitative and quantitative data in given below [1].

Qualitative (inquiry): "Three households reported using chat between the PC and the tablet. One example of this is interesting because it illustrates a creative simultaneous use of the PC and the tablet to accomplish a task. From the tracking data, we noticed that one household was simultaneously looking at the same web site on both the tablet and the PC while using chat. When we asked what was going on, it turned out that two household members were looking at www.realtor.com together to find a house to buy. Even though their PC was located in the dining area adjoining their living room and they were only feet away from each other, they were using chat to send each other URLs to look at. At the same time, they were vocally discussing the items they were viewing."

Quantitative (traffic logging): "On both the tablet and the PC, there was a great diversity of web sites visited. On the tablet, 270 sites accounted for 75 percent of the time spent browsing, and 85 percent of the top 100 sites were visited by only one person. Certain categories of web sites were popular across households (for example, six of the thirteen households visited financial sites regularly), but each household had its own favourite site within those categories."

System design must therefore include ethnography if it is to address the issues of quantifying the user culture. Otherwise, it will be an impoverished system which does not reflect the "social reality." The ethnographic methods normally used in system design are discussed hereafter.

1.1.1 Concurrent Ethnography

Concurrent Ethnography or Ethnomethodology is also referred to as informed ethnography is the most well known technique. As the name implies the ethnographic study is simultaneously done with the design of a new system. The resultant system prototype is then refined based upon the results of the study [1]. The advantage of ethnomethodology is the assurance of the focus upon the user during the developmental process. The disadvantage being the resource consumption; cooperation, coordination, and time.

1.1.2 Evaluative Ethnography

The objective of Evaluative Ethnography is to evaluate a new design model [1]. It is a very narrow approach specifically aimed at targeting the areas affected by the new system [1]. The advantage with evaluative ethnographic is its usefulness in proving or disproving a new design model or theory. Another advantage with an evaluative ethnographic study is the relatively short time frame [1]. However, the narrow view may also blind the ethnographer to important information that is outside the domain of the study [1].

1.1.3 Quick and Dirty Method

The Quick and Dirty Method is a technique used before another ethnographic study. It is an influential and persuasive means of purporting further ethnography and a new system design. As such, it is the most widely use ethnographic study because of time and budget restrictions [1]. The advantages are time and budget, as well as the level of awareness and value of knowledge of the social organization [1]. The disadvantage is the limited understanding of a work culture. As such, the quick and dirty ethnographic study may draw erroneous conclusions about the working culture.

1.1.4 Rapid Ethnography

Rapid Ethnography is a pragmatic approach with a collection of field methods and multiple ethnographic observers intended to afford a realistic understanding of users and their culture. The advantage is the short time frame on par with the quick and dirty method but it is more rigorous and formalized than the quick and dirty method. The disadvantage is the lack of refinement. Choosing "key" informants and a constrained focus can prove to be difficult [1].

1.1.5 Re-examining previous studies

Previous ethnographic studies are useful in orienting designers to the social organization and cultural settings [1]. The advantage is its inexpensive nature. The disadvantage is the unlikelihood of finding suitable study [1].

1.2 Guidelines and Recommendations

The following guidelines are prescribed as the most basic steps in an ethnographic study:

Preparation
_ Understand organization policies and work culture.
_ Familiarize yourself with the system and its history.
_ Set initial goals and prepare questions.
_ Gain access and permission to observe/interview.

Field Study
_ Establish rapport with managers and users.
_ Observe/interview users in their workplace and collect subjective/objective quantitative/qualitative data.
_ Follow any leads that emerge from the visits.
_ Record your visits.

Analysis
_ Compile the collected data in numerical, textual, and multimedia databases.
_ Quantify data and compile statistics.
_ Reduce and interpret the data.
_ Refine the goals and the process used.

Reporting
_ Consider multiple audiences and goals.
_ Prepare a report and present the findings.

Finally, as a rule of conduct in ethnographic studies for system design, the following guidelines are recommended [1]

- Use ethnographic methods early in the design process: The high risk of designing a system for an unknown or misunderstood user warrants the time investment in ethnographic methods.

- Have a well defined scope: The open ended nature of ethnography can be a weakness as well as a strength. It is important to stay focused and to recognize what users are necessary to include in an ethnographic study.

- Choose a proper level of ethnographic study: Time frame and budget constraints will often dictate what level and type of ethnographic method

- Make use of previous ethnographic studies: This should be a precursor to any field study as it requires the least amount of resource expenditure.

- Wear one hat at a time: Trying to play the role of the role of the ethnographer and the designer at the same time can be hazardous. Make sure to understand the user within the context of the current system before attempting to make design changes.

2 FORENEM

FORNEM is a research body which uses video for documentation and archiving of cultural historical empirical material [14]. FORNEM is an extension of a postdoctoral project of Terje Planke from the Institute for Cultural History at the University of Oslo[2]. The concepts the cultural historical research are used in understanding the social configurations, networking and coordination which have to be done before design negotiations are put into place [14]. As such, FORENEM uses activity theory and actor network theory as conceptual frameworks for design processes of reflexive research methodology [14].

Aims

FORNEM main objectives are best captured in the following questions [14]:

- "What difference does digital technology mean for qualitative research in cultural history?
- "What differences exist between interface and system design and cultural historical understanding of design in research processes?
- "How might digital media mediate action based research rather than object based research?

2.1 Concepts

It is the culmination of technology in ethnographic studies which epitomizes FORENEM conceptual paradigm. This implies the use of mobile technology; in particular, handheld devices are used in field work allows the immediate reflexive interpretation of the empirical material [14].

2.2 Methods

It is a new approach to ontological category which distinguishes FORENEM[3].
The action or process ontology together with *real* knowledge representation, that is, storytelling is a conceptual schema which binds all the relevant classificatory entities active within the world of causal commerce in cultural history.

To enshrine the new ontological category, FORNEM developed a new database. The processes are stored as MPEG, and tagged in AVID in categories that comply with the rules of CIDOC standardized categories for cultural heritage [14]. As such, the

[2] This case is the ongoing reconstruction of the third Viking boat from the famous Gokstad excavation in Norway [14].}
[3]The categorization of action rather than representations of objects and texts [14].

enshrinement of cultural historic heritage is a discursive formation and a monument of our time.

2.3 Analysis

The ethnographic technique of choice is therefore participatory observation, extending to a reflexive participatory design [14]. This new ontological approach is aimed at assessing how qualitative cultural historical research methods changes by use of digital tools for documentation, categorization and analyses [14]. FORNEM analyzes are inclusive and shared by using web-logs as a boundary object for the diverging actors that participate in the project [14]. That is, the blogs are a professional communication tool and therefore, a category for the archive [14]. In summary, the analysis of design thus focuses on [14]:

- routines for recording in the field,
- digitalization,
- documentation and
- archiving

2.4 Significance

The importance of ethnography in system design in undisputed. FORENEM is an example of such successful involvement. This project is therefore a necessary continuation of the new reflexive ontological approach. However, due to the very limited discourse and time frame, the scope of this document and therefore project will not do justice to FORENEM. Nonetheless, we offer a novel adaptation using similar philosophical guidelines.

Mobile Systems

3 Mobility

Mobility is the ability and willingness to move or change which is dependent upon motor skills, special tools such as a walking stick, Zimmer Frame or wheelchair, vehicles, road traffic, public transport, etc. Residential mobility depends on availability of houses and being bound to an area because of a job or school, etc. Occupational mobility depends on availability of jobs (depending on the general job market and on one's versatility, quality, etc.) and residential mobility. Academic mobility refers to the possibility for students and teachers to move between different institutions inside and outside their own country. In physics, mobility generally refers to electron mobility. In mobile computing, mobility refers to characteristics of device to handle information access, communication and business transactions while in state of motion.

Mobile Computing

Mobile Computing is a generic term for small, portable, and wireless computing and communication devices (laptops with Wireless LAN technology, Mobile phones, Personal Digital Assistants (PDAs) with Bluetooth or IRDA interfaces, and USB flash drives). Historically, electronic devices (e.g. Radio transmitters, wireless communications systems, etc.) were base stations, operated at fixed locations, typically with large antenna towers[4]. Presently, there are a plethora of mobile computing platforms, for example, dash mount VGA displays, and computers that can provide GPS and other navigation functions for automobile users.

3.1 Base-Mobile-Portable Hierarchy

In ham radio, there is a base-mobile-portable hierarchy, as follows:

- Base station: fixed location, incorporated into a building or other architecture;
- Mobile: attached to or in a vehicle or used by a mobileer;
- Portable: worn or carried. (The word "portable" derives from French "porter" = "to wear", but also includes handheld devices such as handy-talkies, walkie-talkies, handheld computers, as well as wearable computers).

