CAMMP

Converged Advanced Mobile Media Platforms

Theme: Mobile Media Standards

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About Horizon

Horizon is the CAMMP reserch report series with the aim of publishing central discussions and research findings in the CAMMP project. The different issues of Horizon deal with specific research themes and are designed such that the important research questions in the field of mobile media are covered.

The analyses in the different issues give a detailed understanding of the technological development and aim at contributing to the research discussion on the areas of the framework conditions, regulatory issues, user requirements, usability issues and discussions related to the market development and business models/potentials.

An Editor and two Reviewers are appointed for each issue. The content will be delivered by the researchers working in different work packages of the CAMMP project.

Line editor:
Associate Professor Reza Tadayoni.

Abstract

This report contains a description of standards relevant to Mobile Media. The analysis covers Standards and standardization discussions related to bearer technologies, Services and content architectures, Mobile operating systems and end user terminals and devices. The report gives, further, an overview of standardization bodies and organizations relevant to Mobile Media.

Key Words:

Convergence, Bearer technologies, Mobile broadcast standards, Standardization bodies, DVB-H, DMB, MediaFLO, DAB, IMB,TV Anytime, MPEG-7, OMA-BCAST, ESG, Mobile Operating Systems, Smartphones, Tablets.

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Executive Summary

This report presents Mobile Media Standards and gives an overview of the important elements connected to the standards and the standardization process. The field of mobile media is dominated by a number of different standards at network and services/application layer. The standards are partly driven by regional interests and partly by the interests of different industries, including the broadcast, IT and mobile communication industries. The aim of this report has been to identify the major standards and developments which influence the development of mobile media in the future. Some the initiatives and technologies described in this report are either finished or deprecated, but they are still included as they provide some ground-breaking concepts they are considered highly relevant to the CAMMP project.

The report covers standards and standardization discussions related to bearer technologies, services and content architectures, Mobile operating systems and the terminal devices. The report begins with giving an overview over standardization bodies and organizations relevant to mobile media.

Chapters 1 is about standardization organizations and communities. Here we cover the standardization organizations and communities, which deal with the four main areas of work in the CAMMP project, namely: Network platforms, services and content, user profiles and identity management, and context information. We also deal with industry forums like OMA, pre-standardization organizations like WWRF, and more regular standardization organizations like ETSI.

Chapters 2 deals with the standards related to the network bearer technologies. Because we are still in a phase, where a variety of different standards are deployed in different markets, and in particular there are lots of discussions on what would be the winning standard for the infrastructure platforms like DVB-H, DMB, MBMS, etc. we take a close look at these developments and also discuss the future development of these standards. It is very important for the CAMMP project to follow this development in the future and to see to what degree the different standards will be outperformed by each other and to what degree they will complement each other. In particular two developments are important: 1) the combination of DVB-H and IMB, and 2) The combination of Terrestrial DVB-H and a so to speak counterpart satellite DVB-H (DVB-SH). Both of them are efficient solutions for implementing widespread mobile TV networks.

Chapter 3 is about standards related “services and content”. Here the relevant standards and technologies are presented beginning with Electronic Service Guide (ESG), where we will focus on the OMA BCAST standard, which is independent of the chosen physical layer and will be able to implement the service infrastructure for different network platforms and also the combined networks platforms. Furthermore, the chapter contains an overview of standards within the content and metadata description frameworks, including MPEG-7 and TV Anytime. Finally in this chapter the relevant standards related to the Digital Rights Management, User profiles and Identity Management and the context information are presented.

Chapter 4 is about mobile operating systems. This chapter gives an analysis of the mainstream operating systems for mobile terminals. Not all of the available mobile operating systems on the market have been analyzed. Only the most active and company-driven variants have been selected. One common factor is that all of the operating systems are targeted for smartphones. With regards to mobile operating systems, Symbian has for long time been the dominating technology.

However, it seems that in the transition to the smartphones other operating systems like iOS and Android are taking the lead. In the smartphone market some of the operating systems used for iPhone and Blackberry are tightly connected to the business logic of the platforms, with reasonable consumer bases. Hence it is difficult, at least in the near future, to see a winning operating system on the market. However, the Google/Android initiative of developing an OS, which can run on all mobile devices, is important and interesting to follow in the future.

Chapter 5 is about terminals and gadgets and gives an overview of the key factors in development of terminals and a status of new terminals and devices. Furthermore we take a close look on 3 major developments relevant for the CAMMP project, namely the Goggle TV, the Apple TV and the Boxee Box.

1 STANDARDIZATION ORGANIZATIONS AND COMMUNITIES

In this Section we briefly present some of the main industry forums, standardization organizations and communities related to the Mobile Media area of research.

1.1 BROADCAST MOBILE CONVERGENCE FORUM (BMCO FORUM)

The BMCO board is an initiative to identify the trends and possibilities when combining the strengths of digital terrestrial TV with the strengths of mobile communications. Its relevance has become greater, as the possibilities with smart phones have increased over the years, and will still steadily increase allowing to a higher degree reception of broadcast signals on mobile devices. Broadcast compared to ordinary multicast over cellular networks has the following essential strengths:

- Simultaneous and therefore cost-efficient transmission of content to a great number of devices
- High bandwidth with many parallel channels enabling transmission of rich-media formats
- Selective reception of paid content through digital rights management or conditional access
- Cyclic transmission of identical content.

These strengths of broadcasting are complementing and not conflicting with the strengths of mobile communications. The combination of broadcasting and mobile communication opens up novel kinds of potentials. On the mobile side, this includes the following:

- An individual, secure data channel that enables interaction on different partner levels
- Localization and personalization to select among the great variety and quantity of information
- User authentication that allows billing of payable content and services.

The BMCO Forum consists of 14 members that are divided into the following thematic working groups in the field of:

- Regulation and spectrum lobbying
- Interoperability
- Bearer technologies
- Broadcast network structure and coverage expectations
- Generic business models
- Content formats and services
- Outlook 2015.

The forum aims at cooperating with other international organizations, e.g. DigiTAG, Mobile DTV Alliance and OMA, where the last-mentioned is of great interest to the CAMMP project. In particular the working group on interoperability is highly relevant, as this group has worked on implementing recommendation profiles of the OMA BCAST v1.0 precification[1].

1.2 MPEG

The Motion Pictures Expert Group (MPEG) has existed since the early 1990s and is mostly known for the specification of the well-known and widely audio and video formats MPEG-1, MPEG-2 and MPEG-4. More recent members of the MPEG family are MPEG-7 and MPEG-21, and MPEG-7 has gained widespread acceptance as the standard for metadata and associated definition description languages.

MPEG-7, formally named “Multimedia Content DescriptionInterface”, aims at providing standardized core technologies allowing description of audiovisual data content in multimedia environments. This, in principle, applies to both real-time and non-real-time, as well as push and pull applications. MPEG-7does not standardize or evaluate applications, although in the development of the MPEG-7 standard applications have been used for understanding the requirements and evaluation of the technology. MPEG-7 is not aimed at any particular application, it aims to support as broad a range of applications as possible.

