smartmuseum

Project FP7-216923

SMARTMUSEUM

Cultural Heritage Knowledge Exchange Platform

Deliverable D1.2b

Technology and device selection for SM artifact recognition and user data communication

Workpackage WP1 – Local communication and distributed knowledge base access

Task T1.4 - Selection of suitable user hand-held device(s) for demonstrator

Version	**1.2b**	**Date**	Jan. 9, 2009	**Classification**	Restricted	**Status**	Final

Abstract

SMARTMUSEUM (Cultural Heritage Knowledge Exchange Platform) is a Research and Development project sponsored under the European Commission's 7th Framework. The overall objective of the project is to develop a platform for innovative services enhancing on-site personalized access to digital cultural heritage through adaptive and privacy preserving user profiling. Using on-site knowledge databases, global digital libraries and visitors' experiential knowledge, the platform makes possible the creation of innovative multilingual services for increasing interaction between visitors and cultural heritage objects in a future smart museum environment, taking full benefit of digitized cultural information.

The main objective of this deliverable is to specify the user hand held devices to be used for the demonstrator. The devices selected support selections of T1.3 for distributed memory label access and are suitable for demonstrating applications selected in T1.1. They also support GPS/Galileo based positioning, mWLAN.

Revision history

Jan 2009: Updated version – D1.2b with new user device selection created.

1.5 -1.6 Partner's review, 1.1 – 1.4 Updates regarding PDA, smartphone technical testing,

1.0 25.06.08 Technical update included regarding HP PDA and Innovision tags

0.9 Meeting at Florence

0.1 Demonstration of Hyundai PDA with ISO14443 tag access at kick-off meeting.

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Executive Summary

The main objective of this deliverable is to explain selection criterias of museum artifact recognition technologies and user hand held devices to be used for user activity monitoring and assistance for SMARTMUSEUM solution. The deliverable is based on conclusions of SMARTMUSEUM system main architecture and user scenario document, it is main input for WP5 activities.

The report is dedicated for consortium internal and EC use.

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1 Document structure and focus

This document is divided in the following main parts:
1. Description of selected use scenarios and user needs.
2. Selection of (RFID) technologies for OOI recognition and user interest monitoring.
3. Selection of user mobile devices to be used for access of SMARTMUSEUM services, which are compatible with D1.1 and selected object recognition devices.

Changes from version D1.2a to D1.2b are shown in italic.

1.1 Abbreviations

The abbreviations of deeply technical wireless communication terminology used at smartphone specification tables are not listed below.

ASK - Amplitude shift keying, a radio wave modulation method
HCI – Human command interface
CPU – Central (application) processor of a hardware device
IC – Integrated circuit
NFC – Near field communication, magnetic coupling based short range communication in 13.56MHz band
MID – Mobile Internet device
OOI – Object of interest
OS – Operating system
POI – Point of interest
RFID – Radio frequency identification
TBD – To be determined (later)
WLAN – IEEE802.11a/b/g wireless lan communication
UD – User device
WM – Windows Mobile

1.2 Deliverable purpose, scope and context

The overall objective of the SMARTMUSEUM project is to develop a software and hardware platform for innovative services enhancing on-site personalised access to digital cultural heritage.

The main objective of this deliverable is to describe the selection criteria of OOI recognition technologies and components (T1.3) and suitable user hand held devices compatible with SMARTMUSEUM general architecture (D1.1). The selected devices have to be capable for applications selected in T1.2 for final demonstrator and follow the worldwide trends of mobile communication and personalized services to create the actual market value for SMARTMUSEUM results at the end of project.

The technologies and actual devices of SMARTMUSEUM solution have to

- support applications of final demonstrators as described in D1.1[1],
- be compatible with the system's architecture described in D1.1,
- follow market and technology trends of mobile devices,
- be based on hardware and software components of leading vendors to guarantee their long term availability and support.

The intended audience of D1.2 includes:

1. Primarily SMARTMUSEUM Partners involved in developing the user application software for mobile device(s) including low level communication mechanisms and graphical user front end programming (WP3).
2. Project partners involved in integration (WP5).

1 http://smartmuseum.eu/wiki/images/b/b6/D1.1_Deliverable_Architecture_and_scenarios.pdf

2 SMARTMUSEUM requirements towards the user devices

As defined at D1.1, two main scenarios will be supported by the SMARTMUSEUM solution:

- **Inside scenario –** user visiting a museum**.** This scenario may include outside tours on territory of the museum when artifacts or other OOIs are equipped with RFID tags or numbered. Main communication method for databases is wireless LAN, user device shall be optimized for multimedia applications.

- **Outside scenario** – the user is making an outside tour (for example in a city, or visiting some cultural heritage areas) and he/she is identifying large objects. This scenario assumes that user carries personal cellular phone which may not have RFID reader and has GPS/Galileo receiver instead. Main communication method is GPRS or other paid service.

Due to the present technological limitations, especially regarding high-end NFC phones/MIDs, for short term applicability of SMARTMUSEUM solution two different devices will be used:

1. **User device for museums** - This device will be museum owned as traditional audio guide device with extensive multimedia capabilities and HF RFID support. The device shall be optimized for maximum multimedia performance as requested by user needs evaluation[2] and therefore should have powerful processor, standard user interfaces and durable design. After the project end those devices will be used continuously at participating museums.
2. **User owned SM device** – This device is a conventional smartphone with GPS/Galileo receiver, owned by the SM user that supports and contains the SM software and can be used at any museum supporting the SM solution and for finding other OOIs. HF RFID support is additionally recommended, not obligatory feature. A typical smartphone should be selected to validate the SMARTMUSEUM solution applicability in everyday life.

2.1 Evaluation of user and museum needs

The user needs evaluation is shown in Table 1. Around 80 persons were interviewed. M-AWG represents average rating of IMSS and HM representatives. HM-Pro shows average of selected professionals (curators, art historians, enthusiasts) interviewed at HM. U-AWG represents rates of nonprofessionals (members of SM teams, walk-in tourists).

The analyze can be concluded as:

- both users and service providers are interested in getting/offering suggestions to related items, other places of similar topics,

- users and service providers are interested in optimal visit plans,

2 http://smartmuseum.eu/wiki/index.php/WP1

- users and service providers are interested in full multimedia experience,
- museums are looking for better statistics,
- users are interested in site load balancing and experience sharing.