3.2 The Boundary between Mobility and Portability

"Mobile" (vehicular) and "portable" (wearable or hand-held) computing platforms merged by the early 1980s. The car phones, known then as "bag phones" that had a

[4] Widespread use of automobiles gave rise to smaller devices operating at 6 volts. In the 1950s, the transition to 12 volt automotive electrical systems gave rise to a large number of 12 volt devices, such as two-way radios, referred to as mobile rigs. A large industry, with companies such as Motorola sprung up to support the growing need for mobile devices, such as taxicab radios, police radios, and other 12 volt under dash equipment, as well as trunk mount systems.

cigarette lighter plug for automotive use, were small enough to carry around for portable use. At the same time, 12 volt mobile phones began to be used as portable phones, 12 volt portable computers appeared. Currently, the fuzzy boundary between mobile and portable wherein many small handheld phones and computers will operate on 12 volts from a cigarette lighter socket, as well as from self contained batteries[5].

4 Wireless

"Wireless" was a term used to mean a radio receiver, referring to its use as a wireless telegraph. The term was widely used in the UK, long after radio was being used for other signals, such as music. The founding principles and inventions of wireless technology are attributed to Nikola Tesla. Currently, "wireless" refers to communication without cables or cords, mainly radio frequency and infrared waves. Common uses include the various communications defined by the IrDA and the wireless networking of computers. Low powered radio waves, such as those used in networking to transmit data between devices, are often unregulated. However, high powered transmission sources are regulated, usually requiring government licenses to broadcast on a specific wavelength.

Wireless Standards

To address all wireless standards is clearly beyond the scope of this discourse. We thought it would suffice to merely list the salient standards in the context of our own system.

_ Bluetooth
_ Data corruption
_ DSRC
_ Federal Communications Commission
_ HIPERLAN
_ HIPERMAN
_ IrDA
_ Radio
_ Ultra Wideband
_ WiFi
_ WiMAX
_ Wireless campus
_ Wireless energy transfer
_ Wireless networking
_ Wireless Security

[5] Today almost every vehicle currently manufactured has numerous onboard computers. There is also a proposal to have these connect by wireless ad-hoc networks, to form what would likely be the world's largest network. Since we are almost never away from someone's car somewhere, we could also use such a network to link to portable handheld or wearable computers, and thus have a near complete coverage of most urban or suburban areas.

5 Wireless networks

Wireless networks are telephone or computer networks that use radio as their carrier or physical layer. The most prominent are listed below:

- Wireless LAN - local area networks
- Wireless PAN - personal area networks
- GSM - Global standard for digital mobile communication, common in most countries except North America, South Korea and Japan
- PCS - Personal communication system - not a single standard, this covers both CDMA and GSM networks operating at 1900 MHz in North America
- Mobitex - pager based network in the USA and Canada, built by Ericsson, now used by PDAs such as the Palm VII and Research in Motion BlackBerry
- GPRS - General Packet Radio Service, upgraded packet based service within the GSM framework, gives higher data rates and always-on service
- UMTS - Universal Mobile Telephone Service (3rd generation cell phone network), based on the W-CDMA radio access network
- AX.25 - amateur packet radio
- NMT - Nordic Mobile Telephony, analog system originally developed by PTTs in the Nordic countries
- AMPS - America Mobile Phone System
- D-AMPS - Digital AMPS, also known as TDMA

Wireless LAN

A wireless LAN or WLAN is a wireless local area network that uses radio waves as its carrier: the last link with the users is wireless, to give a network connection to all users in a building or otherwise[6]. WLAN is expected to continue to be an important form of connection in many organizational and social settings. Initially WLAN hardware was expensive and only an alternative to cabled LAN in places where cabling was difficult or impossible. Presently, WLAN components are inexpensive enough to be used as a general purpose network, including in the home, with many being set-up so that one PC (a parent's PC, for example) can be used to share an Internet connection with the whole family (whilst retaining access control at the parents' PC). Industry specific solutions and proprietary protocols were replaced by standards in the early 1990s, by various versions of IEEE 802.11 (Wi-Fi) and HomeRF (2 Mbit/s, intended for home use, unknown in the UK).

However, the deficiency of default security of Wireless connections is a growing issue, where many Broadband (ADSL) connections are now offered together with a Wireless Base station/ADSL Modem/firewall/Router access point. Furthermore, built in Wireless Networking eliminates the need for an additional plug-in (PCMCIA) card. In the scenario where the network is enabled, by default, the laptop's ease of access is a problem. Windows XP accentuates this problematic situation by making it easy to setup a PC as a

[6] The backbone network usually uses cables.

Wireless LAN 'base station' and allowing all the PCs in the home to access the Internet via the 'base' PC. Since there is a lack of expertise in setting up such systems, the sharing of Internet connections are not entirely uncommon. The most notable interference is with mobile phones, since 802.11b operates at is 2.4GHz. There are two possible types of infrastructure: Peer-to-peer or ad-hoc mode and the so called infrastructure mode.

Peer-to-peer : This mode is a method for wireless devices to directly communicate with each other. Operating in ad-hoc mode allows wireless devices within range of each other to discover and communicate in peer-to-peer fashion without involving central access points. Typically used by two PCs to connect to one another, so that one can share the other's Internet connection for example.

Infrastructure mode: This mode of wireless networking bridges a wireless network to a wired Ethernet network. Infrastructure mode wireless also supports central connection points for WLAN clients. A wireless access point is required for infrastructure mode wireless networking, which serves as the central WLAN communication station. Typically used by a stand-alone base station (such as a Broadband/ADSL connection box).

5.1 Wi-Fi

Wi-Fi or IEEE 802.11 denotes a set of Wireless LAN standards developed by working group 11 of the IEEE LAN/MAN Standards Committee (IEEE 802). The original 802.11 is now called "802.11 legacy". The 802.11 family currently includes six over-the-air modulation techniques that all use the same protocol, the most popular (and prolific) techniques are those defined by the a, b, and g amendments to the original standard; security was originally included, and was later enhanced via the 802.11i amendment. Other standards in the family (c, h, n) are service enhancement and extensions, or corrections to previous specifications. 802.11b was the first widely accepted wireless networking standard, followed (somewhat counter intuitively) by 802.11a and 802.11g. 802.11b and 802.11g standards use the unlicensed 2.4 gigahertz (GHz) band. The 802.11a standard uses the 5 GHz band. Operating in an unregulated frequency band, 802.11b and 802.11g equipment can incur interference from microwave ovens, cordless phones, and other appliances using the same 2.4 GHz band.

5.1.1 802.11 legacy

The original version of the standard IEEE 802.11 released in 1997 specifies two raw data rates of 1 and 2 megabits per second (Mbit/s) to be transmitted via infrared (IR) signals or in the Industrial Scientific Medical frequency band at 2.4 GHz. IR remains a part of the standard but has no actual implementations. A weakness of this original specification was that it offered so many choices that interoperability was sometimes challenging to realize. It is really more of a "meta-specification" than a rigid specification, allowing individual product vendors the flexibility to differentiate their products. Legacy 802.11 was rapidly supplemented (and popularized) by 802.11b.

5.1.2 802.11b

The 802.11b amendment to the original standard was ratified in 1999. 802.11b has a maximum raw data rate of 11 Mbit/s and uses the same CSMA/CA media access method defined in the original standard. Due to the CSMA/CA protocol overhead, in practice the maximum 802.11b throughput that an application can achieve is about 5.9 Mbit/s over TCP and 7.1 Mbit/s over UDP. The dramatic increase in throughput of 802.11b (compared to the original standard) along with substantial price reductions lead to the rapid acceptance of 802.11b as the definitive wireless LAN technology. 802.11b is usually used in a point-to-multipoint configuration, wherein an access point communicates via an omni directional antenna with one or more clients that are located in a coverage area around the access point. With high-gain external antennas, the protocol can also be used in fixed point-to-point arrangements, typically at ranges up to eight kilometres (km) although some report success at ranges up to 120 km where line of sight can be established. This is usually done in place of costly leased lines or very cumbersome microwave communications equipment.

802.11b cards can operate at 11 Mbit/s, but will scale back to 5.5, then 2, then 1 Mbit/s, if signal quality becomes an issue. Since the lower data rates use less complex and more redundant methods of encoding the data, they are less susceptible to corruption due to interference and signal attenuation. Extensions have been made to the 802.11b protocol (e.g., channel bonding and burst transmission techniques) in order to increase speed to 22, 33, and 44 Mbit/s, but the extensions are proprietary and have not been endorsed by the IEEE. Many companies call enhanced versions "802.11b+". These extensions have been largely obviated by the development of 802.11g, which has data rates up to 54 Mbit/s and is backwards compatible with 802.11b. The first widespread commercial use of the 802.11b standard for networking was made by Apple Computer under the trademark AirPort. On the non-Apple market, Linksys could be considered the current leader.

5.1.3 802.11a

The 802.11a amendment to the original standard was ratified in 1999. The 802.11a standard uses the same core protocol as the original standard, operates in 5 GHz band, and uses a 52-subcarrier OFDM (Orthogonal Frequency Division Multiplexing) with a maximum raw data rate of 54 Mbit/s, which yields realistic net achievable throughput in the mid-20 Mbit/s. The data rate is reduced to 48, 36, 34, 18, 12, 9 then 6 Mbit/s if required. 802.11a has 12 non-overlapping channels, 8 dedicated to indoor and 4 to point to point. It is not interoperable with 802.11b, except if using equipment that implements both standards. Since the 2.4 GHz band is heavily used, using the 5 GHz band gives 802.11a the advantage of less interference. However, this high carrier frequency also brings disadvantages. It restricts the use of 802.11a to almost line of sight, necessitating the use of more access points; it also means that 802.11a cannot penetrate as far as 802.11b since it is absorbed more readily, other things (such as power) being equal.