[1] Link to implementation recommendation profiles from BMCO Forum is available from Internet: *www.bmcoforum.org/index.php?id=191*.

1.3 TV-ANYTIME

The TV-Anytime Forum has developed specifications to enable audio-visual and other services based on mass-market high volume digital storage in consumer platforms – simply referred to as local storage. The development of specificationswas carried out in the period of 1999-2003, and the specifications are now transferred to ETSI [ETSI TVA], while TV Anytime work has shifted to implementation focus in the regional Developers and Users’ Group.

The underlying reference mechanism, the Content Reference IDentifier or CRID, was turned into an Internet specification by IETF. The long-term goal is that CRIDs should be available for use by cell phones, PDAs, digital TV receivers and other consumer devices for fetching content, either from a broadcast stream or over IP-based networks[2].

The TV-Anytime Forum consisted of four different work groups, which concentrate on different aspects of exploiting the improvements in high capacity storage, to provide users with a higher degree of personalization of their TV experience. A central part of the work done by the TV-Anytime Forum was to develop a metadata specification, which would allow for maximum interoperability between content providers and service providers. It is meant to be a metadata format for broadcasters, encompassing all their needs and including three types of metadata described above.

1.4 3RD GENERATION PARTNERSHIP PROJECT (3GPP)

3GPP (3rd Generation Partnership Project) is a major standardization body dealing with future 3G networks and services. Important activities include the specification of a flexible service architecture based on IP Multimedia Subsystem (IMS) and the Generic User Profile (GUP) framework.

1.5 OPEN MOBILE ALLIANCE (OMA)

As already mentioned, Open Mobile Alliance (OMA) specifies service enablers and service environments for mobile services. Some of the important ones address device management and device profiles, e.g. User Agent Profile (UAProf), which is part of the WAP 2.0 specification [OMA UAProf] and is based on W3C’s CC/PP (see below). OMA also specifies service enablers for digital rights management (OMA DRM), service guides (OMA BCAST) and Secure User Plane Location (SUPL).

1.6 ETSI

ETSI has published a comprehensive user profile guide [ETSI 2005a], in which it was suggested that details of the users and their personal preferences are included in a user profile, in such a way that the system may use them to deliver the required behaviours and information. This may also be included for sharing a device or service with another person, while it distinguishes three different types:

- Base profile
- Device and service profiles
- Situation-dependent profiles.

The goal has been to create a well-founded guide for service and device developers to solve the common issues of user profile management in both personal and business applications.

The document provides guidelines relevant to users’ need to manage their profiles for personalization of services and terminals. It defines a common content of a user profile. It also describes how to set up and maintain the user profile, e.g. creation of profiles from templates, profile updating and data storage. Interesting elements are the profile inheriting data model and the live template.

[2] Available online: *www.en.wikipedia.org/wiki/Crid*

The work has later been continued in new task forces under ETSI, e.g. Specialist Task Force STF 342, "Personalization and User Profile Management Standardization" and Specialist Task Force STF 287: "User-oriented handling of multicultural issues in multimedia communications".

1.7 W3C

The World Wide Web Consortium (W3C) is – among many other topics – dealing with specification of device profiles, Composite Capabilities/Preference Profile (CC/PP), which describe device capabilities. These are in a natural way combined with the user's preferred settings for his or her personal devices.

W3C has also made the specification for the commonly used protocol SOAP[3], which uses XML[4] technologies to define an extensible messaging framework providing a message construct that can be exchanged over a variety of underlying protocols. The framework has been designed to be independent of programming models and other implementation specific semantics. This is used in e.g. Liberty Alliance together with the OASIS SAML[5] specification.

Finally, the Platform for Privacy Preferences (P3P) enables websites to express their privacy practices in a standard format that can be retrieved automatically and easily interpreted by user agents.

1.8 WWRF

The Wireless World Research Forum (WWRF) aims to develop a common global vision for the future of wireless to drive research and standardization with a 10-15 years time horizon towards the year 2020. WWRF is a global organization, which was founded in August 2001, comprising over 140 members from five continents and representing all sectors of the mobile communications industry and research community. The forum consists of several working groups, e.g. "Human perspective and future service concepts", "Services and service architectures" and "Security and trust", and research is published in the form of Whitepapers, Outlooks and "Book of Visions". User requirements, user profiles, usage scenarios and business models for new services are some of the issues considered.

1.9 THE KANTARA INITIATIVE

The increased focus on identity management is reflected in the newly formed "Kantara Initiative" launched in the spring of 2009[6]. As stated on its website, it aims to be a "robust and well-founded focal point for collaboration to address industry issues we all share: Interoperability and Compliance Testing; Identity Assurance; Policy and Legal Issues; Privacy; Ownership and Liability; User Experience and Usability; Cross-Community Coordination and Collaboration; Education and Outreach; Market Research; Use Cases and Requirements; Harmonization; and Tool Development." It is not a standardization organization, but rather an interoperability forum, and already several working groups are active in developing solutions for identity management and accelerating the adoption of these solutions.

1.10 LIBERTY ALLIANCE

Liberty Alliance is a prime exponent for identity management and single sign-on (SSO) frameworks. A user can have several identities including the "real" identity and virtual identities, and these are obviously closely linked to the user profile.

The Liberty Alliance Project (LA) is a global organization working to define and drive open technology standards, privacy and business guidelines for federated identity management [Liberty]. Liberty Alliance provides technology, knowledge and certifications to build identity into the foundation of mobile and web-based communications and transactions. There are over 150 diverse member companies and organizations in Liberty Alliance, including government organizations, end-user companies, system integrators, and software and hardware vendors.

Groups in Liberty Alliance develop mechanisms to handles identities enabling interoperability and seamless user experiences as well as business relationship between different entities in a distributed environment. The specifications build on existing standards like SAML, SOAP, WS-Security, XML, etc.

1.11 OPENSOCIAL FOUNDATION

The OpenSocial [OpenSocial API, 2008] community is advancing the state of the social web. The aim is to make it easier for everyone to create and use social applications. Nowadays, continuously, more and more devices and gadgets need to give users a way of supplying user-specific information.

OpenSocial, a non-profit foundation jointly proposed by Yahoo, MySpace, and Google, provides a common way for websites to expose their social graph and more, by taking into account the user preferences (<UserPref>) section in the XML file describing the user input fields that are turned into user interface controls when the gadget runs. OpenSocial provides a way for application data to persist on a social networking site, as well as specifying the different ways that an application can be viewed within an OpenSocial container.

1.12 OASIS

The Organization for the Advancement of Structured Information Standards (OASIS) is a global consortium that drives the development, convergence and adoption of e-business and web service standards. Technical work is carried out under the following categories: Web Services, e-Commerce, Security, Law & Government, Supply Chain, Computing Management, Application Focus, Document-Centric, XML Processing, Conformance/Interoperability and Industry Domains.
The specification for the Security Assertion Markup Language (SAML) protocol used in Liberty Alliance has been specified by OASIS [OASIS].