SMARTMUSEUM applications and their rating	HM-Pro	M-AWG	U-AWG
Collecting external URLs during museum visit (bookmarking for trip).	3,8	0,0	3,0
Proposing visiting plan/itinerary.	4,5	4,0	4,2
Full contextual multimedia experience.	4,5	4,0	4,1
Audio.	4,5	2,5	3,8
Suggestions to related (inhouse) items (ontology, location etc. based matches)	4,5	4,0	4,1
Recommendation system (other users with similar? profiles).	1,8	2,0	2,4
User load balancing (proposing different routes for visitors).	3	1,0	3,7
Gathering statistics of visits: room statistics, time statistics.	4,3	4,0	3,3
User feedback, rating and voting.	3,8	3,5	3,6
Creating user logical networks (of people with similar interests) during visits.	1,5	3,0	2,2
Storing user comments/knowledge to RFID tags (predefined or moderated).	3,3	4,0	3,1
RFID based guidance (for storing information messages), e.g. for navigation.	3,3	3,0	2,9
Proposing other museums/places with similar or related topics.	4,8	4,5	3,9
Outdoor tagging (incl active tags): suggestions to come in for a visit.	4,5	4,5	3,2
Find similar restaurant/museum: based on social network knowledge.	4	3,5	3,1
Extended profiling (for food, traveling, lifestyle).	3	0,0	2,7
Educative interactive games.	3	3,3	3,1
Publishing visit information on the web (user preference!).	2,5	3,5	3,0
Purchase recommendations based on visited items or tags.	2,3	4,0	2,6

Table 1 User preferences

From perspective of user device technical parameters the analyze demonstrates importance of multimedia capabilities. Other preferences do not have direct impact to technical requirements of the devices.

2.2 Required technical features of user device

The required features can be described as follows:

- **User positioning** – User position estimation with accuracy of ±10m (outdoor) or room grid (indoor, by map presence). The main attention shall be on a satellite reception (GPS, Galileo) based positioning methods. Due to the lower accuracy, the positioning using cellular network base station grid is left out of the scope of the project.
- **Object of Interest recognition** – Detecting that certain object is interesting for the SM user. Feedback can be received through RFID tag access recognition of user commands monitoring reading, through manual OOI selection from HCI based on GPS or any other positioning information.
- **Multimedia content presentation –** File playback and streaming, mobile audio and video multimedia formats: AVI, H264 (MPEG-4 AVC), H263, RealAudio, MP3, AAC satisfying generic quality requirements.
- **Content storage** – Onboard media storage for preloaded digital content.

- **Audio synthesis** – Capability of text to voice synthesis (recommended feature).
- **SMARTMUSEUM database access –** Generic web browsing capability to access the digital content and user profile databases over wireless networks meeting privacy requirements.
- **Application software support –** There will be background application software running on user device monitoring user location, collecting user-OOI interaction information. The user device should provide a usable GUI in order to control the application software regarding privacy and activity level.
- **Personal area networking –** The feature to establish automated communication with neighborhood user devices for broadcasting user interest data if requested by user.
- **RFID tag administration** – application software that allows to update the content of tags.
- **Mechanical durability** – Device design should be suitable for heavy usage.
- **Software portability** – Mainstream operating systems should be used to minimize application software porting costs.

The museum owned user device shall be optimized for SMARTMUSEUM indoor scenario. User owned device shall be optimized for outdoor scenario.

Feature	**Technology**	**Quality requirements**	**Comments**
User positioning	WLAN	standard	main technology
	Bluetooth	standard	secondary technology
	HF RFID	standard	supporting technology, pull mode
OOI recognition	HF RFID	standard	
Multimedia content presentation		high	powerful CPU ≥300MIPS
Content storage		high	≥ 2GB
Audio synthesis	TBD	standard	existing speach synthesis technology to be used
SMARTMUSEUM database access	web browser	standard	WLAN or GPRS/xG connectivity
Application software support		standard	
Personal area net-working for "friend-finder" feature	WLAN	standard	Selection between WLAN and BT to be made later
	Bluetooth 2.0	standard	

RFID tag administration		standard	
Mechanical durability		high	
Software portability		high	Mainstream OS to be used
Display size		≥ 3.5-inch	Recommended size

Table 2 Museum owned user device requirements

Feature	**Technology**	**Quality requirements**	**Comments**
User positioning	GPS/Galileo	standard	main technology
	Cell/WiMax/LTE network base station	standard	secondary technology
	HF RFID	standard	supporting technology, pull mode
OOI recognition	GPS/Galileo	standard	location based object recognition
	HF RFID	standard	
	User manual input		
Multimedia content presentation		standard	limited by screen size, battery and wireless channel throughput
Content storage		standard	≥ 64MB
Audio synthesis	TBD	standard	manufacturer dependent
SMARTMUSEUM database access	web browser	standard	
Application software support		standard	
Personal area networking for "friendfinder"	WLAN	standard	Selection between WLAN and BT to be made later
	Bluetooth 2.0	standard	

Wide area networking	HSDPA (3G+), UMTS (3G)	standard	
	EDGE (2.75G), GPRS (2.5G)	standard	2G access is used as "fallback networks" when no 3G is present
RFID tag administration		NA	
Mechanical durability		standard	
Software portability		standard	Mainstream OS-s to be supported
Display size		≥ 2-inch	Average display size

Table 3 User owned user device requirements

3 Museum artifact recognition and user activity monitoring

Position based (large) object recognition for street scenarios is out of scope of present chapter and will be described in user mobile device selection chapter. SMARTMUSEUM is not targeting any new developments in physical layers of wireless communication.

3.1 Optical and RF identification

By museum indoor case, where precise item pointing is essential, two alternative object recognition technologies can be used: optical 2D barcode (e.g. QR code, Fig. 1) and short range passive radio identification (RFID). By both cases labels can be installed on glass case close to the artifact.

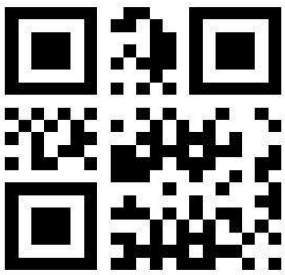

Figure 1 QR code label example

The advantage of optical recognition is that no extra hardware is needed in case of camera phones, the disadvantages are weak read dependability and online communication presence required. RFID tags have countable price of 0.05-2 EUR depending on technology and require a special reader hardware. Details will be given below. Advantages are label writability, relatively high read rate for short distances, presence of internal memory by certain technologies.

In SMARTMUSEUM like applications (e.g. Postmuseum in Stockholm, UbiLife people support project in Finland[3]) RFID based object recognition is more widely used compared to barcode labels. Both technologies are used in Japan for outdoor public information services, including tourist navigation assistance with trends towards RFID technology.