Different countries have different regulatory support, although a 2003 World Radio telecommunications Conference made it easier for use worldwide. 802.11a is now approved by regulations in the United States and Japan, but in other areas, such as the European Union, it had to wait longer for approval. European regulators were considering the use of the European HIPERLAN standard, but in mid-2002 cleared 802.11a for use in Europe. In the US, a mid-2003 FCC decision may open more spectrums to 802.11a channels.

5.1.4 802.11g

In June 2003, a third modulation standard was ratified: 802.11g. This favour works in the 2.4 GHz band (like 802.11b) but operates at a maximum raw data rate of 54 Mbit/s, or about 24.7 Mbit/s net throughput like 802.11a. It is fully backwards compatible with b and uses the same frequencies. Details of making b and g work well together occupied much of the lingering technical process. In older networks, however, the presence of an 802.11b participant significantly reduces the speed of an 802.11g network. The 802.11g standard swept the consumer world of early adopters starting in January 2003, well before ratification. The corporate users held back and Cisco and other big equipment makers waited until ratification. By summer 2003, announcements were flourishing. Most of the dual band 802.11a/b products became dual-band/tri-mode, supporting a, b, and g in a single mobile adaptor card or access point.

While 802.11g held the promise of higher throughput, actual results were mitigated by a number of factors: conflict with 802.11b-only devices (see above), exposure to the same interference sources as 802.11b, limited channels (only 3 fully non-overlapping channels like 802.11b) and the fact that the higher data rates of 802.11g are often more susceptible to interference than 802.11b, causing the 802.11g device to reduce the data rate to effectively the same rates used by 802.11b. The move to dual-mode/trimode products also carries with it economies of scale (e.g. single chip manufacturing). The use of dual-band/tri-mode products ensures the best possible throughput in any given environment.

A new proprietary feature called Super G is now integrated in certain access points. These can boost network speeds up to 108 Mbit/s by using channel bonding. This feature may interfere with other networks and may not support all b and g client cards. In addition, packet bursting techniques are also available in some chipsets and products which will also considerably increase speeds. Again, they may not be compatible with some equipment.

5.1.5 802.11n

In January 2004 IEEE announced that it had formed a new 802.11 Task Group (TGn) to develop a new amendment to the 802.11 standard for local area wireless networks. The real data throughput will be at least 100 Mbit/s (which may require an even higher raw data rate at the physical layer), and should be up to 5 times faster than 802.11a or 802.11g, and perhaps 20 times faster than 802.11b. It is projected that 802.11n will also offer a better operating distance than current networks. There are two competing variants of the 802.11n standard: WWiSE (backed by companies including Broadcom) and TGn Sync (backed by Intel and Philips). The standardization process is expected to be completed by the end of 2006. 802.11n builds upon previous 802.11 standards by adding MIMO (multiple input multiple output). The additional transmitter and receiver antennas allow for increased data throughput through spatial multiplexing and increased range by exploiting the spatial diversity, perhaps through coding schemes like Alamouti coding.

5.1.6 Certification

Because the IEEE only sets specifications but does not test equipment for compliance with them, a trade group called the Wi-Fi Alliance runs a certification program that members pay to participate in. Virtually all companies selling 802.11 equipment are members. The Wi-Fi trademark, owned by the group and usable only on compliant equipment, is intended to guarantee interoperability. Currently, "Wi-Fi" can mean any of 802.11a, b, or g. As of fall 2003, Wi-Fi also includes the security standard Wi-Fi Protected Access or WPA. Eventually "Wi-Fi" will also mean equipment which implements the 802.11i security standard (also known as WPA2). Products that say they are Wi-Fi are supposed to also indicate the frequency band in which they operate (2.4 or 5 GHz).

5.1.7 Standards

The following standards and task groups exist within the working group:

_ IEEE 802.11 - the original 1 Mbit/s and 2 Mbit/s, 2.4 GHz RF and IR standard
_ IEEE 802.11a - 54 Mbit/s, 5 GHz standard (1999, shipping products in 2001)
_ IEEE 802.11b - Enhancements to 802.11 to support 5.5 and 11 Mbit/s (1999)
_ IEEE 802.11d - international (country-to-country) roaming extensions New countries
_ IEEE 802.11e - Enhancements: QoS, including packet bursting
_ IEEE 802.11F - Inter-Access Point Protocol (IAPP)
_ IEEE 802.11g - 54 Mbit/s, 2.4 GHz standard (backwards compatible with b) (2003)
_ IEEE 802.11h - 5 GHz spectrum, Dynamic Channel/Frequency Selection (DCS/DFS) and Transmit Power Control (TPC) for European compatibility
_ IEEE 802.11i (ratified 24 June 2004) - Enhanced security
_ IEEE 802.11j - Extensions for Japan
_ IEEE 802.11k - Radio resource measurements
_ IEEE 802.11n - Higher throughput improvements
_ IEEE 802.11p - WAVE - Wireless Access for the Vehicular Environment (such as ambulances and passenger cars)
_ IEEE 802.11r - Fast roaming
_ IEEE 802.11s - Wireless mesh networking
_ IEEE 802.11T - Wireless Performance Prediction (WPP) - test methods and metrics
_ IEEE 802.11u - Interworking with non-802 networks (e.g., cellular)
_ IEEE 802.11v - Wireless network management

5.1.8 Community networks

Due to the unsecured setup of many wireless office networks the "people on the street" may connect to the Internet. Subsequently, there efforts have been made by volunteer groups to establish wireless community networks to provide free wireless connectivity to the public.

Positioning Systems

6 Positioning Standards

The term positioning has more than one meaning. In business terminology, "positioning" refers to the place in the market. "Positioning" also refers to the careful placement of objects. In particular, by the use of precise navigation: for example, in the term "Global Positioning System".

Galileo Positioning System

The Galileo positioning system (not to be confused with, or abbreviated to, GPS) is a planned satellite navigation system, intended as a European alternative to the United States Global Positioning System (GPS). Usage of the acronym "GPS" in this article refers only to the existing United States system. The system is intended primarily for civilian use, unlike the US system, which is run by and primarily for the US military. The US reserves the right to limit the signal strength or accuracy of the GPS systems, or to shut down GPS completely, so that non-military users cannot use it in time of conflict. The precision of the signal available to non-military users was limited before 2000 (a process known as selective availability). The European system will not (in theory) be subject to shutdown for military purposes, will provide a significant improvement to the signal available from GPS, and will, upon completion, be available at its full precision to all users, both civil and military.

The European Commission had some difficulty trying to secure funding for the next stage of the Galileo project. European states were wary of investing the necessary funds at a time of economic difficulty, when national budgets were being threatened across Europe. Some states, such as France, strongly supported Galileo because it would demonstrate an end to reliance on United States technologies. Other states felt that it would be better to continue getting the service for free from the US, rather than paying for it themselves. Following the September 11, 2001 Terrorist Attack, The United States wrote to the European Union opposing the project, arguing that it would end the ability of the US to shut down GPS in times of military operations. On January 17, 2002 a spokesman for the project somberly stated that "Galileo is almost dead" as a result of US pressure. A few months later, however, the situation changed dramatically. Partially in reaction to the pressure exerted by the US, European Union member states decided it was important to have their own independent satellite based positioning and timing infrastructure. All European Union member states became strongly in favour of the Galileo system in late 2002 and, as a result, the project actually became over funded, which posed a completely new set of problems for the companies involved.

The European Union and European Space Agency then agreed in March 2002 to fund the project, pending a review in 2003 (which was finalized on May 26, 2003). The starting cost for the period ending in 2005 is estimated at EUR 1.1 billion. The required satellites - the planned number is 30 - will be launched throughout the period 2006-2008 and the system will be up and running and under civilian control from 2008. The final cost is estimated at EUR 3 billion, including the infrastructure on Earth, which is to be constructed in the years 2006 and 2007. At least two thirds of the cost is will be invested by private companies and investors, the remaining costs are divided between the European Space Agency and the European Union. An encrypted higher bandwidth Commercial Service with improved accuracy will be available at an extra cost, while the base Open Service will be freely available to anyone with Galileo compatible GPS receiver. The European Union has agreed to switch to a range of frequencies known as Binary Offset Carrier 1.1 in June 2004, which will allow both European and American forces to block each other's signals in the battlefield without disabling the entire system.

6.1.1 Political Implications

As well as being an impressive technological achievement and a hugely practical tool, Galileo will be a political statement of European technological independence from the United States. A strong motivator for seeking technological independence is the policy of the United States government to employ only American companies for the building of components for the GPS.

6.2 Global Positioning System

The Global Positioning System, usually called GPS (the US military refers to it as NAVSTAR GPS), is a satellite navigation system used for determining one's precise location and providing a highly accurate time reference almost anywhere on Earth or in Earth orbit. It uses an intermediate circular orbit (ICO) satellite constellation of at least 24 satellites. The GPS system was designed by and is controlled by the United States Department of Defence and can be used by anyone, free of charge. The GPS system is divided into three segments: space, control, and user. The space segment comprises the GPS satellite constellation. The control segment comprises ground stations around the world that are responsible for monitoring the flight paths of the GPS satellites, synchronizing the satellites' on-board atomic clocks, and uploading data for transmission by the satellites. The user segment consists of GPS receivers used for both military and civilian applications. A GPS receiver decodes time signal transmissions from multiple satellites and calculates its position by trilateration.