1.13 IDENTITY COMMONS

Identity Commons is a community of groups working together on the creation of an open identity and relationship layer for the Internet covering the whole range of social, legal and technical issues **(see Figure 1-1)**. Identity Commons counts notable members like Google, IBM, Microsoft, VeriSign and Yahoo, just to mention a few.

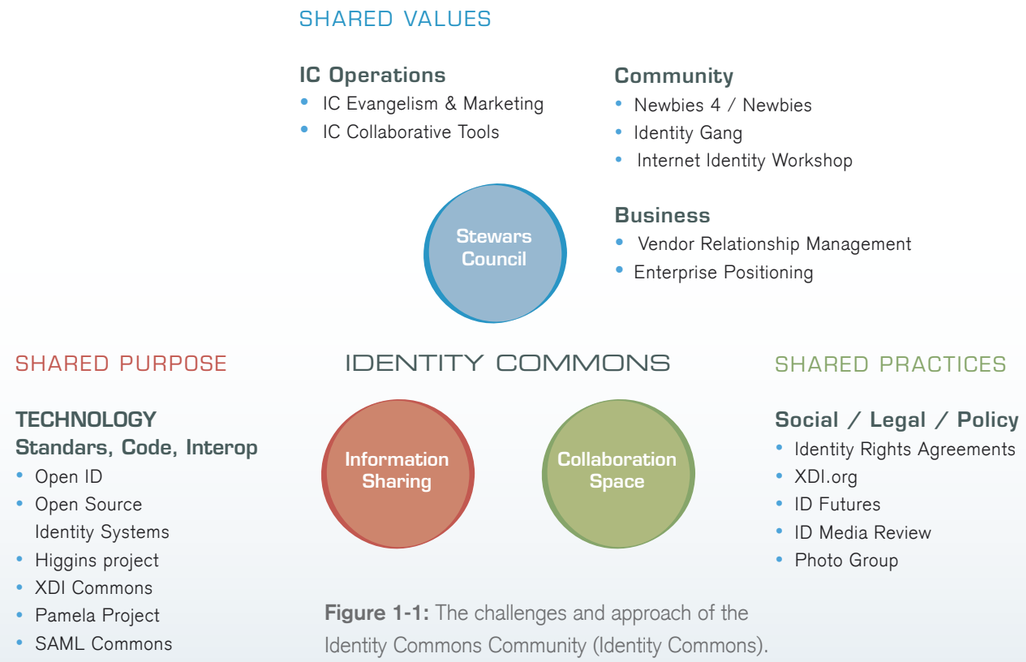

Figure 1-1: The challenges and approach of the Identity Commons Community (Identity Commons).

[3] Simple Object Access Protocol. | [4] EXtensible Markup Language. | [5] Security Assertion Markup Language.
[6] Available from Internet: *www.kantarainitiative.org* [cited 2nd October 2009; 11:30].

The community has working groups considering all serious on-going initiatives and completed projects to make recommendations for further deployment and lead the trends towards an open common identity deployment for all IP-based services and therefore also available for mobile terminals. The most prominent working groups on technologies and initiatives cover OpenID, OSIS (Open Source Identity Systems), Higgins Project, SAML Commons, XDI Commons and the Pamela Project.

2 NETWORK AND BEARER TECHNOLOGIES

This section deals with the standards related to the network and bearer technologies.

2.1 INTRODUCTION

Mobile TV is a service, which requires a number of different technologies and standards in different parts of the value network to work together. Some of these technologies are developed in relation to other services and later adapted to mobile TV, and some of them are specifically developed to enable mobile TV services to be provided to the market. The focus of this section is on network technologies, as this has been the prime area of policy discussions. However, the development of other technologies on the production side and on the service and device side can also have a major influence on the overall development of the market. **Figure 2-1** shows a simple schematic overview of different elements included in the value network for mobile TV provision.

The Figure illustrates that there will be service providers, who take the content from the professional content providers as well as the user-generated content and combine it into a service, which will be delivered to the users by means of a network infrastructure. The service providers can either be mobile operators, broadcasters or third party broadcast service operators. In several markets, the mobile operators act as service providers - a solution that may facilitate the development of the market, as the mobile operators have access to the customers and are key players in bringing the terminals to the market. Another important issue is that a combination of networks will be used in many actual implementations, for example a combination of broadcast and 3G, where the TV content is delivered through the broadcast network and the return channel is established through 3G. The level of sophistication of the terminals (hardware and software) and the implemented service infrastructure are decisive for the degree of interactivity and integration of user generated content.

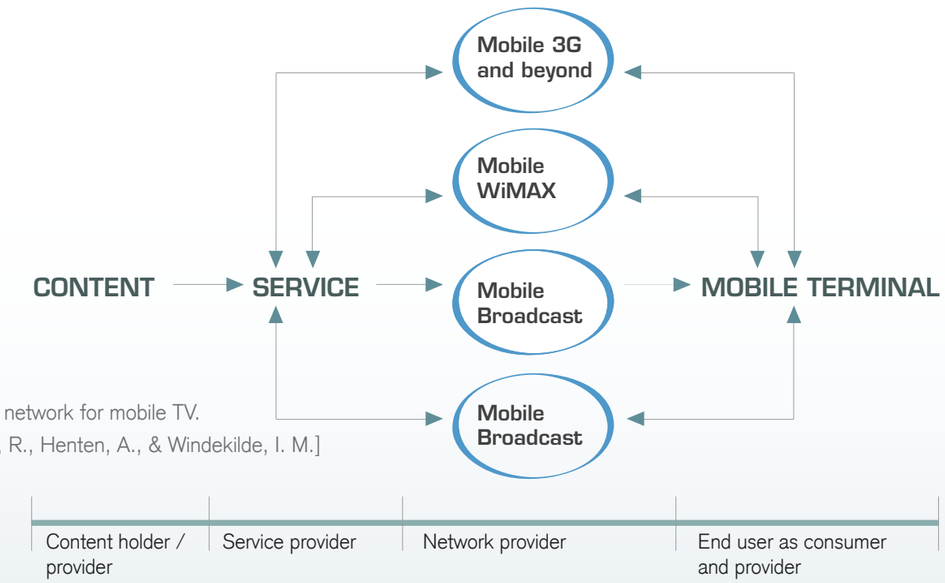

Figure 2-1: Value network for mobile TV. [Source: Tadayoni, R., Henten, A., & Windekilde, I. M.]

The description in the following covers the different technological solutions for network infrastructures and the scenarios, where a combination of different network infrastructures is used to deliver mobile TV services.

2.2 THE INTERNET

Mobile TV services can be accessed through the Internet in several ways. First, the development of Wi-Fi-enabled mobile terminals provides the possibility of using Internet services in locations, where Wi-Fi networks are available. Second, the development of mobile Internet platforms on the 3G and beyond-3G networks and the flat rate business models provided by the operators make access to mobile Internet easy. As the market data shows, the penetration is fast[7]. Third, content from the Internet can be downloaded to the mobile devices and consumed offline in the form of podcasts or similar.