3.2 Selection of SMARTMUSEUM RFID technology

In SMARTMUSEUM application context the RFID system can be characterized by read range and tag capacity. Only passive, power source less tags are considered for the museum application. The optimal tag access range for SMARTMUSEUM applications, depending on average object density on cases shall be around 10cm. Read range mainly depends on operation frequency and coupling (magnetic or electric field) method. Inductive (magnetic) link solutions operating in gigahertz range, e.g. short range UHF EPC Gen2[4] RFID or passive TransferJet[5] are in development phase yet. Therefore, by simplified understanding low operating frequencies mean short RFID tag access range (< 0.2m) and vice versa by portable devices. It has to be noticed that operation frequency ranges of readers vary in different continents, especially important in UHF range and therefore universal UHF mobile RFID devices are very unlikely to become available. Main properties of leading technologies are listed in 4.

Based on the data presented in 4 potential candidates for SMARTMUSEUM artifact recognition technologies are UHF RFID and HF RFID. As stated in D1.1 architecture

3 http://www.ubilife.fi/
4 http://www.epcglobalinc.org/home
5 http://www.sony.net/SonyInfo/News/Press/200801/08-002E/index.html

document, offline data access should be supported. The largest UHF tag IC available at the moment - UCODE HSL[6] from NXP (ISO 18000-6B) is going to be obsolete, the latest NXP IC G2XM contains 240 bit EPC area and 512 bit user memory, neither satisfying SMARTMUSEUM needs. Based on the reasons listed HF RFID technology is the only suitable for the project. From technological side it is reasonable to embed UHF reader into the cellular device and perhaps after five to seven years it could be optimal to use magnetic link UHF tags for SMARTMUSEUM like applications.

	Low Frequency LF	**High Frequency** HF	**Ultra High Frequency** UHF	**Microwave** uW
Frequency range	30-300 kHz	3-30 MHz	300-1000 MHz	2-30 GHz
Main operating frequencies	125-134 kHz worldwidely	13,56 MHz worldwidely	433 MHz worldwidely, 902-928 MHz USA, 865-868 MHz EU, 950-956 MHz Japan, 920-925 MHz China	2,45 GHz worldwidely
Read range (<1W radiated power or max allowed)	1-7 cm	1-7 cm	up to 4 m	up to 1 m (0,5 W ERP)
Access speed	below 1 kbps	up to 1 Mbps	usually 40-160 kbps	usually 10
Tag data space	ID only	Up to several kilobytes, largest tags so far	Up to 0,5 kB, expected to increase in the further	Usually ID only
General comments	Slow, expensive tags, handheld readers available	Some cell phones include reader, well and worldwidely standardized, medium tag price	Simple and cheap tags, reader configuration depends on region	Rare, most popular in Japan
Existing standards	ISO 11784, ISO 11785	ISO 15693, ISO14443A,B	ISO 18000-6B,C	ISO 18000-4
Relevance to SM solutions	low	highest	medium	low

Table 4 Leading RFID technologies in SM context

6 http://www.nxp.com/acrobat_download/literature/9397/75011867.pdf

3.3 Description of HF RFID standards

High frequency (HF) vicinity RFID communication is specified by ISO 15693, ISO 14443 standards. The first one, targeted for tags containing only ID and becoming popular for single use transport tickets is out of the project focus. ISO 14443A corresponds to tag brand Mifare from NXP/Philips most widely used in the world. The conventional access speed is 106kbps, modulation schema is 100% ASK, Miller encoding. Sony developed competitive IC under brand FeliCa working at 212kbps 10% ASK modulation depth with Manchester encoding. Both modulation schema support speeds up to 1 Mbps, access range for handheld devices is 2-5 cm due the power supply limits. FeliCa (not ISO standardized) is widely used in Far-East. The most of reader ICs support both standards, meaning devices bought in Japan should work in Europe with European ISO14443A tags. The same IC can read ISO 15693 tags as well, making 13.56MHz RFID technology extremely flexible and universal.

Joint venture between NXP and Sony was established in 2007 to produce universal chips, showing continuation of related technology development around the world for the next years. Mifare is the most widely installed contactless smart card (technically RFID tag with large memory and secure microcontroller) technology in the world with about 1.2 billion smart card chips and more than seven million reader modules sold (Contactless News, 2006). FeliCa ICs shipment was 170 million units in 2006 and 30 million of these are mobile FeliCa chips for use in mobile phones (osaifu-keytai[7]) in Japan. From instrumentation point of view those phones should be compatible with proposed SMARTMUSEUM tag access solution. Based on information of NTT DoCoMo there were over 200000 contactless payment terminals installed in Japan (Sept. 2007) and 3.7 Milions of DCMX service subscribers. The number of RFID based contactless payment service subscribers increased 5 times in one year[8]. Booming of cellular RFID technology can be expected in Europe as well creating technological base for wide usage of SMARTMUSEUM solution.

3.4 HF RFID Tag selection

The security features of HF tag access are not relevant in the present project context. The most essential parameter for tags to be selected is data area. Suitable tags for SMARTMUSEUM include:

1. ISO14443-A, NXP Mifare Standard 1k tags with total memory size of 1 kbyte, writable memory 720 characters[9],
2. ISO14443-A, NXP Mifare Standard 4k tags with total user memory size of 3480 bytes[10],
3. ISO14443-A, NXP Mifare DESfire tags with total writable memory size of 7 kbytes[11],
4. It is recommended to use tags compatible with NFC Forum 1 specification, e.g. Topaz, Jewel tags from Innovision[12]. So far the largest tags available contain 96 bytes of rewritable and 6 bytes of OTP memory that is insufficient for most of SMARTMUSEUM applications.

7 http://www.nttdocomo.co.jp/english/service/osaifu/index.html
8 http://www.nttdocomo.co.jp/english/corporate/ir/binary/pdf/library/presentation/080108/all_e.pdf
9 http://www.nxp.com/acrobat_download/other/identification/M001053_MF1ICS50_rev5_3.pdf
10 http://www.nxp.com/acrobat_download/other/identification/M043541_MF1ICS70_Fspec_rev4_1.pdf
11 http://www.nxp.com/acrobat_download/datasheets/MF3ICD8101_SDS_N_1.pdf
12 http://www.innovision-group.com/products.php

Data retention time of all those tags is 10 years and maximum access speed up to 848 kbps.