The system consists of a "constellation" of at least 24 satellites in 6 orbital planes. The GPS satellites were initially manufactured by Rockwell; the first was launched in February, 1978, and the most recent was launched on November 6 2004. Each satellite circles the Earth twice every day at an altitude of 20,200 kilometres (12,600 miles). The satellites carry atomic clocks and constantly broadcast the precise time according to their own clock, along with administrative information including the orbital elements of their own motion, as determined by a set of ground based observatories. The receiver does not need a precise clock, but does need to have a clock with good short-term stability and receive signals from four satellites in order to find its own latitude, longitude, elevation, and the precise time. The receiver computes the distance to each of the four satellites from the difference between local time and the time the satellite signals were sent (this distance is called a pseudo range). It then decodes the satellites' locations from their radio signals and an internal database. The receiver should now be located at the intersection of four spheres, one around each satellite, with a radius equal to the time delay between the satellite and the receiver multiplied by the speed of the radio signals. The receiver does not have a very precise clock and thus cannot know the time delays. However, it can measure with high precision the differences between the times when the various messages were received. This yields 3 hyperboloids of revolution of two sheets, whose intersection point gives the precise location of the receiver. This is why at least four satellites are needed: fewer than 4 satellites yield 2 hyperboloids, whose intersection is a curve; it's impossible to know where the receiver is located along the curve without supplemental information, such as elevation. If elevation information is already known, only signals from three satellites are needed (the point is then defined as the intersection of two hyperboloids and an ellipsoid representing the Earth at this altitude).

6.3 GSM Positioning

Global System for Mobil Communications (GSM) is the standard for mobile telecommunications used in Europe. There is usually no coverage in mountainous and rural regions. GSM is a cell based structure which is geographically divided into a number of smaller areas called cells. The cells have a radius from 50 meters to 15 kilometres. Access points in each cell transmit all telephone signals. Consequently, cellular phones are logically located in one specific cell. Urban areas and cities, where the system is overloaded, cells are split into smaller cells. The positioning of the GSM device is localized to the cell the user is in. Therefore, accuracy is synonymous with cell density.

6.4 IrDA Positioning

Infrared Data Association (IrDA) is a standard that supports high data rates, from 2.4Mbps to 11.5Mbps. However, Infrared (IR) devices need a direct line-of-sight for contact and seldom transmit longer than 2 meters. It has therefore, a limited application. This means that IrDA systems require several access points. One advantage with IrDA is that it does not interfere with other electronic devices. It is also relative inexpensive compared to WLAN, and Bluetooth. The Active Badge Systems (ABS) is an example of an IrDA positioning system[7]. Applications in which Active Badge information has been used include telephone call routing, security and environmental control. IrDA is often used as an indoor positioning system

6.5 Bluetooth Positioning

Bluetooth is an open standard for short-range wireless speech and data communication. It uses radio waves, has usually a range of 10 meters and can share files at 1Mbps[8]. Since

[7] It is a small computing device worn by personnel. Each badge has a globally unique code that is periodically broadcasted through an infrared interface. The infrared signals reflect off walls and furniture to flood the surrounding area, and are picked up by a network of sensors placed around the building. By determining which badges were seen by which sensors, it is possible to deduce the location of a badge. This further provides a hint to the location of the badges owner.

[8] There are also specifications where Bluetooth has a range up to 100 meters, though these are rarely used.

Bluetooth does not require a line-of-sight between sender and receiver and can even communicate through walls. It is relatively inexpensive and it is easy to use. Location or acknowledgement is automatic. Positioning is similar to GSM; that is by identifying the closest base station. However, Bluetooth is short range. Devices that are out of range will not be interrupted by the sender. A prototypical tour guide at the Museum in Grimstad uses Bluetooth positioning. Content is specific to each base station. A disadvantage with Bluetooth is the time taken to set up new connections - between 5 and 10 seconds. Consequently, if the user moves quickly past the range of a base station, positioning will not be possible.

6.6 Ultrasound Positioning

High frequency sound waves, that is, sound above the audible range of human hearing, >20 000 Hz, is known as an Ultrasound. Ultrasound is best known for its medical use. Ultrasound or sonography, in medicine, is a technique that uses sound waves to study and treat hard to reach body areas. In scanning with Ultrasound, high frequency sound waves are transmitted to the area of interest and the returning echoes recorded. Ultrasound is non-invasive, involves no radiation, and avoids the possible hazards such as bleeding, infection or reactions to chemicals. Ultrasound has several desirable properties that make it ideal for location-aware applications.

- It does not penetrate solid walls, so location per room is simple to achieve.
- It does not require line-of-sight between the tags and the detector.
- Ultrasound waves are not subjected interference.
- Ultrasound does not interfere with electronic equipment and is therefore ideal in environments that are sensitive to the electromagnetic radiation from radio systems and have needs for tracking equipment.

The ultrasonic location system is based on the principle of trilateration; position finding by measurement of distances. A short pulse of Ultrasound is emitted from a transmitter called a sender attached to the object to be located, and the times-of-flight of the pulse to receivers mounted at known points on the ceiling is measured. The speed of sound in air is known, and the distances from the sender to each receiver are calculated based on this. Given three or more distances there is enough information to determine the 3D position of the sender, and hence that of the object on which it is mounted. However, Ultrasound positioning requires an extra device for transmitting signals.

6.7 Wi-Fi Positioning

Wireless LAN connection to Internet/Intranet is immediate and has a range of up to 100 meters. WLAN can also create intranets by virtue of their vicinity. The latest WLAN standard can theoretically share files at 108 Mbps, however real throughput is closer to 50Mbps. Positioning with WLAN, is threefold

- Association with access points.
- Signal strength of access point beacon.

- Signal strength of multiple access point beacons.

Accuracy is therefore from 100 m to 1 m. One disadvantage with WLAN is that walls and iron objects can interfere with the signal.

6.7.1 The Ekahau Positioning Engine

The Ekahau Positioning system is a set of software components that enables location tracking in any standard Wi-Fi network (802.11 a/b/g). Unlike competing technologies that require special infrastructure on site, Ekahau is a software solution that works with any off-the-shelf Wi-Fi access point. Ekahau uses its own patented Bayesian positioning algorithms to calculate the position of a WLAN device such as PDA, Laptop and Palm. More access points results in the better accuracy. 5-7 access points will provide up to 1-meter average accuracy and 3-5 access points provides up to 2-3 meter average accuracy. Unlike many competing positioning technologies, such as Cordis RadioEye, Ekahau does not apply propagation or triangulation methods that suffer from radio wave multipathing, scattering or attenuation effects. Thus it is very suitable in environments with a lot of disrupting elements. This would therefore, be the ideal solution as a positioning engine.

7 Tags and Receivers

Bar Code and Scanner

Quasi-positioning in grid environments is also possible using bar codes. It is a common practice in warehouses and requires only the scanning of barcodes for positioning. The client requests information for particular barcode and the server returns the relevant information based on a predetermined "grid system." However, such positioning is limited and inconvenient due to the extremely limited range.

7.1 Radio Identification

Radio Identification (RFID) uses the same principle as barcode scanning but has a very usable range (3 to 100m) depending on the RFID standard. It is by far the cheapest solution (USD 0.80 - 40 per tag) and most flexible in the numbers of users, simultaneous reading (hundreds to thousands).

8 Privacy

We consider the privacy issue to be void since our model obtains only passive identification where the positioning is done by the client. However, we concede that with a real positioning system with active positioning, such concerns are just. Nonetheless, given the context, the nature of the public domain, a museum or otherwise, we once again reiterate the voluntary nature of using such a system and device. Furthermore, the nature of such a system means that privacy is no more encroaching than the volunteering of a credit card payment.

Requirements Specification

9 System Requirements

Functional Requirements

1. The system should store information about people (tourists) and their usage of the mobile devices, including content and position.

2. The system should store information about each mobile device and their status (on loan, reserved, available etc.).

3. The system should store information about every mobile device in use and the persons using them.

4. The system should store information about relationships between mobile devices, people, content and position.

5. The system should support the registration of new users, mobile devices, exhibitions and loans or rentals.

6. The system should support the editing of users, mobile devices, exhibitions and loans or rentals.

7. The system should support inquiries about the availability of mobile devices (reservations included).

9.1 User Requirements

1. The system should be easy to use and learn.

2. The system should run any web application.

3. The system's user interface must be navigable.

10 System Constraints

Development Cost: Financially a void issue because there was no budget allocated. However, we used a lot of time which had to be constrained by virtue of the discourse limitations.
Hardware Cost: Once again, financially void. A mobile device was shared and a work environment was granted.
Time to Operation: Although the first tier will be prototyped, the system as a whole will not be realized in the near future and therefore beyond the prediction of this analysis.
Ease of Training: As one of the essential functional requirements, we expect a relatively smooth transition. With the added advantage of novelty for all actors involved.