The first and second solutions are based on unicast technology, which is not the most efficient way of delivering TV services to mass audiences and is more appropriate for offering streaming services in an on-demand manner like YouTube. The podcast solution becomes more and more interesting and important as the terminals become more advanced and the memory capacity becomes cheap. Podcast has the disadvantage of not being able to deliver live services and network-based services, but the majority of TV content is not live, and offline TV services can be downloaded to the mobile terminals. Hence, the service provider can offer a number of "virtual TV channels" composed so that the content is placed on the terminal through, e.g., podcast.

The discussions on mobile TV through mobile Internet are very much similar to the discussions on Internet TV/WEB TV, when it comes to the technological parameters as well as the policy and business oriented issues. The services are based on best effort, and the provisions are global and beyond national or European regulations. These are not direct competitors to the managed mobile TV provisions discussed in the following. However, it is important to follow this development, as the changes and innovations in the field happen fast, and future developments may shift the balance.

The podcast and in particular the virtual TV services discussed above could be complementary platforms/services to the network-based services. The service providers can, for instance, compose their services based on these virtual TV services and other live services without the users being aware of the content placement problem (on the terminal or from a network). To implement this, there would be a need for transparent procedures that settle the rights of the service providers to utilize the resources (e.g. storage capacity) on the devices.

2.3 MOBILE 3G AND BEYOND

Mobile TV through public mobile infrastructures (3G and beyond), also called in-band mobile TV services, is provided in several markets, where 3G networks are implemented. One of the main drivers for the development from 2G to 3G was foreseen to be video and TV services. TV and video services were seen as important revenue generators and one of the reasons for the operators to pay huge sums for 3G spectrum. The experience so far shows that 3G and particularly 3.5G will be driven mainly by mobile Internet services. However, several 3G operators have dedicated TV services delivered as packages with a variety of services at different prices, strongly inspired by the satellite and cable TV provisions in basic, optional and premium packages. The main questions are, whether the operators earn any money on these services and whether the 3G and beyond networks

[7] According to Ericsson, the number of mobile broadband users will be higher than that of fixed broadband users in 2011, and in 2012 more than 50% of European citizens will have access to mobile broadband. In Denmark, for example, more than 550,000 mobile subscribers used mobile broadband in the first half of 2008, and the market is growing with 20% every month. (Source: Presentation named "LTE introduction or Mobile Internet Evolution" by Lars Nielsen, CTO, Ericsson Denmark. The presentation is not publicly available, but can be acquired by contacting the authors of this paper).

Table 2-1 Profile bit rates

Profile	Video resolution	Frame rate (f/s)	Maximum bit rate
A	QCIF (176 x 144)	15	128 Kbps
B	CIF (352 x 288)	15	384 Kbps
B	QCIF (176 x 144)	30	384 Kbps
C	CIF (352 x 288)	30	2 Mbps

Source: *ETSI TS 102 005.*

In **Table 2-2**, the downlink and uplink capacities of the current and near future mobile networks are shown.

Table 2-2 Down- and uplink capacities[8]

Network	Downlink	Uplink	Availability
3G (WCDMA)	2 Mbps	384 Kbps	High
3.5G (HSPA)	14 Mbps	2 Mbps	Medium
3.9G (LTE)	100 Mbps	50 Mbps	Start date: 2009

Source: *"HSPA, the undisputed choice of mobile broadband", white paper by Ericsson 2009, AND "Towards a global mobile broadband", white paper from UMTS forum 2008.*

It is important to note that these are theoretical figures, and that the real capacity delivered to the devices is below these theoretical figures and decreases as the distance from the transmitters increases **(see Figure 2-2)**. Another important issue is, that the bandwidth is shared by a number of users, and that the actual capacity available for one user depends on the number of users sharing the same network node.

The conclusion is, that the provision of acceptable TV quality requires, at least, HSPA and that it may be more realistic to wait for LTE networks to be implemented. Even in HSPA, only a few people can use the services in a mast's coverage area at the same time. If the services become popular, massive investments in the network will be needed. However, as already mentioned, the market has not shown to be sufficiently profitable to bear massive investments.

LTE and in particular eMBMS (evolved Multicast Broadcast Multimedia Service) and IMB implemented on LTE can change this situation and establish a powerful infrastructure, which can also be used for mobile TV services. This is particularly important in Europe as LTE seems to be the preferred 4G technology in Europe.

[8] These are the typical numbers. The bit rate depends on the assigned frequency bandwidth. Also important to mention is that there are different versions of standards and, for example, HSPA+ has an uplink capacity of 11.5 Mbps and a downlink capacity of 28 Mbps.

From a policy and regulatory point of view, the allocation and assignment of spectrum for LTE (and beyond LTE) networks is important. The allocation of the "digital dividend" spectrum is essential and on the policy agenda in several countries. The assignment process of the spectrum has started in some countries. Sweden, for example, has assigned 140 MHz of spectrum to four different mobile operators (three times 2 X 20 MHz and one time 2 X 10 MHz)[9]. With regard to the digital dividend in Denmark for example, the Ministry of Science, Technology and Innovation has allocated research resources for a one year period to evaluate examples of other services/applications than TV in these frequency bands. The beyond 3G technology platforms like LTE can play a major role here.

2.3.1 IMB

GSM Association (GSMA) now endorses Integrated Mobile Broadcast (IMB), which is part of the new 3GPP standard from release 8, hoping to speed up the global adoption of mobile data and broadcast services. IMB is a technology that enables delivery of broadcast services, based on techniques that are aligned with the existing FDD WCDMA[10] but also allows deployment in the TDD spectrum in the 1900MHz band. This allows for seamless handover in various bands between IMB delivery and existing deployed IP bearer technologies. The TDD spectrum has earlier been used to broadcast band width demanding video services in a specification called TDtv developed by the company Nextwave Wireless[11]. The technology combined UMTS TD-CDMA[10] solutions and 3GPP Release 6 Multimedia Broadcast Multicast Service (MBMS)[12] to deliver Mobile TV. It operated in 3G spectrum bands available worldwide at 1900 MHz and 2100 MHz. It was for some reason never applied and is today discontinued. The idea, however, lives on in the IMB standard.

2.3.1.1 IMB IN LTE

CAMMP has focused on DVB-H as the broadcast technology, but as this technology has not yet been implemented in Denmark (and probably never will), other technologies have to be considered. After the first two test

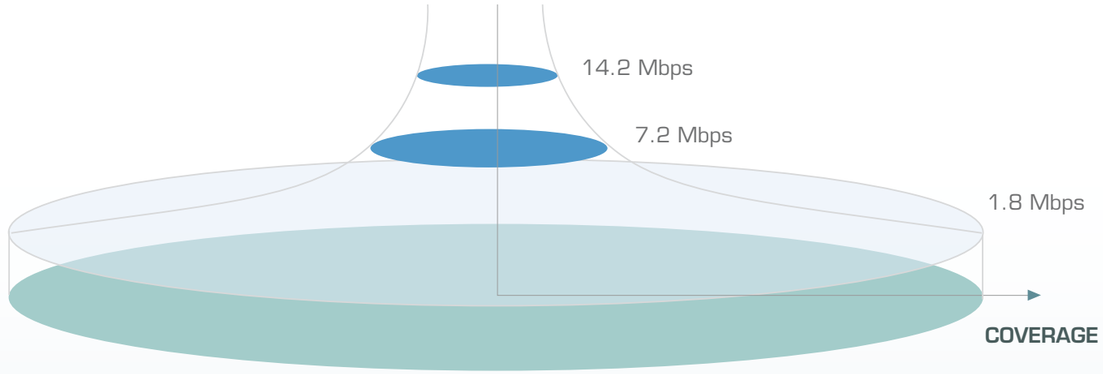

Figure 2-2: Bit rate as a function of coverage (Source: Ericsson).