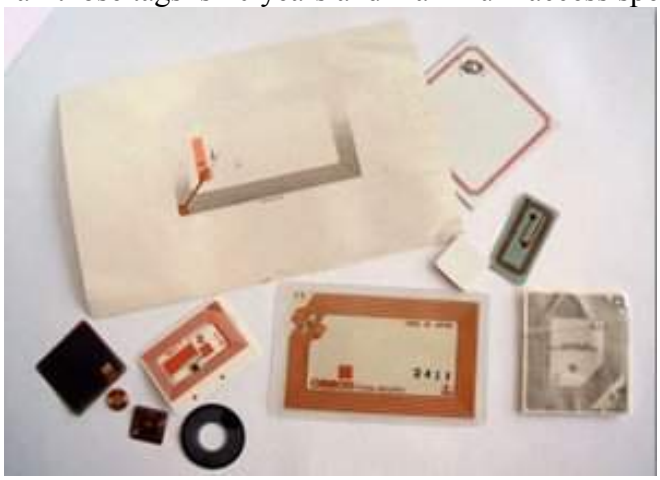

Figure 2 HF RFID tags[13]

Some 13.56 MHz tags are shown on the Figure 2. The data area of tags should be protected for read only purposes. Tags with project logo should be purchased for museum installation. Procurement negotiations started with Confidex, Ltd., Finland. Nokia supports for their existing and coming low end NFC phones (Series 40 OS) NFC type 1,2, Mifare 1k and 4k tags.

3.5 HF RFID reader module selection

Nokia 6212 Classic NFC phone was tested by ELIKO. There are no consumer level PDA or MID device available on European market with built in RFID reader. Attachable HF card reader has to be used for museum device. The market analysis showed that the reasonable RFID reader options are:

- SD card reader (for museum device),
- Bluetooth reader to be used with any other phone.

The suitable devices found are:

SDID 1020 from Wireless Dynamics[14] and Cathexis Bluetooth RFID pen reader[15].

Figure 3 Selected RFID access devices (not in scale).

13 http://www.rfidc.com/docs/introductiontorfid_technology.htm
14 http://www.wdi.ca/docs/SW06-0008-DS%20-%20SDiD%201020.pdf
15 http://www.cathexis.com/products-and-services/idblue%E2%84%A2-hf.aspx

The WDI SDID device and its software were tested by Apprise with Hyundai PDA and ISO 15693 compatible tags.

Figure 4 RFID technology PDA test set

Hyundai Win Mobile 5.0 PDA with WDI RFID reader attached.

Figure 5 RFID technology test set with HP iPAQ 214 Enterprise Handheld

iPAQ 214 PDA withWDI RFID reader attached.

Figure 6 RFID technology test set with Nokia 3220 NFC phone

Nokia 3220 NFC phone with sample HF RFID tags.

Figure 7 Figure 8 Japanese KDDI (AU) RFID enabled RFID phone

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A Japanese phone using competing FeliCa HF (ISO-14443A noncompliant) RFID technology. Universal reader ICs are expected to be available in 2010.

4 User device selection

This section describes actual selection of museum- and user owned guiding devices to be used for SM demonstrator. The museum owned device will be used in real service at IMSS and HM. The user owned device shall be selected as a typical (high end) smartphone presenting the performance and feature of market leading devices.

4.1 Market watch of suitable user multimedia devices

In order to select the most suitable device (and operating system) for the SMARTMUSEUM, an analysis was made based on some of the above questions that are considered to be more relevant to the project and feasible within the task T1.4 scope.

During 2008, smartphones will strengthen their position on the market by drawing huge attention as a result of intensifying competition among the players, who are trying to secure a more attractive handset line-up. The smartphone market is still growing very healthily, as expected, 72% year on year. It is expected to be near the 200 million smartphones sold in 2008 mark in 11 months time. In 2008, smartphones will occupy 22% of the entire mobile device market, helping increase web-based services on the mobile network. The market for smartphones will grow from around 10% of the total handset market in 2007 to 31% of the market in 2013.

Of the annual figures, Nokia shipped over 60 million of the 118 million total, with just over half the market, with RIM in second place on 12 million, with noone else (including HTC, Motorola and Sony Ericsson) even getting close. The market share of RIM, Apple are increasing and Nokia's own slowly decreasing[16]. Nokia's market share has held pretty steady too, showing that S60 and Symbian OS are still working out very well for them.

The smartphones are taking over the functions of (high end) multimedia PDAs. For example, coming SonyEricsson Experia has ARM11 CPU running with 520MHz and HP iPAQ914 has PXA320 CPU running the same speed. Both devices employ Windows Mobile OS. However, to have broader field of potential SMARTMUSEUM solution users, less powerful (user owned) smartphone devices should be supported as well.

Looking more specifically at the stats from Q4 of 2006-2007:

16 http://www.smarthouse.com.au/Phones/Industry/T4H4E7U5, Sept 2008

Worldwide converged smart mobile device market
Market shares Q4 2007, Q4 2006

Vendor	Q4 2007 shipments	% share	Q4 2006 shipments	% share	Growth Q4'07/Q4'06
Total	35,522,360	100.0%	20,667,200	100.0%	71.9%
Nokia	18,802,480	52.9%	11,114,630	53.8%	69.2%
RIM	4,046,860	11.4%	1,829,260	8.9%	121.2%
Apple	2,320,840	6.5%	-	0.0%	NA
Motorola	2,301,260	6.5%	1,463,090	7.1%	57.3%
Others	8,050,920	22.7%	6,260,220	30.3%	28.6%

Source: Canalys estimates, © canalys.com ltd. 2008
Converged smart mobile device market: smart phones and wireless handhelds

Figure 8 Smart mobile device market Q4 2006 and Q4 2007

For high-end PDAs and MIDs performing over 300MIPS, to be referred as museum owned devices in the SMARTMUSEUM context, the market is shared between OSs[17]: Palm OS - 14.9% (declining), Windows Mobile - 49.2% (increasing), RIM Blackberry - 25.0% (increasing), Symbian OS - 5.8% (increasing), Linux kernel based OSs - 0.7% (stable), others - 4.4% (stable).

The iPhone (400MIPS application processor with dedicated video decoder) and RIM devices were left out of focus of current project because of lack of required iPhone and Blackberry OS expertise and missing RFID hardware support.

In terms of OS, Symbian OS powered 67% of all smartphones (incl. low end devices) sold during the year, with Microsoft's Windows Mobile on 13% and RIM's Blackberry on 10%. The highest computing performance among the Symbian based devices have Nokia N96 with its ARM9 family CPU (ca 330MIPS), Samsung SGH-G810 OMAP2430 (ca 330MIPS). Around 116 million smartphones were shipped in 2007, meaning market-share of about 67% for Symbian and less than the 72% market-share it had in 2006. However, if we look at Symbian's share of the overall handset market, it grew from about 5.1% in 2006 to 6.7% in 2007. The better way to evaluate performance of Symbian and other OS vendors would be to look at the market-share they have of the total handset market and not just the smartphone segment. It is important to remember that smartphone segment is the fastest growing segment in the handset market - just over 10% of total handsets shipped in 2007 were smartphones, but by 2012 over 25% of total handset shipments will comprise of smartphones. This means that OS vendors including Symbian can continue to earn strong profits even while losing smartphone market-share, simply because in terms of handset units, 70% of smartphones shipped in 2007 will be less than 40% of smartphones shipped in 2012. Therefore, OS vendors will continue to profit as long as they keep achieving growth in terms of smartphone shipments.