11 Actors

Actor Description

Tourist
Role: A person who tours the museum exhibitions. The tourist’s basic need is to be able to view or hear site-specific media.
Characteristic: The systems users include many and very different tourists.
Examples: Tourist A is by an exhibition. Proximity or vicinity tags triggers the activation of site specific media streaming.

Ethnographer
Role: A person who observes tourists behaviour. The Ethnographers basic need is to be able to observe tourists movement and content.
Characteristic: The Ethnographers view the systems reports.
Examples: Ethnographer E is interested in looking at the behaviour of tourists around this new exhibition. E analyzes the activity around and at the exhibition.

Administrator
Role: A person who administrates all the systems functionality. The Administrators basic need is to be able to administrate.
Characteristic: The systems administrator manages the tools and users of the system.
Examples: Administrator A has to create a new ethnographer who wants to analyze tourists at a new exhibition.

Positioning System
Role: The complementary system determines the position or specific location of actors with mobile devices.
Characteristic: The system locates users and tags.
Examples: Access points triggered by user activity, obtains a location by vicinity.

12 Activities

The activity diagram describes the main processes involved.

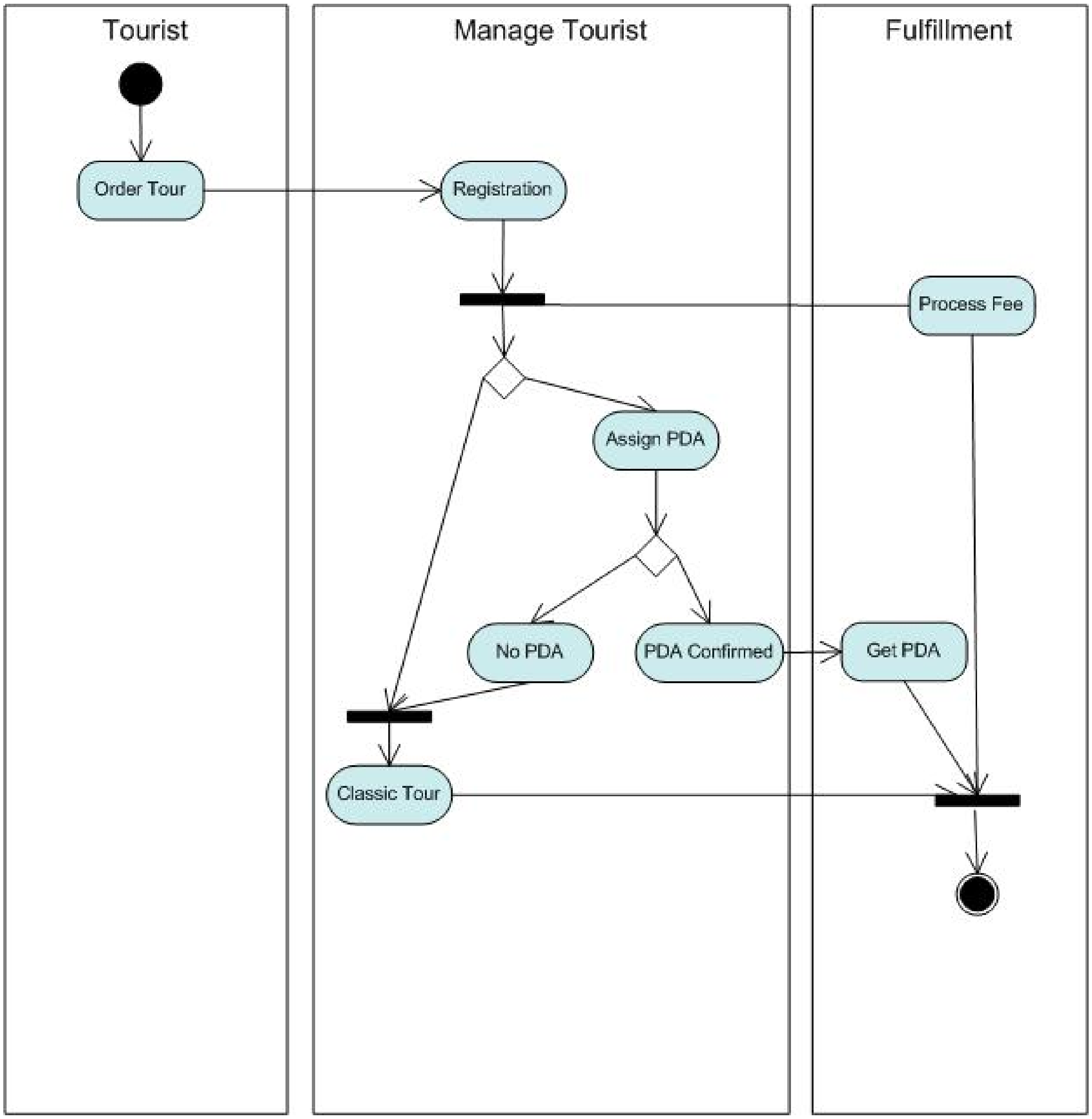

Figure 1. Activity diagram.

Activity Description

View Media
Role: Enable users to view or hear site-specific media.
Relation: Needs the position and site specification.

View My Position
Role: Enables users to view their position in the local area.
Relation: The local area legend location track.

View Tourists
Role: Allows ethnographers and administrators to analyze users' movement.
Relation: Used in surveillance and ethnographic reports.

Manage Tourists
Role: Add and remove new users from the registry.
Relation: Security and receipts for payments.

Analyze Activity
Role: Allows ethnographers and administrators to get an overview of user activity (movement and content).
Relation: Used in surveillance and ethnographic reports.

Ethnographic Reportage
Role: Allows ethnographers to get a quantitative overview.
Relation: Used in ethnographic studies.

13 Use Cases

Use Case Description

View Media
Precondition: Tourist with mobile device wonders in the vicinity of a specific exhibition.
Trigger: The mobile device reads a tag and the tag are identified.
Post condition: The system returns with a location specific content.
Variations: The media is wrong or unavailable.

View My Position
Precondition: A user wonders where in the museum she is and where the most exciting or new exhibitions are.
Trigger: The user selects the desired exhibitions.
Post condition: The system returns with the user's location and shows a suitable path to the requested exhibition.
Variations: The location is wrong. The exhibition is not current.

View Tourists
Precondition: Ethnographer wonders how people are reacting to the new exhibition.
Trigger: Ethnographer selects motion or content analysis.
Post condition: The system returns with periodic analyses.
Variations:

Manage Tourists
Precondition: A tourist wants to tour the museum.
Trigger: Receptionist enters tourist's details into the system.
Post condition: The system returns with an allocated mobile device.

Variations: Tourist already exists in the system.

13.1 Use Case Model

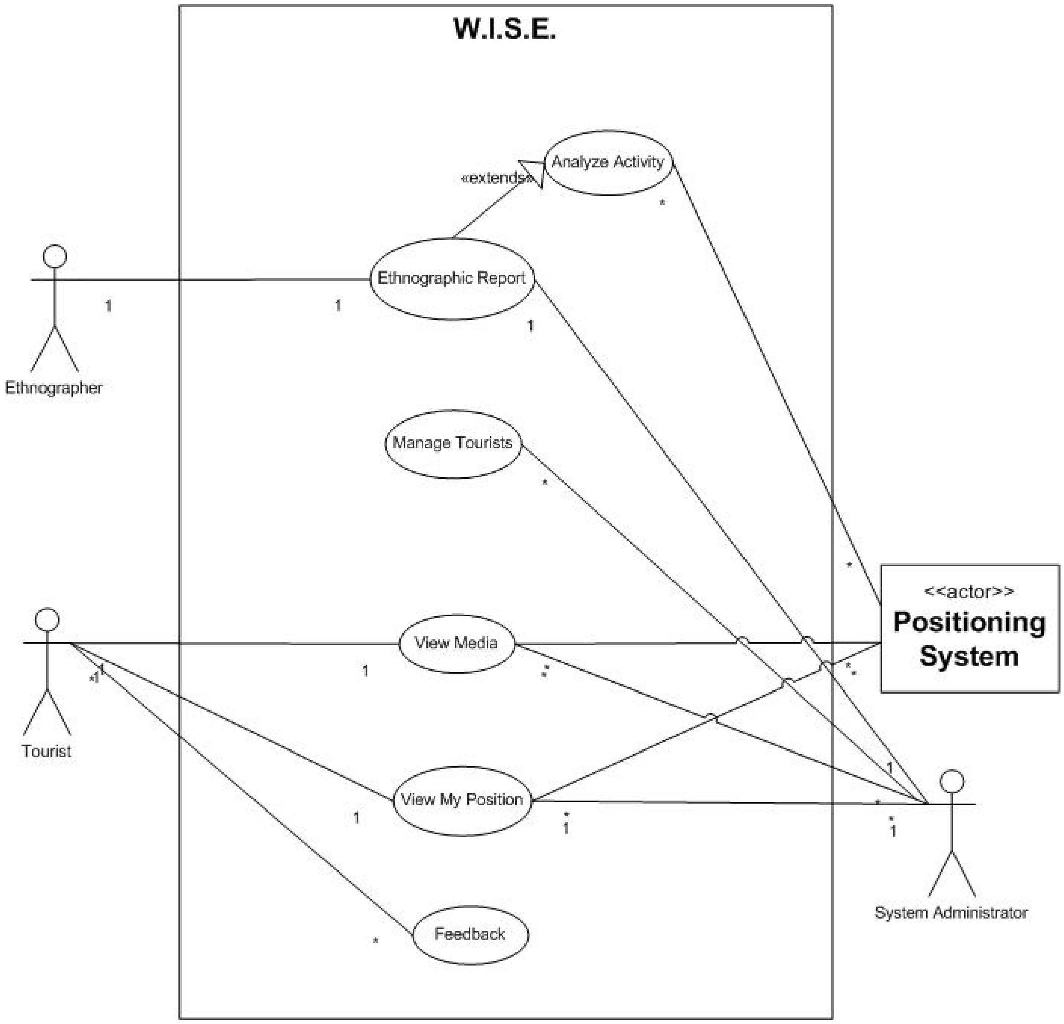

Figure 2. Use Case Model.