[9] The Swedish Post and Telecom agency. It is available from Internet: *www.pts.se/*.
[10] Available from Internet: *www.umtsworld.com/technology/overview.htm* [cited 3rd October 2009; 1:24].
[11] Available from Internet: *www.nextwave.com/non_ie/about_nextwave/index.html* [cited 3rd October 2009; 0:58].
[12] Available from Internet: *www.3gpp.org/ftp/Specs/html-info/FeatureOrStudyItemFile-2544.htm* [cited 3rd October 2009; 1:47].

iterations in CAMMP it has become more evident that there is a need for a mobile broadcast technology to be able to fill out the increasing demand for capacity. Various independent reports have shown that 3G and the upcoming LTE will only cover a fraction of the near future capacity demands. If mobile TV services are included, a calculation has shown that LTE technology would only hypothetically cover up to 2% of the actual customer needs[13]. This can be compared to the predictions from Cisco saying that global mobile data consumption will exceed two exabytes per month in 2013, with video content counting for 75% of the network load[14]. Creating a hybrid solution with a broadcast and a data link technology is a possible solution to best meet the demands of the many persons on the move. Some services are particularly suited for broadcasting.

These are[15]:

- Clip casting
- Music/audio streaming (most popular tracks)
- Application container frameworks
- Linear mobile TV
- Event live streaming
- Podcasting
- Over the Air software downloads (e.g. gaming updates).

while more specific content with a more on-demand nature has to be delivered using a data-link technology. A possible solution is to implement IMB, which is a relatively cheap[16] upgrade of the existing 3G base stations, in order to be able to broadcast IP-based content along with existing 3G services. IMB should already be a part of the upcoming LTE base stations hard- and software. IMB utilizes various existing unpaired TDD spectrum bands in the W-CDMA air interface standard nationally applied in Denmark and many other countries in the world. Each of the unpaired 5 MHz bands should be able to deliver around 4.4 Mbps that is needed for the earlier proposed types of services. **Figure 2-3** is taken from an IP Wireless white paper[15], and in short it states the main reasons for selecting an IMB solution along with the existing 3G+ networks.

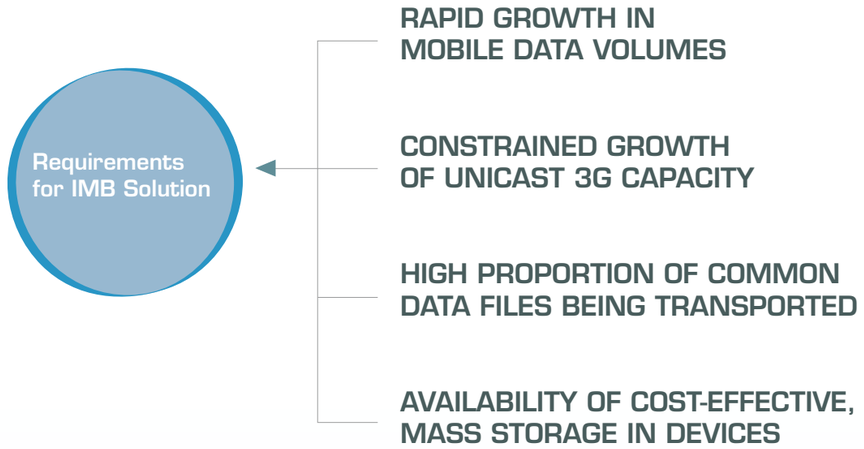

Figure 2-3: Main drivers for implementing an IMB solution in existing unicast networks [IPWireless].

CAMMP is looking into the many possibilities of IMB, covering both literature studies and possible technical implementations. This includes testing of different broadcasting strategies using local caching on devices to store predictive user content consumption. One of the other reasons to test IMB is the fact, that the standard specifies the use of the OMA BCAST standard as the service announcing and provisioning technology. This technology is also used in DVB-H and is there-fore already a part of the CAMMP testbed called "CAMMP'US". With modifications, the OMA BCAST server in the CAMMP platform can be enabled to support IMB or other IP-based technologies as well.

2.4 MOBILE WIMAX

WiMAX is an acronym for Worldwide Interoperability for Microwave Access and a telecommunications technology that provides wireless transmission of data in a variety of ways, ranging from point-to-point links to full mobile cellular-type access. WiMAX in the original version of the standard (IEEE 802.16) is specified a physical layer operating in the 10 to 66 GHz range, but later versions added specifications for the 2 to 11 GHz range. There is no uniform globally licensed spectrum for WiMAX, even though the WiMAX Forum already published three licensed spectrum profiles: 2.3 GHz, 2.5 GHz and 3.5 GHz. In the unlicensed band, 5.X GHz is the approved profile, but telecom companies are unlikely to use this spectrum, as they do not own and control the spectrum.

Today, the most applied versions of WiMAX are:

- 802.16d frequently referred to as: "Fixed WiMAX", since it has no support for mobility
- 802.16e also known as "Mobile WiMAX" introduced support for MIMO and also mobility.

802.16e uses the scalable OFDM modulation scheme with multiple access (SOFDMA), as opposed to the OFDM in 802.16d. Besides giving the opportunity to assign subsets of subcarriers to specific users, SOFDMA (S-OFDMA) also adds scalability to the OFDMA modulation scheme. This means that the FFT[17] size is varied through the sub-carrier frequencies, giving small FFT sizes to lower bandwidth channels and larger FFT size to wider channels. By keeping the sub-carrier frequency spacing constant, SOFDMA has proved that the system complexity is reduced in the smaller channels and performance of the wider channels is improved. The theoretical quality is around 10 Mbps at a distance of 10 km, but in urban areas with no line-of-sight to the antennas the link is usually lower.