17 http://en.wikipedia.org/wiki/Pda

Open Handset Alliance including the Google-Android initiative and Nokia's recent acquisition of Trolltech are seen as developments in favour of Linux[18]. All this is true but Linux is still way behind to be in a position to challenge Symbian's market dominance. Further, Symbian's agreements with various industry players including handset vendors and large number of operators means that it will continue to be the major handset OS vendor for a good number of years to come. *Only one Android based smartphone (GPhone) was available for TMobile networks at the end of 2008 (by HTC) making its evaluation too complex for SMARTMUSEUM solution.*

4.2 User device core hardware components

This section specifies recommendations for CPU selection. The second component of high importance – the LCD screen – shall be maximized by size and resolution for museum owned user device, no specific technical requirements apply.

As described earlier, museum owned user device shall be maximized for multimedia performance mainly limited by application processor the screen size should be at least 3,5". User owned device, optimized for size and weight (display size 2-3"), has weaker computing performance requirements and is out of scope of this CPU selection section.

Devices from HTC, HP, Asus, FujitsuSiemens, Nokia, RIM, Dell, Apple were analyzed to select suitable, multimedia presentation optimized museum device. This selection is not relevant to user owned device due the weaker computational power requirements. The central processors candidates include Marwell 270, 320 XScale series up to 620MIPS, TI OMAP family, Samsung SC32400 family up to 400MIPS, ARM11 and 9 up to 530MIPS. The majority of high-end smartphones are based on Marwell CPUs well supported under Windows Mobile and Linux, both environments were tested by ELIKO. HTC is using more rare ARM1136 CPU, Nokia 770 and 800 Internet handheld and E90 Communicator are based on OMAP CPUs that may be more weakly supported as well. Devices based on (not XScale) ARM and TI CPUs are less recommended for SMARTMUSEUM museum owned device because may need more development effort. There are currently no modern MIDs in production having dedicated video accelerator similarly to obsolete Dell Axim 510. However, based on consumer reviews Marwell 320 devices have close multimedia performance comparing with the top performing Axim 510 device. SMARTMUSEUM like projects use Dell Axim, (Postmuseum in Stockholm), iPAQ family (Trento adaptive museum guide hardware solution)[19].

18 http://www.abiresearch.com/Blog/Wireless_Blog/472, Jan 2008
19 http://www.cri.haifa.ac.il/

4.3 User device OS selection

Besides the specific SMARTMUSEUM requirements towards the selection of the suitable user device that were identified in the previous sections, there exist a variety of other criteria that influence the selection process. In the following section we will try to define those criteria and to answer to some of them that are relevant to the project objectives.

The operating system in handsets is the focus of attention. High saturation in developed markets means that carriers can no longer compete on price and tariff alone to capture new subscribers. Carriers need to differentiate themselves at all levels (handsets, services, and user interface) to achieve growth and protect their own subscriber bases. Additionally, generating higher data revenues is critical as carriers cannot continue to grow their businesses on voice services alone. Therefore, the OS is becoming increasingly important as devices need to evolve to support more complex service offerings from carriers.

Careers play an important though invisible role on the SMARTMUSEUM scenarios as well.

There are some general questions listed below within this context:

- What are the key drivers, barriers, and latest trends influencing the smartphone market?
- What are the high-level business and technology issues and critical considerations for addressing the smartphone market?
- What can handset vendors, OS vendors and mobile operators do to increase smartphone adoption?
- How are silicon vendors and application developers influencing the smartphone market?
- What are some current and future feature sets of smartphones?
- What recent developments in smartphone hardware components have occurred?
- What is the impact of handset royalties on the smartphone market?
- Why is there increasing interest in smartphone operating systems?
- What does a SWOT analysis of all major smartphone operating systems reveal?
- Who are the key industry players and what are their initiatives for the smartphone market?
- What are the detailed forecasts for smartphones and the smartphone OS market?

Based on partners' competences, Windows Mobile (WM) and Symbian are considered for SM demonstrator – WM for (high end) museum owned device and Symbian as the market leader OS of smartphones for presenting typical user owned device.

4.4 Windows Mobile OS overview

Windows Mobile (WM) is a Microsoft embedded operating system combined with a suite of basic applications for mobile devices. It is based on the Microsoft Win32 API. Mobile powered devices able to run Windows Mobile include smartphones (cellular connected devices) and PDAs (disconnected devices).

Originally appearing as the Pocket PC 2000 operating system in April 2000 and based on Windows CE 3.0, Windows Mobile has been updated several times. The current version Windows Mobile 6.0 (based on Windows CE 5.2) has been released in February 2007 (a minor upgrade, WM 6.1 appeared in April 2008). This last major version optimized for flexibility and modularity will be used in SM within the "inside scenario". The next release of WM is scheduled for 2010.

Microsoft has officially retired the terms « Pocket PC » and « Pocket PC Phone Edition ». In the future, conventional terms will be used when refering to WM 6 powered UD: « WM 6 standard or professional » for smartphones, and « WM 6 classic » for PDAs.

Evaluation of WM 6.0 multimedia presentation capabilities showed that the content should be stored in WMF file format.

WM releases 6.0 / 6.1 contain a set of new features, among them :

- .net compact Framework preinstalled in ROM
- AJAX and Javascript support in Internet Mobile Explorer
- VoIP support
- UMA (Unlicenced Mobile Access) support
- Improved Bluetooth stack
- Voice command (optional)

4.5 Usage of Windows Mobile OS

For software developments, two main options can be used when implementing a mobile application:

- writing « native code » with Visual C++,
- writing « managed code » that works with the **.NET compact Framework.**

The .NET Compact Framework is a subset of the .NET Framework. It consists of the base class libraries and has additional libraries that are specific to mobility and device development. The .NET Compact Framework runs on a high performance JIT Compiler. The Common Language Runtime (CLR) is built from the ground up to be specific to the .NET Compact Framework so that it runs more efficiently on small targeted devices that are limited in memory and resources.

In context of the SM project, the .NET Compact Framework can be used for:

1. Rapidly developing mobile applications.
2. Developing applications that take advantage of Web services or data in XML.
3. Developing applications by using either Java or C#.
4. Developing applications that users can move to different devices with different CPUs or a variety of Windows versions.