14 Domain Model

This domain model is an oversimplification. However, it was necessitated by virtue of many unknown qualities and quantities at InterMedia.

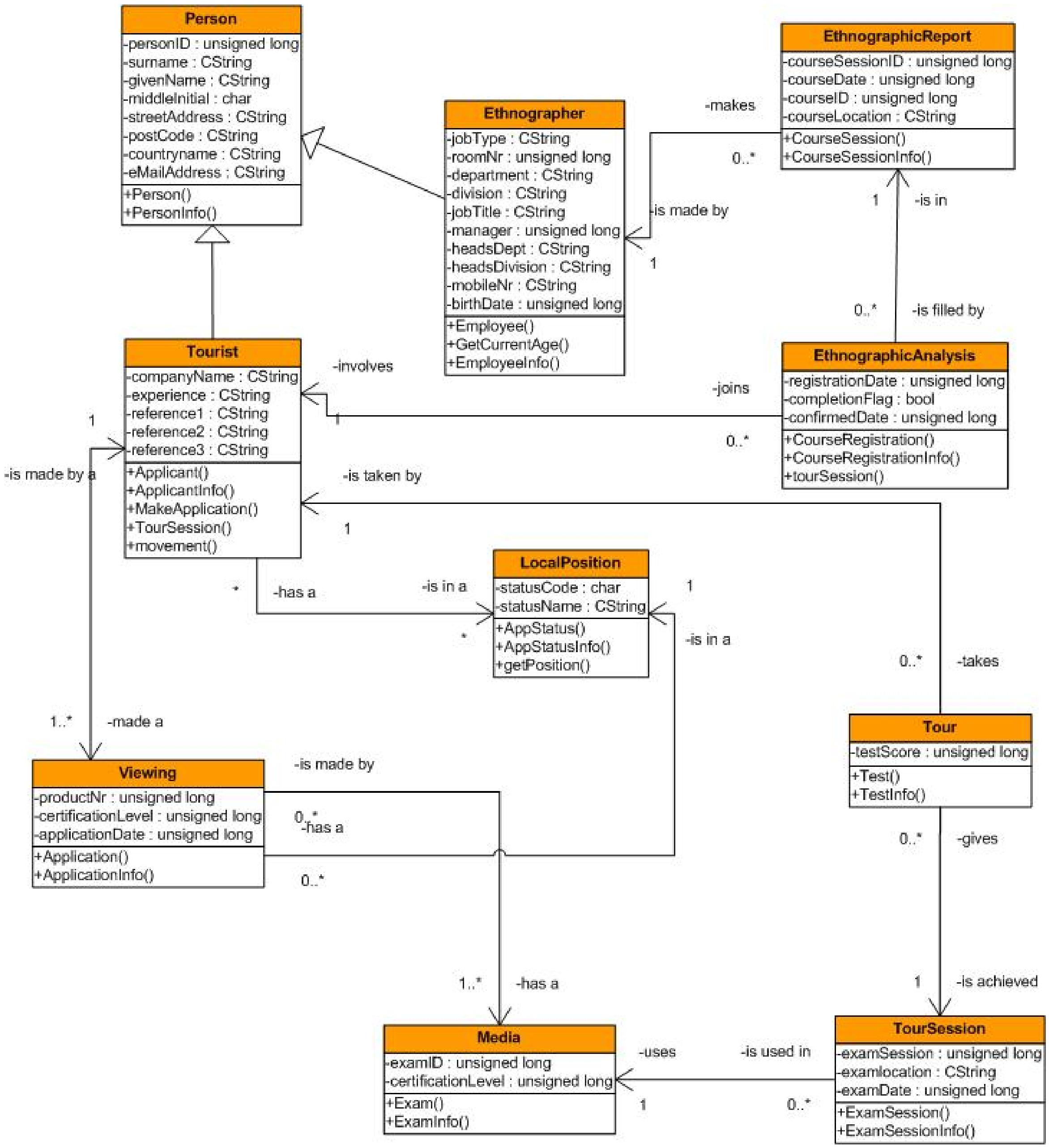

Figure 3. Domain Model.

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W.I.S.E.

Design

Part II

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May 11, 2005

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15 The Task

15.1 Purpose

The envisaged mobile information system will improve the quantity and quality field work of ethnographers by providing computer supported surveillance of people around historico-cultural sites and exhibitions. The aim in surveillance is to enable location-specific media to be delivered on-demand. For example, close proximity to an archaeological relic will trigger or enable the user to see the video of the excavation on the handheld device. The other purpose of the envisaged system is the culmination of an action-based ontology and a narrative.

15.2 Objectives and Goals

The envisaged system would primarily provide content/media in the form of video (with supplementary pictures, graphics, sound, etc.) on mobile devices. The target devices will be limited to PDAs because of the resolution required to view media in the form of video. Previous systems have been platform dependent. Most notably, the proprietary positioning engines have had this disadvantage. The main aim is therefore to support both Windows Mobile and Symbian-based PDAs. Not being platform specific means that we can avoid proprietary solutions, that is, no unnecessary financial burden of purchasing an enterprise positioning system. It also means that there are no "off-the-shelf" non-compliance issues.

Our first objective is therefore to make the content delivery mechanism for the envisaged system. Admittedly, this was in itself a very ambitious task. Although we had originally planned the time, work units and resources, we soon realized that it grew far beyond the scope of INF5261. Without making uncertain commitments to this project, which was neither thesis relevant nor paid work, we conceded to focus upon content delivery. Although a system design is included in this document, it is, by no means, a fair representation of the envisaged system.

15.3 Corrections to the Analysis

Although we envisaged a two-tiered mobile information system, where the first tier of this system is the delivery of content to the handheld device based on a location provided by the user, and the second tier of the system is some kind of movement and management system. It became apparent that such a bisection or modularization of the system was a serious gross generalization.

It would now seem that the envisaged system has three parts; the content delivery, the positioning and the ethnography. The main reason for this critical refocus was due to our lack of knowledge about the depth and variety of ethnography. As such, it would have been erroneous to simplify ethnography to a single activity as analysis. Such a gross trivialization of ethnography could therefore not reflect the true generic nature of our vision. We consequently amended our use case model which is reflected in the design model.

16 Quality Assurance

16.1 Compliance

The main reasons for our choice of Wi-Fi positioning and RFID tagging is range, cost and the near ubiquity of the wireless standard. For very similar reasons, we choose to develop the client with Flash, Perl and MySQL. Using a MySQL database is simple and free. For the purposes of prototyping, Perl presented itself as the best and fastest tool. We choose Flash to create the GUI because Flash is simply the best when it comes to aesthetics, versatility and usability. Compounded with these features, Flash will function equally well in Windows and Symbian-based PDAs.

Nonetheless, such a discursive formation, collective effort and vision are not so easily documented. Therefore, we have consciously maintained a very general and consequently generic standard for documentation to obtain a better overview of the project. It comes as no surprise that the big picture is obviously not the technology in itself but its application. Accordingly, ethnography is central to our theme. In essence, the social relatedness of ethnography, as part of a human-computer interaction research, encompasses the development process and its outcomes. This is a kind of holistic thinking in research and design results in an exemplification - the prototype.

16.2 The Experiential Dimension

There is obviously a critical distinction between applying technological solutions for the sake of technology itself, and applying technological solutions because it presents itself as the best or most beneficial possibility. This is the reason why ethnography plays such a vital role in mobile information systems development. In particular, the enshrinement of this historico-cultural heritage into several different media must have a user's perspective. Usability is therefore a "W.I.S.E." objective. As such the envisaged system must cater for at least four types of touring. The most elementary type of tour would be a quick tour. Quick tours are possibly simple narratives, like audio, passive enough to allow more freedom to roam at will. A more comprehensive tour is a "triggered" tour as well as a more leisurely and educational tour.

The prototype is a full screen application which utilizes the very limited display on the PDA. Although, we initially thought of using thumb navigation, we did not get the time to implement it. However, it is small features like thumb navigation which add to the usability and therefore experiential dimension of the prototype.