The reason why WiMAX is considered in this state-of-the-art document compared to other data link technologies, e.g. Wi-Fi and the like, is the aim of the applications. While Wi-Fi is made for enabling end users to provide connectivity between local devices, WiMAX is a long-range system, covering many miles/kilometres, which typically uses licensed spectrum. However, due to its long-range operating spectrum (2-66 GHz), it is possible to use unlicensed spectrum as well. It provides a direct point-to-point Internet connection from an Internet Service Provider to the end user. Another reason is due to technologies proposed by vendors like Nextwave. They have created a product called MXtv enabling the WiMAX providers to allocate bandwidth for broadcast (e.g. mobile TV and radio) and on demand services (interactivity and VOD) at the same

[13] "Seamless unicast and broadcast services to meet increasing mobile TV and video consumption", page 2, bmcoforum White Paper 2010.
[14] Cisco Visual Networking Index: "Global Mobile Data Traffic Forecast Update", 29 Jan 2009. Available from Internet: *www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.html*.
[15] "Integrated Mobile Broadcast (IMB): The Power of Predictive Broadcasting for 3G Multimedia Applications", White Paper, IPWireless, September 2009.
[16] Compared to implementing a complete co-existing DVB-H solution, with only a very few number of compatible terminals available. Most 3G terminals on the Danish market should be able to be upgraded to support IMB with a software update, unlike a possible DVB-H upgrade that requires both a hard- and software update.
[17] Fast Fourier Transform.

time [Nextwave]. WiMAX also enables local content insertion and micro-broadcasting, which means delivery of specific content within restricted areas during e.g. sports games or concerts, or within airports, shopping malls etc.

2.5 MOBILE BROADCAST

Mobile broadcast platforms are essentially broadcast TV infrastructures optimized for mobile reception. There are different standards on the market. The services are viewed using mobile terminals, which are enabled for one of these standards, and there can be a return path for interactivity and on-demand services through an IP network based on Wi-Fi, 3G or beyond, etc.

Broadcast networks are characterized by one-to-many transmission and high capacity. By combining broadcast and a return channel (offered by a mobile operator), the service provider can split the services into different elements and transmit the elements with high capacity requirements and mass appeal within the broadcast networks. This combined platform enables service providers to develop new services including high quality video/audio components and interactive services.

It is important to mention that the on-demand aspects will also be addressed in these platforms, because the return channel offered by the mobile operator can also be used as a forward path to deliver on-demand services to the users. Therefore, the same content, which is delivered "live" over the broadcast channel, can also be sold to individual users at other times. This creates several possibilities for packaging the content in different forms and delivering it to the users in specific contexts using different business models.

The main advantages of the mobile broadcast platform are, that video/TV is transmitted within the broadcast networks, and that one person's use of video/TV services doesn't influence the use of others. This is a very important advantage for the video/TV services with mass appeal. An important drawback of these platforms is that it needs specific mobile terminals, which can connect to broadcast networks.
A number of different standards for mobile broadcast platforms exist on the market. Apart from the technological efficiency issues, a number of other issues are related to the mobile broadcast standards. The spectrum issue is a main problem for literally all mobile broadcast standards, in particular the ones like DVB-H, which preferably use the UHF spectrum. UHF spectrum is valuable to all mobile communication technologies, and even though new spectrum is released with the transition from analogue to digital TV, it is not at all certain that parts of this spectrum will be used for mobile TV. Other market actors from the communication sector are pushing for their interests.

The satellite platforms play an important role, because: **1)** technological developments have improved the capabilities of the satellite platforms as a feasible mobile broadcast platform, **2)** the spectrum resources are assigned commercially using fast mechanisms, **3)** the resource allocation and assignment for the satellite platforms is not within the jurisdiction of the individual national governments, **4)** it is easy to enable wide-area service provisions, for example pan-European services, which is very difficult in the UHF band. As seen in the following, however, the satellite standards for mobile broadcast are in many cases combined with a terrestrial infrastructure to enable the provision of services in the urban areas and also for the provision of indoor services.

A number of competing standards for mobile broadcast are emerging, the major ones are described in the following.

2.5.1 DVB-H

DVB-H is a part of DVB family of standards. It is developed by the DVB group and standardized by ETSI. DVB-H is recommended by the EU commission to be used in the EU countries. There have been a number of commercial operations in different European countries, including Italy, Finland and Austria. However, DVB-H doesn't seem to become a commercial success in any of the European markets.

The idea of making a solution to enable mobile reception of DVB-T started back in 1998, and this has led to the standard signals in DVB-H specifications that were published as ETSI Standard EN 302 304 in Nov. 2004. DVB-H is an extension of DVB-T with some backwards compatibility, i.e., it can share the same multiplex with DVB-T. DVB-H, however, differs from DVB-T by some specific technologies that are needed, when moving from a technology designed for rooftop reception and easy access to power supplies to a technology, where the receiver is mobile and power consumption is definitely an issue. The three most significant differences in the technologies are:

- Multi-Protocol Encapsulation – Forward Error Correction (MPE-FEC) scheme is used to improve the robustness and mobility of the signal and improve the reception performance in the difficult reception environments both indoor and outdoor. The MPE technology makes it possible to transport data network protocols on top of MPEG-2 transport streams
- Time slicing – where the signal is sent out in bursts at a higher bit rate (normally 2 Mbps) and the handheld only powers up the receiver to fetch the data bursts. The stream is then played back from the memory introducing an extra delay compared to real time. Time slicing reduces the hand held's battery power consumption (up to about 90%– 95% on the reception) and ensures more seamless handovers
- 4k mode modulation for Orthogonal Frequency Division Multiplexing (OFDM), where DVB-T only has 2k and 8k modes. This technology is a trade-off between making big single frequency networks (SFN) due to problems with reflections and echoing and problems with Doppler effects when moving in motion (e.g. going by train). A short "in-depth" interleaver was introduced for 2k and 4k modes that lead to better tolerance against impulsive noise.

A single DVB-H frequency band of 8 MHz in a typical operating environment can carry between 20 and 40 channels in good quality with video encoded in H.264 and sound in AAC. Statistical multiplexing is also possible in DVB-H, ensuring optimum use of bandwidth to deliver services. DVB-H is designed for use in Bands III, IV and V as well as the L-band.

The DVB-H standard has been used in mobile TV pilot projects in many countries and regions and is now fully implemented in some of these. DVB-H mobile TV services are on air in Italy, Finland, Switzerland, Austria, the Netherlands, Vietnam, Malaysia, India, the Philippines, Albania, Nigeria, Kenya and Namibia. More than fifty DVB-H technical and commercial trials have taken place all over the world, and further commercial launches are expected in France, Germany, Spain, Russia, Indonesia, Taiwan and elsewhere. Some additional work is on-going within the DVB Project revising the DVB-IPDC systems layers following extensive implementation experience. Such work includes efforts towards harmonization with the OMA BCAST specifications, which is a standard for the electronic service guide (ESG) replacing the old ESG format called DVB-CBMS.

2.5.1.1 DVB-H2

A proposal for a new standard replacing DVB-H called DVB-H2 has been made, but this is not finalized yet. The specification is being developed with respect to the DVB-T2 standard making DVB-T2 and DVB-H2 closely interrelated. Just as DVB-H used the same transmission scheme as DVB-T with some extensions to enable reception of mobile TV, DVB-H2 is expected to use some of the same technologies and transmission parameters available on DVB-T2. DVB-H2 has the following features:

- MIMO[18] antenna array technologies allowing the data capacity to be increased notably whilst providing far more robust reception quality. In DVB-T2 only MISO[19] is available
- Low-density parity check (LDPC) and BCH[20] error correction coding [BCH]. LDCP allows a higher code rate at a lower error floor rate [LDCP], and BCH is used to correct multiple random error patterns [BCH]. These technologies are also used in DVB-T2
- 1.7 MHz bandwidth channels as a minimum, whilst DVB-H has a minimum of 5 MHz. This makes it possible to transmit DVB-H2 in the DAB band III channels and makes it especially suitable for local digital radio multiplexes, more due to spectrum usage issues than technical possibilities.