4.6 Symbian OS overview

Symbian OS is the world-leading open operating system that powers the most popular and advanced smartphones today from the world's leading handset manufacturers. It is being developed by Symbian Ltd, a software licensing company that supplies the operating system for many data-enabled mobile phones. With over 110 million Symbian smartphones shipped, high smartphone growth in developing markets, and increasing mass market requirements, Symbian's addressable market is broadening across segments and regions. Symbian based phones are most popular in Japan (most of the NTT DoCoMo Foma series devices) as well that is important in SM user context. Symbian OS v9.5, the latest evolution of Symbian OS, delivers over 70 new features for high-performance, more powerful smartphones at mass market costs.

The SM partner - WebGate has Symbian experiences and interests to commercialize outputs of SM projects.

Symbian OS technology has been designed with these key points in mind:

1. to provide power, memory and input and output resource management specifically required in mobile devices
2. to deliver an open platform that complies with global telecommunications and Internet standards
3. to provide tools for developing mobile software for business, media and other applications
4. to ensure the wide availability of applications and accessories for different user requirements
5. to facilitate wireless connectivity for a variety of networks

4.7 Usage of Symbian OS

Nokia has made Symbian OS its strategic choice for smartphone operating systems. Nokia S60 Software, currently the most widely used software platform in the smartphone market worldwide, runs on Symbian OS - as does the advanced Nokia Series 80 Communicator devices. The Symbian OS-based Nokia Series 90 platform delivers touch screen technology and an advanced software development environment for media-rich applications. The number of Symbian handset announcements at 2007 year's Mobile World Congress including four handsets from Nokia (N96, N78, 6210 Navigator and 6220 Classic), the KT610 handset from LG, and the G810 handset from Samsung, also indicate a strong start for Symbian in 2008.

What are the benefits of Symbian OS?

1. Wide selection of applications available for a range of mobile phones
2. Implements industry standard protocols, interfaces and management services for IT system integration
3. Application development using industry standard Java and C++ languages
4. Extensive connectivity options - including GSM, GPRS, CDMA, WCDMA, WiFi and Bluetooth

What are the drawbacks of Symbian OS?

- Lack of devices with RFID readers regarding EU market. (We have reasons to believe that RFID enabled devices will appear in the near future; however, this information comes from unofficial sources.)
- Too many UI platforms used within Symbian. For example, Nokia S60 and SE UIQ3 are completely incompatible, which means that should we expand the list of supported Symbian devices, we would need to re-write the client application for as many UI platforms as necessary.
- Lack of touch screen enabled Nokia S60 devices. Even though Nokia are planning to release a touch screen device in the next six months, we will need to develop the UI based on existing navigation conventions.

4.8 Conclusion of UD OS selection

Based on the technical analysis of high-end PDAs and market trends the Windows Mobile OS will be used at museum owned user device. The selection corresponds to the present situation in top performance device segment, minimizes the software development risks and allows reusing existing competence of INRIA and APPRISE.

Based on the market share analyze and vast experience WEBGATE has in developing Symbian based applications, the SM consortium decided to use Symbian platform for the purposes of the SMARTMUSEUM application outside scenario.

5 User device selection for SM demonstrator

Based on previous analysis, it is recommended to select Windows Mobile based MID, preferably with Marwell XScale CPU as museum owned handheld device and high-end smartphone, preferably Symbian/Nokia S60 OS based, as user owned SM demonstration device. The cellular connectivity requirements of user owned devices are considered as conventional without any special attention.

The descriptions in red in the following tables indicate technical weaknesses against SM requirements, green features are essential in current project context, additional advantages are marked in blue.

The following devices were analyzed:

- Museum owned device: Asus A696 PDA Navigator, HP iPAQ Enterprise Handheld.
- User owned device: Nokia N96, Samsung SGH-G810.

5.1 Asus A696 PDA-navigator

There are similar AsusTek PDA devices available. This particular device was selected due the most powerful CPU available in company production line. Presence of GPS is not required for museum owned guiding device.

Figure 9 Asus A696 PDA

		System features	
1	Date announced	01.12.2007	
2	Operating system	Windows Mobile 5.0	Relatively obsolete OS
3	Processors available	Marvell PXA272 processor @416 MHz	Moderate performance
		Memory	
4	Memory	64 MB SDRAM	
5	Onboard flash memory	256 MB Flash memory	Insufficient for content storage
		Audio, Slots, and Ports	
6	Audio	Integrated microphone and speaker (Full duplex)	Standard earphone jack is an advantage

		1 x 3.5mm earphone jack	
7	Ports	1.1 MiniUSB host and device	USB host is an advantage
8	Slots	SDIO/MMC slot	Suitable form factory for RFID modules
		Graphics and Input/Output devices	
9	Display	3.5” 65K color display, 16 bit QVGA (240x320 resolution)	
10	Input devices	touch screen, stylus	
		Communication features	
11	Wireless	802.11b/g, Bluetooth 2.0 with EDR	
12	GPS/Galileo	GPS-module on SiRF III chipset	Not to be used
13	Infrared	IrDA, SIR 115.2kbps	Additional useful feature
		Software	
14	Software installed	Windows Mobile Office Outlook; Windows Mobile Office; Internet Explorer Mobile; Windows Media Player Mobile; Microsoft ActiveSync; Windows Mobile Device Center; MSN Messenger; Games; Calculator; Audio Recorder	
		Product specifications	
15	Dimensions (w x d x h)	11.7cm x 7.08cm x 1.57cm	
16	Weight	158 g typical	
		Energy Efficiency	
17	Battery	1200 mAh Lithium-ion	
18	Power supply	AC Adapter	
		Main comments	
19	All features satisfy SM needs except flash memory size for (backup) content storage.		

Table 5 Asus A696 PDA features

5.2 HP iPAQ214 Enterprise Handheld

This device is the most modern PDA available on the market. The device was found after the Florence meeting.

Figure 10 HP iPAQ 21x PDA

		System features	
1	Date announced	April 2008	
2	Operating system	Windows Mobile 6.0	No upgrade to WM6.1
3	Processors available	Marvell PXA310 processor @624 MHz	Highest performance among single CPU MIDs
		Memory	
4	Memory	128 MB SDRAM	
5	Onboard flash memory	256 MB Flash memory	
		Audio, Slots, and Ports	
6	Audio	Integrated microphone and speaker (Full duplex), 1 x 3.5mm earphone jack	Standard earphone jack is an advantage
7	Ports	1.1 MiniUSB host and device	USB host is an advantage
8	Slots	1x SDIO/MMC slot, 1x HC CF slot	SDIO is suitable form factory for RFID modules, CF slot can be used for content storage, slots can be used simultaneously
		Graphics and Input/Output devices	
9	Display	4.0” 65K color display, 18 bit VGA (640x480 resolution)	Largest screen available, some sources list 16 bit color depth.
10	Input devices	touch screen, stylus	
		Communication features	
11	Wireless	802.11b/g with WPA,	

		WPA2 (personal and enterprise) security, WMM (802.11e support), Bluetooth 2.0 with EDR	
12	GPS/Galileo	NA	
13	Infrared	NA	
		Software	
14	Software installed	Windows Mobile Office Outlook; Internet Explorer Mobile; Windows Mobile Office; Windows Media Player 10 Mobile; Microsoft ActiveSync; Windows Mobile Device Center; MSN Messenger; Games; Calculator; Audio Recorder; iPAQ Wireless Manager; HP Photosmart Mobile; HP Mobile Print	
		Product specifications	
15	Dimensions (w x d x h)	7.5cm x 1.8cm x 13.4cm	
16	Weight	190 g typical	
		Energy Efficiency	
17	Battery	2200 mAh Lithium-ion	High capacity battery
18	Power supply	AC Adapter	
		Main comments	
19	Fully satisfies SM museum owned device requirements.		