17 Technical Platform

17.1 Equipment

- The system is designed for a wireless network and for use on a standard PDA
- PDA's with any web browser, or an independent Flash Player, which supports Flash Player 6.0 or later.
- The network standards are 802.1.1 b\g.
- A Symbian or Windows Mobile operating system.

17.2 System Software

The systems data will be stored in a database available over the network, and accessed via a web server. We have used the following:

- Apache - web server
- mySQL - database
- Perl – back-end code
- AMF::Perl – open-source Flash Remoting middleware

17.2.1 System Interface

The system will be distributed over an internal wireless network. The mobile device will read a position, pass this on to the Flash client which will then request all relevant media at this position to be delivered by the server for viewing.

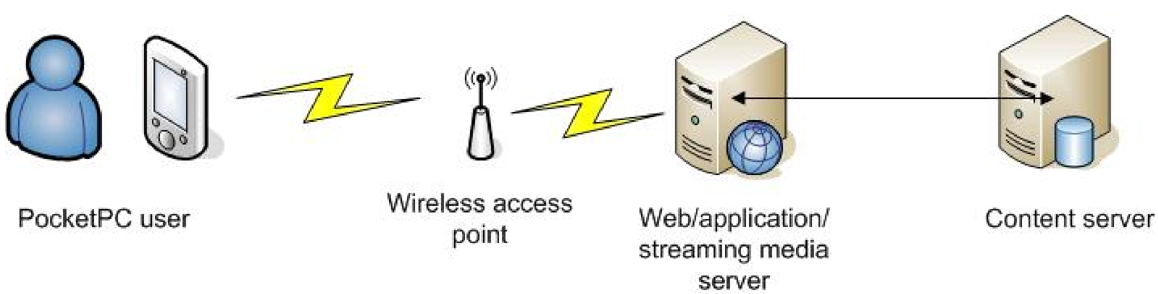


Figure 4 Simplified view of the system interface

18 Design Model

18.1 Use case diagram

Below is the user case diagram for the system showing the various functions that a museum visitor may perform.

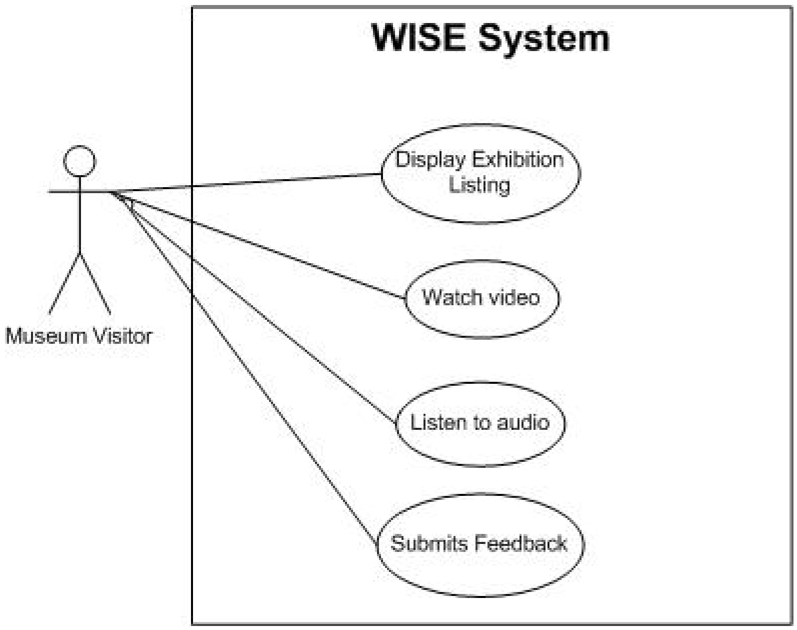


Figure 5 Use case diagram

18.2 Sequence diagram

Below is the sequence diagram showing the various activities between the client and the back-end.

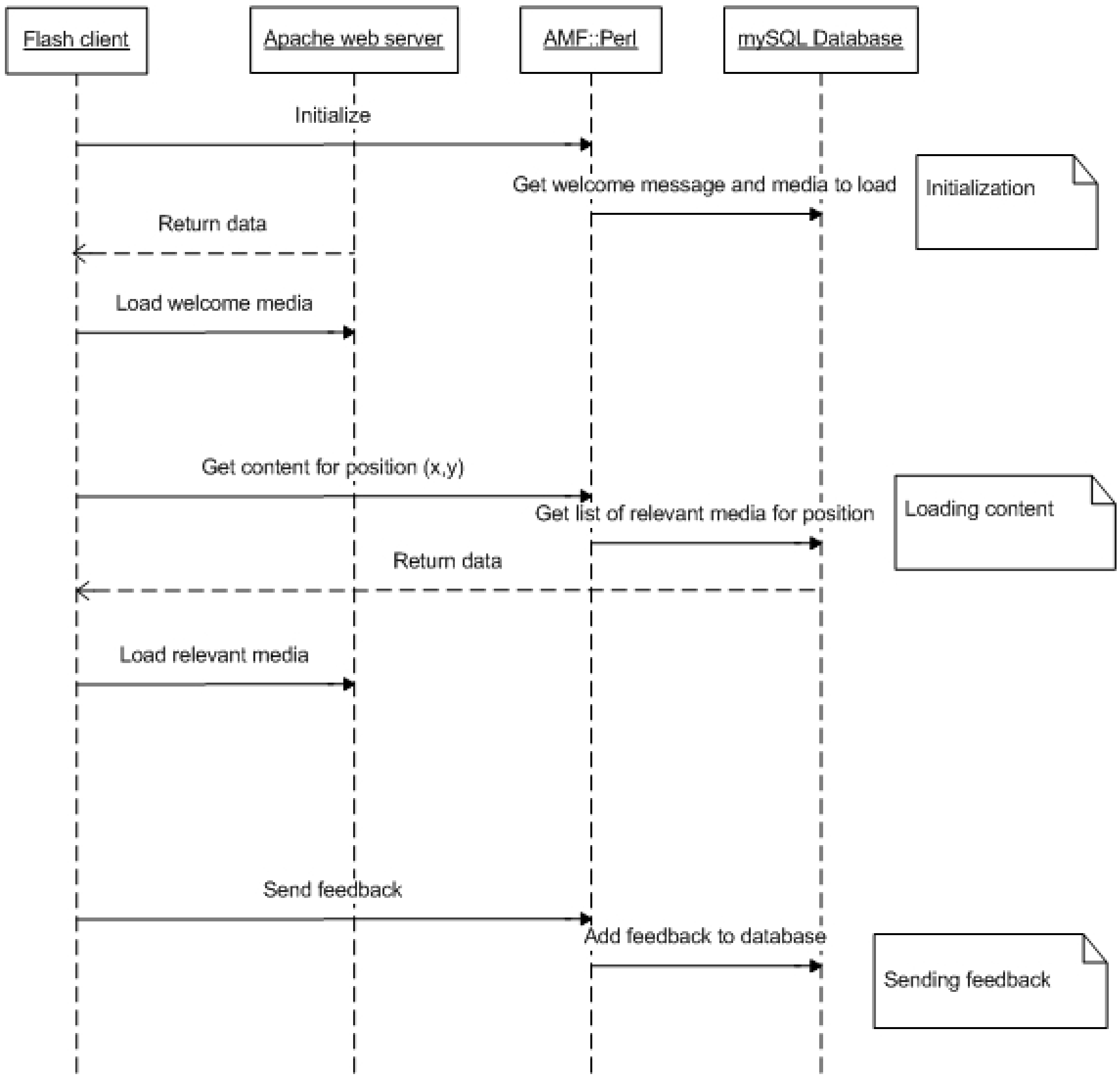


Figure 6 Sequence diagram

18.3 Database model

18.3.1 Description

Table name: **position**
This table contains the x and y coordinates used to position the mobile device. Each set of relevant coordinates will have an associated ID which is then used by the locator table.

Table name: **locator**
The locator table matches the position ID with a relevant media ID, used by the media table to define sets of media for a specific location.

Table name: **type**

This table contains a list of types of media. The name is matched to an existing content table (text, audio, video or image)

Table name: **media**

This table contains the media itself. The ID is not unique so a position may be associated with a media ID (via the locator table), but have several types of media available. The type ID defines which table to look up the content using the content ID.

Tables: **text, audio, video, image**

These tables contain the content itself and/or URLs to where the streaming media (audio and video) can be found.