How successful the DVB-H2 will be depends on the work carried out by DVB on next generation handheld called DVB-NGH. A study finalized in May 2008 suggested taking a hybrid DVB-SH and DVB-T2 solution in consideration as a

[18] Multiple Input Multiple Output.
[19] Multiple Input Single Output.
[20] Bose, Ray-Chaudhuri and Hocquenghem.

Figure 2-4: Co-existence of DVB-H and DVB-SH.

starting point for DVB-NGH (DVB-NGH). This would more or less make the DVB-H2 standard redundant, especially if MIMO is introduced in DVB-NGH, which is strongly indicated.

2.5.2 DVB-SH

DVB-SH (Digital Video Broadcast – Satellite services to Handhelds) is another evolution of DVB-H and like its predecessor also a mobile broadcast standard designed to deliver video, audio and data services to small handheld devices, such as mobile telephones and PDAs. DVB-SH can be used in any frequency band below 3 GHz, including UHF, L-band and S-band, and in terrestrial, satellite or hybrid networks. Typically, DVH-SH operates around 2.2 GHz, and the system and waveform specifications have been published as ETSI standards (TS 102 585 and EN 302 583). However, the S-Band is very demanding in terms of signal coverage due to the shorter wavelength, requiring a quite dense terrestrial repeater network in urban areas. DVB-SH in a hybrid satellite/ terrestrial system will allow the use of a satellite to achieve coverage of large regions or even whole countries. However, in areas where direct reception of the satellite signal is not possible, terrestrial gap fillers can be used to provide coverage. It could also be a hybrid DVB-H/SH solution as displayed in **Figure 2-4**.

DVB-SH contains different algorithms, like e.g. DVB-H, to ensure resistance to data package loss. One of the algorithms is MPE-iFEC (Multi-Protocol Encapsulation - inter-burst Forward Error Correction), which is an extension of the traditional MPE-FEC (Multi-Protocol Encapsulation Forward Error Correction) used in DVB-H. The extension through inter-burst FEC provides additional time diversity yielding a highly flexible channel interleaver. This offers time diversity from about 100 milliseconds to several seconds depending on the targeted service level and corresponding capabilities of the terminal, e.g. lowering memory load on small devices. Finally, the DVB-SH standard compared to DVB-H allows for the omission of a 64QAM modulation scheme improving the bandwidth and support for 1.7 MHz bandwidth channels for e.g. local radio stations (as with DVB-H2). The chipset manufacturer Dibcom has released a DVB-SH compatible chipset with dual RF tuners supporting VHF, UHF, L-Band and S-Band frequencies [DiBcom].

In DVB-H, DVB-T and many other terrestrial networks OFDM (Orthogonal Frequency Division Multiplexing) are often used as the modulation scheme. For DVB-H a special version containing FEC called Coded OFDM or simply COFDM is used instead, but it is in general identical. DVB-SH introduces a second scheme called Time Division Multiplex (TDM), which is known from traditional circuit switched communication (e.g. PSTN) to carry a fixed number of channels using a constant bandwidth per channel. Taking **Figure 2-4** into account this yields the following two reference architectures for DVB-SH:

- OFDM both on the satellite and the terrestrial link – generally referred to as SH-A
- TDM on the satellite link and OFDM for the terrestrial link – generally referred to as SH-B.

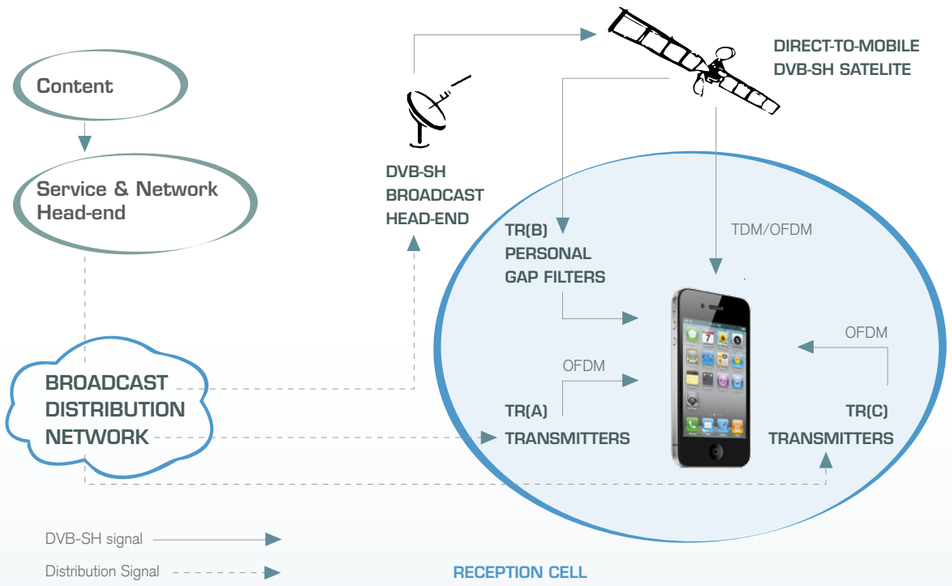

Figure 2-5: Conceptual example of a broadcast system using either modulation scheme SH-A or SH-B [DVB-SH].

More tests on the different modulation schemes and networks performance were carried out during 2009, when the first commercial trials are launched, after the Eutelsat's W2A satellite containing DVB-SH technology has been put into orbit [Eutelsat]. Alcatel Lucent, as the main driver for the technology, has predicted that DVB-SH will gradually take over for DVB-H, as more handsets will be supporting DVB-SH in the near future [Alcatel Lucent].

2.5.3 THE EUREKA 147 (DAB) STANDARDS FAMILY (NID)

Whereas the DVB standard was originally designed for stationary reception using the full 7-8 MHz of existing TV channel rasters, the Eureka 147 family of digital broadcasting standards was intended to solve the problem of reliable digital broadcasting to simple mobile receivers moving at very high speeds using fractional 1.536 MHz sub channels of the 7 MHz raster.

The modulation scheme employed is non-coherent D-QPSK (Differential Quadrature Phase Shift Keying) as opposed to the coherent DVB modulation schemes of QAM and regular QPSK. This means that synchronization of the receiver local oscillator is not required, as only the phase shifts compared with the previous two-bit symbols are considered for each subcarrier, and together with a frequent null symbol ensures virtually instantaneous recovery from loss of signal.

The signal employs not only the frequency interlacing useful for countering frequency selective fading, but time interlacing is also applied to make it resistant to frequency flat fading and the impulse noise and drop-outs generally encountered in automotive applications.