Table 6 HP iPAQ 21x PDA features

5.3 Nokia N96 Overview

Nokia N96 is a candidate for user owned SM device mainly for outdoor user scenarios.

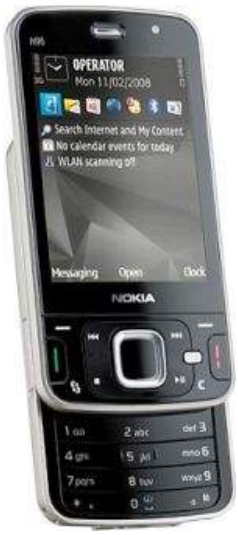

Figure 11 Nokia N96

		System features	
1	Date announced	1Q 2007	
2	Operating system	Symbian OS 9.3, Dev platform S60 3rd Ed Feature pack 2	
3	Processors available	ARM9 @264 or 332MHz	Exact CPU type is unknown, clock rate data vary
		Memory	
4	Memory	128 MB SDRAM	
5	Onboard flash memory	16GB Flash memory + 256MB ROM	
		Audio, Slots, and Ports	
6	Audio	1 x 3.5mm earphone jack	
7	Ports	2.0 Hi-speed USB device, TV-OUT	
8	Slots	1x Micro SD	No RFID reader available
		Graphics and Input/Output devices	
9	Display	2.8” 16M color display, (24bit QVGA 240x320 resolution)	
10	Input devices	Numeric keypad, acceleration sensor, 5Mpix camera, Nokia wireless keyboard available	No touch screen

		Communication features	
11	Wireless	HSDPA/UMTS/GSM 850, 900, 1800, 1900MHz; 802.11b/ g with WPA security, Bluetooth 2.0 with EDR A2DP, DVB-H Class C TV receiver, FM RDS receiver	Dual transfor mode (voice+data) HSDPA/UMTS up to 3.6Mbps/384kbps (DL/ UL), EGPRS 296kbps/177.6kbps (DL/UL), Bluetooth RFID reader is an option
12	GPS/Galileo	A-GPS	
13	Infrared	YES	
		Software	
14	Software installed	S60 3rd Ed Feat pack 2 GUI, Nokia Maps, 150 city maps to purchase, Nokia Music Store, Nokia Audio Manager, Nokia Web Browser with Mini Map, Flash Lite 3.0. Support for JavaScript, Flash video, e-mail, VPN clients, browser based video access, RSS reader, Nokia Internet radio. Nokia Nseries PC Suite connectivity for USB and Bluetooth	Audio formats: MP3, AAC, AAC+, WMA; Video formats: H.263/SP, H.264/AVC, WMV9 CIF/QVGA, RealVideo, Flash Video, LiveTV; 30fps 640x480 video recording, foto formats JPEG, EXIF
		Product specifications	
15	Dimensions (w x d x h)	10.3cm x 5.6cm x 1.8cm	
16	Weight	125 g typical	
		Energy Efficiency	
17	Battery	950 mAh Lithium-ion	200/220 h standby time (WCDMA/GSM)
18	Power supply	AC Adapter	
		Main comments	
19	Allows demonstration of all SM features of outdoor scenario.		

Table 7 Nokia N96 features

5.4 Nokia N97

An alternative Symbian based smartphone to be considered as user owned SM device.

The advantage over previous selection: better manufacturer support (Nokia) to Webgate. The N97 has touchscreen that allows to realize similar user interfaces for PDA and cell phone. The device is expected to be on sale in June 2009.

Figure 12 Nokia N97

		System features	
1	Date announced	1.11.08	
2	Operating system	Symbian OS 9.4, Dev platform S60 5th ed	
3	Processors available	ARM11	
		Memory	
4	Memory	128 MB SDRAM	
5	Onboard flash memory	32GB ROM	
		Audio, Slots, and Ports	
6	Audio	1 x 3.5mm earphone jack	
7	Ports	2.0 Hi-speed USB device	
8	Slots	1x Micro SD/TransFlash	No RFID reader port available
		Graphics and Input/Output devices	
9	Display	3,5” 16M color display, (360x640 resolution)	
10	Input devices	QWERTY keyboard, accelerometer, touchscreen, proximity sensor	
		Communication features	
11	Wireless	HSDPA/UMTS/GSM 850,	Bluetooth RFID reader is

		900, 1800, 2100MHz; 802.11b/g with WPA security, Bluetooth 2.0 A2DP, FM RDS receiver	an option
12	GPS/Galileo	A-GPS	
13	Infrared	YES	
		Software	
14	Software installed	Flash Lite 3, Pocket office (doc, ppt, pdf); Java MIDP 2.0; mobile printin; email	Audio formats: MP3, AAC, AAC+, WMA; Video formats: H.263/SP, H.264/AVC, WMV9 CIF/QVGA, RealVideo, MPEG4 video recording,
		Product specifications	
15	Dimensions (h x w x d)	117.2 x 55.3 x 18.3 millimetres	
16	Weight	150 g typical	
		Energy Efficiency	
17	Battery	1200 mAh Lithium-ion	
18	Power supply	AC Adapter	
		Main comments	
19	Allows demonstration of all SM features of outdoor scenario.		

Table 8 Nokia N97 specification

5.5 Conclusions regarding user device selection

HP iPAQ 214 device is selected as museum owned user device for SM solution demonstration. Nokia N97 smartphone is selected as user owned SM user device for demonstrating SM solution features. *N96 device will be used for initial testing.*

6 Technology updates

Nokia 6212 Classic NFC became available, November, 2008

Nokia 6212 was tested by ELIKO performing significantly faser than previous NFC phone Nokia 3220.

Nokia N97 announced, November, 2008

New Symbian cell phone Nokia N97 announced that is first Nokia smartphone with touchscreen.