18.3.2 Model

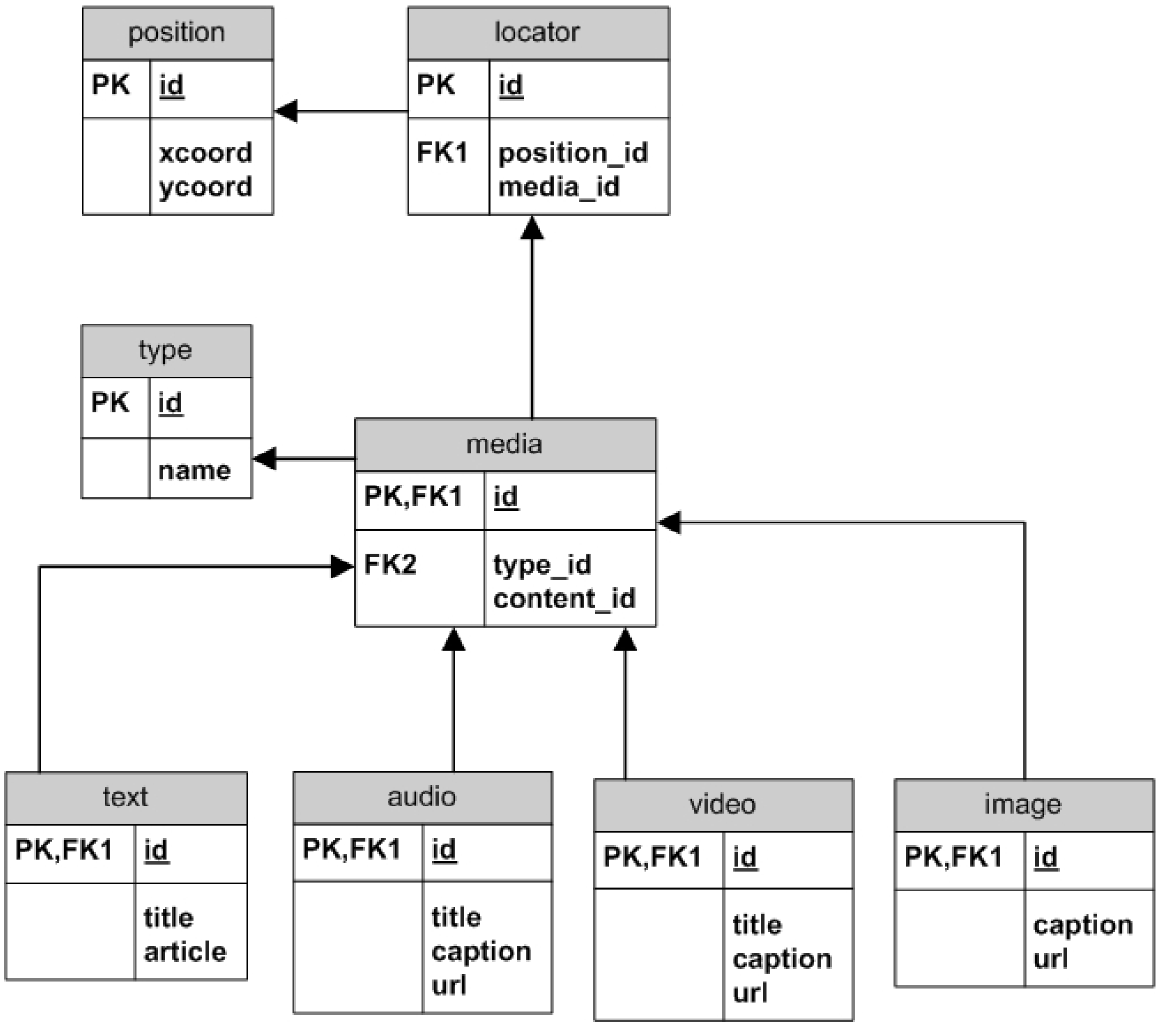


Figure 7 Database model

19 Prototype

19.1 Software

The prototype's user interface was designed using Macromedia Flash MX 2004 Professional and coded in ActionScript. There are many reasons for choosing Flash over other technologies such as VB.NET and Java which are mentioned in the ________________________

The middleware is written in Perl and uses AMF::Perl, an open-source Flash Remoting technology. This communicates directly with the mySQL database which contains all the content and relevant grid positions.

19.2 Hardware

The prototype was tested on a HP iPAQ Pocket PC h6340 running Windows Mobile 2003. The client (a single Flash SWF file) was run using Ant Mobile FlashAssist (www.antmobile.com) which allows it to be run full-screen allowing for a better user experience.

19.3 Hardware and software issues

19.3.1 Video playback

The hardware on the Pocket PC is unfortunately quite limited. Due to this all video had to be downgraded and rendered at 177x140 running at 12 frames per second. This severely limits the "fun factor" but provides a usable and quite stable user experience.

19.3.2 Streaming media

Due to the hardware limitations streaming media was occasionally unstable when streaming from an internet server. However, we envision the media to be located on an intranet server and thus provide a better experience. By publishing the content to a server located at the university itself we were able to diminish some of these issues.

19.3.3 Memory issues

The Pocket PC has limited memory, which was especially visible when displaying various types of media such as video and images at the same time. To bypass these issues the prototype constantly loads and unloads items to limit memory usage.

20 Recommendations

20.1 Future Development

20.1.1 Positioning – the second tier

The second tier of this system would be implementing the positioning system itself. As discussed above, we believe that RFID is the way to go. Socket Communications have developed an RFID Reader Card (http://www.socketcom.com/product/RF5300-542.asp) which sends the tag ID codes it reads to any Windows application as virtual keystrokes.

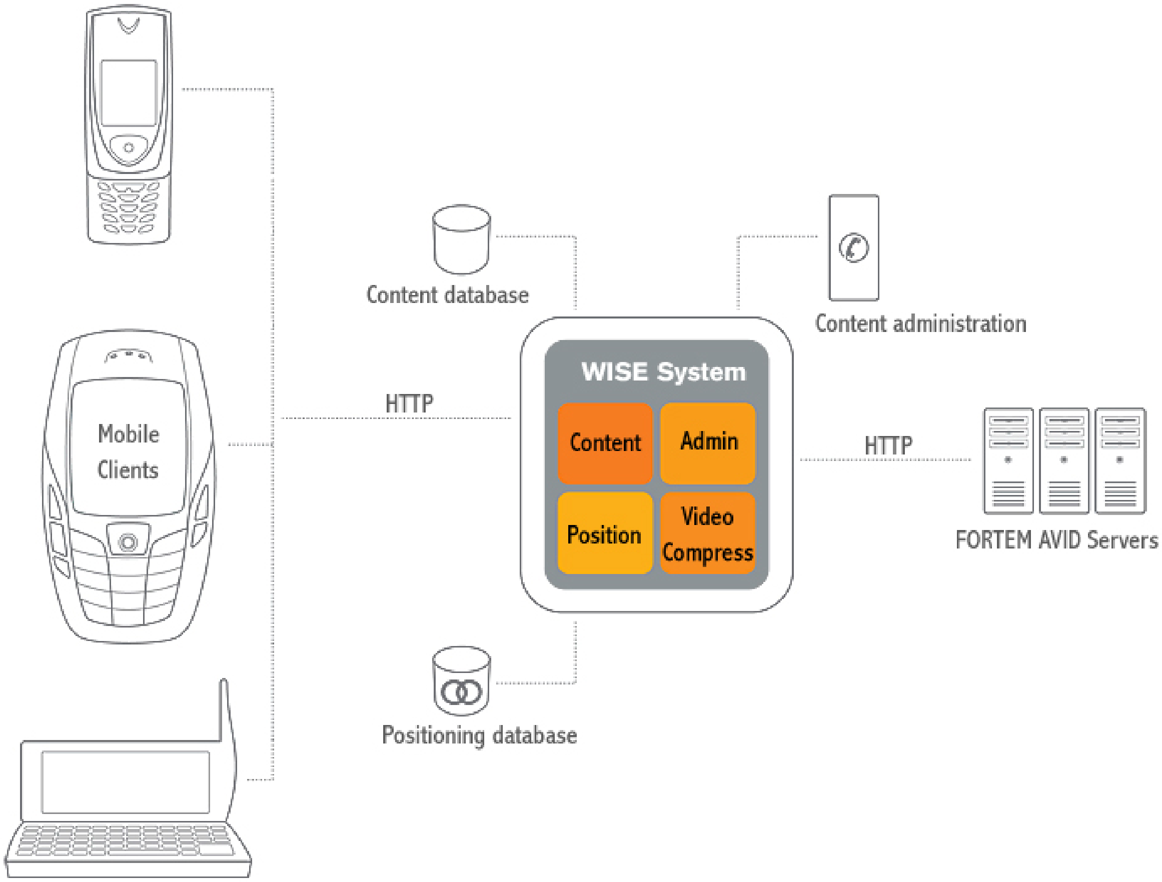
This solution would be perfect for the Flash client, because implementing this new system would simply consist of a key listener that transmitted any received tag IDs to the back-end. The position would be calculated there, any relevant media found and then sent back to the client.

The great thing about this solution is that we would be able to avoid writing a custom C/C++ application to interact directly with the card reader using a provided SDK. This in itself is of tremendous benefit.

20.1.2 Using another wrapper

We chose FlashAssist as the client's wrapper because it allowed us to run the Flash content at full-screen, hiding both the navigation and command bars on the PocketPC. However, it is possible that this is not best way to present the client. Experimenting with another "wrapper" such as a custom VB.NET/C# application (Windows Mobile only) may provide better performance when running the SWF. This however is pure speculation, but is definitely worth an attempt.

20.1.3 Future envisioned component architecture



In the future we envision supporting additional mobile devices when these become powerful enough to deal with streaming video and the Flash Player.

Another addition would be content administration in the form of a web-publishing tool for administrative purposes. On-demand video compression may also be possible, but would probably cause too much overhead.

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