Japanese RFID cell phone tests completed, 27th August, 2008

KDDI SonyEricsson RFID enabled cell phone was tested in Europe with ISO14443-A (Mifare) tags. The phone requires special services to be launched not supported through the roaming and Mifare tag support could not be verified..

Test of iPAQ214 device, 13th August, 2008

iPAQ214 was procured and validated by ELIKO.

Innovision, 30th May, 2008

Innovision, manufacturer of NFC Topaz reference tags announced their roadmap of tags providing memories up to 2kbytes[20]. First samples of product based on the platform are expected to be available 2nd half of year 2008. The NFC compatible 2k tag is optimal for SMARMUSEUM application and it may be more cost efficient comparing with NXP Mifare Classic 4k and DESFire tags. Innovision 2k tags satisfy SM Architecture needs requiring at least 1kbytes of tag space. NFC Forum Type 1 compatibility of tags guarantees further accessibility with phones targeted for wireless ticketing applications.

20 http://www.innovision-group.com/press_view.php?newsID=120

7 Final conclusions

The scope of the SMARTMUSEUM project involves the right choice of user device from a number of perspectives, such as technical requirements and market considerations.

- Based on the goal the deliverable concluded user needs and SM use scenarios based on ideas of deliverable D1.1.

- Two different devices will be used for SM demonstrator to cover both inside and outside user scenarios and to cover different user segments (users acquiring SM services with their own smartphone and users using onsite equipment): HP iPAQ 214 Windows Mobile will be used as museum owned guiding device and Symbian based Nokia *N97 (N96 as a backup device)* will be used as an example of typical user owned SM device. The selections should be in accordance of mobile Internet device demand and OS market share in next 2-4 years.

- HF RFID technology specified by ISO14443A standard and its components will be used for museum indoor scenario artifact recognition. The selected devices are SDIO form factory reader from Wireless Dynamics and Mifare 1k, (NXP S50) 4k (S70) type tags.

Appendix 1

Symbian Technical specification

7.1 Core OS

Security, Privacy and Content Protection

- Application capability management
- Application data caging
- Cryptographic algorithms – DES, 3DES, RC2, RC4, RC5 and AES
- Cryptographic token framework
- DRM framework and reference implementation
- IPSec and VPN client support plus SSL and TLS
- User permissions prompting

Open Environments

- Standard C environment
- Standard libraries including partial POSIX support (P.I.P.S)

Location-Based Services

- GPS, A-GPS (terminal-assisted / terminal- based) and network-based positioning
- Mobile originated and mobile terminated requests (including emergency requests)

Telephony

- Multimode Etel (2.5G / 3G)
- GSM Phase 2+
- HSCSD
- GPRS, classes A, B and C (R97/98)
- EDGE (CSD and GPRS)
- WCDMA (3GPP R4 and R5 IMS support)
- HSDPA, HSUPA
- SMS (3GPP TS 23.040 V6.5.0)
- EMS (3GPP TS 23.040 V4.5)
- SIM Application Toolkit
- SIM and USIM support
- Quality-of-Service framework
- Support for multiple primary and secondary PDP contexts
- Third party OTA API

Networking & Comms

- Bluetooth v2.0 (L2CAP, RFCOMM, SDP, GAP and SPP) plus profile support
- Bluetooth stereo headset support
- USB v2.0 High Speed (Mass storage, ACM, WHCM) and USB On-The-Go support
- WLAN
- IrDA & serial
- OBEX over Bluetooth, IrDA and USB
- Bearer independent EAP-SIM/AKA
- Non-seamless network bearer mobility
- TCP, IPv4, IPv6, MSCHAP v2, PPP
- TCP/IP plug-in framework
- HTTP plug-in framework -HTTP 1.1, Pipelining
- WAP push
- Connectionless WSP
- Multihoming, NAPT

Multimedia

- Video capture and playback framework
- Audio capture and playback framework
- Camera interface supporting multi-megapixel cameras and advanced features
- Tuner interface
- Digital TV hardware abstraction
- Hardware abstraction layer for multimedia acceleration
- Audio and video codec interfaces compliant with OpenMax IL 1.0
- Image conversion (all common formats) with scaling enhancements

Graphics

- Bitmap and vector font support with advanced font effects
- 2D graphics support including OpenVG implementation
- 3D graphics support including OpenGL ES APIs
- Multiple display support

Persistent Data Services

- Embedded SQL database

Generic OS Services

- Extensive language support including: Thai, Arabic, Hebrew, Japanese, Chinese, Hindi, Brahmic and Vietnamese scripts

- Unicode 3.0

Kernel & Hardware Services

- ARMv5, v6 and v7 support
- L2 cache support
- Defragmentation of physical RAM
- Demand paging of read-only code and data
- Hardware-dependent support for "VFP" floating point acceleration and accelerated maths functions
- High performance file server with FAT filesystem support
- MMC and SD card support including media >2GB

Generic Middleware

Security Management

- Cryptographic services
- Certificate management (X509 certificates)
- Secure Software Install
- MIDP 2.0 support

Application Protocols

- Multimedia Transfer Protocol (MTP) over USB plus data provider for files and folders
- White/black list URI service
- SIP/SDP

Multimedia Middleware

- High-level multimedia service abstraction
- RTP, RTCP

System GUI Frameworks

- Flexible application and UI frameworks
- Control and windowing environments

Application Services / Logic

Remote Management Application Daemons

- Over-the-air firmware upgrade (FOTA)
- OMA Client Provisioning v1.1
- OMA Data Synchronization v1.2
- OMA Device Management v1.2

Enterprise Application Services

- Calendaring including vCalendar v1.0 and interoperability with Microsoft Exchange and Lotus Notes servers
- Contacts management including vCard v2.1
- IMAP4 including IDLE support, RFC2177 and RFC 3501
- POP3 implementation compliant with RFC 1939
- SMTP implementation compliant with RFC 2821
- SMTP Service Extension for Authentication, RFC 2554, Secure SMTP over Transport Layer Security, RFC 3207
- Secure email using TLS with IMAP, POP3, and ACAP, RFC 2595
- Extensible framework for push email solutions

Java

- CLDC HI 1.1.1s (JSR139)
- Bluetooth (JSR082) including OBEX
- Content Handler (JSR211)
- JTWI (JSR185)
- MIDP 2.0 (JSR118)
- Mobile 3D Graphics (JSR184)
- Mobile Media 1.1 (JSR 135)
- PIM & FileGCF (JSR075)
- Wireless Messaging 1.1 (JSR120) including CBS
- Support for JSR248

PC Connectivity

- MTP over USB
- Mobile Active Sync
- Calendar and contacts sync framework

Tools and Documentation

- Eclipse- and CodeWarrior-based development environments
- Library of books from Symbian Press
- Developer portal at developer.symbian.com