The underlying transport mechanism thus provides an extremely robust, flexible and scalable solution that imposes virtually no limitations to the type of content that may be transmitted within the maximum net bit rate of 2.304 Mbit/s.

The Eureka 147 standards family has been continually evolving since the first version of the ETSI standard ETS 300 401 was published in February 1995 and now encompasses both MPEG-1 layer II audio codec DAB (Digital Audio Broadcasting), AAC+ audio codec DAB+, MPEG-4 multimedia DMB (Digital Multimedia Broadcasting) and DAB-IP (Internet Protocol) with receivers that are generally backwards compatible.

The first two standards allow the efficient and reliable broadcasting of audio services with PAD data, and DAB is now in use in virtually all European countries and many more around the world. At least 500mio people already live in areas covered by DAB transmitters and may receive over a 1.000 different programming services.

The introduction in 2007 of DAB+ with the AAC+ codec created a possibility for a more efficient use of spectrum with more services on each multiplex. So far, the DAB+ standard is used in Singapore, Malta and Australia and is considered by New Zealand, Italy, India, Switzerland and Canada.

A single DAB multiplex can in fact simultaneously transport any Eureka 147 application or a mix thereof on any transmitter or SFN (Single Frequency Network) compliant with the original DAB standard. The only limitation is determined by the total capacity of the multiplex and the fact that receivers can only pick out the application(s) from the multiplex that they have been designed for.

For example, a multiplex in Korea or China may carry two DMB TV channels alongside several DAB radio channels, while Switzerland will combine DAB and DAB+, France will use DMB and Germany and Italy expect to use all three.

DAB transmitters for audio services generally operate in VHF Band III (174-240 MHz) and therefore can have coverage areas almost as large as the analogue FM transmitters in Band II that they are intended to eventually replace. This is probably the reason why Norway has chosen DMB in Band III for its mobile TV, initially covering 30% of the population, whereas Germany and other densely populated nations generally opt for DMB in the L Band (1.452-1.492 MHz).

However, low frequency means long wavelengths and antennas that are generally too large to integrate into handheld terminals. Most DAB receivers use whip antennas, and their size means that the leading European manufacturers of small handheld terminals have lost interest in the VHF band and are concentrating on e.g. the high end of the UHF band, where the wavelengths are short enough to integrate reasonably efficient antennas into the receiver.

The CEPT has also reported that it will be feasible for national telecommunications authorities to convert DVB-T allotments in band III into T-DAB assignments (ECC Report 116), and this may well happen in many European countries.

2.5.4 DMB-T

DMB[21] is a 'Korean' standard, which is based on the European DAB standard and is standardized by ETSI. DMB is backed by Korean industry; however, also some European broadcasters are backing the standard. One of the reasons for the interest from European broadcasters is that huge amounts of DAB spectrum resources are allocated to the European Public Service broadcasters, and they want to use it for more than digital radio.

Another way of using DAB platform for Mobile TV services is DAB-IP, which denotes delivering of IP datagram through the DAB network. The advantage of DAB-IP is its reliance to the IP protocol stack and the synergy with the content and service development in the IP platforms, including the Internet.

DMB and DAB-IP allow rich media services, including high quality streaming video services. The most prominent users are Germany and particularly Korea, where more than 7 million mobile DMB TV receivers have been sold.

2.5.5 MEDIAFLO

MediaFLO is a proprietary standard developed by QUALCOMM. The interest beyond the US market has not been so significant. With regards to the data capacity and the number of services, MediaFLO is comparable with DVB-H. There was a commercial operation of MediaFLO standard in the US, but it will be terminated from spring 2011[22]. Compatible terminals from Motorola, Samsung and LG are, however, still available for a limited period on the US market.

MediaFLO uses a broadcast technology called Forward Link Only (FLO). The FLO physical layer operates in the VHF/UHF/L-band frequency range with channel bandwidths from 5 MHz and up to 8 MHz like DVB-H. Like other terrestrial broadcast technologies it also uses the OFDM modulation scheme, but unlike DVB-H and other similar technologies it only enables 4K-subcarrier mode with the only possible guard interval length of 1/8. This makes MediaFLO more rigid and less adaptable to different topologies.

The technology features advanced forward error correction (FEC) technologies combining parallel-concatenated convolutional codes (PCCC also called turbo code) and the well-known Reed-Solomon correcting code (RS) also used in e.g. WiMAX and DVB-H. However, in FLO each packet also contains a Cyclic Redundancy Check (CRC) yielding the surplus that the RS code needs not be calculated for data that are correctly received, giving a statistical power reduction on the terminal over time. RS is a variant of the BCH algorithms. The turbo code packet lengths and the time interleaving in MediaFLO are very short, which has given some surpluses regarding fast channel tuning[23] and service delivery, but on the other hand problems regarding robustness to errors and power consumption on the terminals. Tests with DVB-SH have proven that it is more beneficial to carry out the whole channel coding and time interleaving at the physical layer than to combine channel coding and time interleaving at the link layer with channel coding at the physical layer [DVB-NGH].

MediaFLO has been applied in various countries in either trials or full-blown solutions. One of these countries is USA. Here, the MediaFLO technology is used for broadcasting in the 716-722 MHz frequency band (UHF Channel 55) with 12 channels in total [MediaFLO USA]. Each channel uses a bandwidth of 200-250 kbps, and the transmitters operate at powers of 50 kW, allowing coverage of a 30-40 km area depending on the topology [Qualcomm]. Various vendors like Motorola, Samsung and LG have terminals, and examples of the quality of MediaFLO are available on YouTube [YouTube]. Apparently the picture quality is not very high, probably due

[21] DMB is developed both for satellite and terrestrial platforms. In this article when we talk about DMB we mean Terrestrial DMB (T-DMB).
[22] Available from Internet: *www.flotv.com/press-room*.
[23] Two seconds channel change in average compared to DVB-H´s average of four seconds.

to the high frame rate, as each channel has to stay within the limits of 250 kbps. The quality is, however, kept as high as possible due to the possibility of statistical multiplexing in MediaFLO known from high-end broadcast MPEG-2 encoders. In 2010 all MediaFLO services in the US were discontinued.

2.5.6 DVB-T2

The DVB-T2 draft standard (EN 302 755) was ratified by the DVB Steering Board[24] on June 26, 2008, published on the DVB homepage as 'DVB-T2 standard BlueBook"[25], and was handed over to ETSI by DVB.ORG on June 20, 2008[26].

The final standard was adopted in Sept. 2009 and it is expected to be put into service in 2012, where many countries shut down the analogue transmission. HD services were expected to be launched under T2 in England by 2009/2010.

In the following we seek to provide a concise, yet fairly technical review of the new technologies in DVB-T2 vs. DVB-T.

2.5.6.1 ERROR PROTECTION

DVB-T2 introduces a new type of error protection based on "Base Band frames" and LDPC Data packed into the base tape (base band) frames. The Base Band frames are error protected by LDPC error correction.

LDPC is an abbreviation for Low Density Parity Check code. LDPC is a trouble-shooting code, which is particularly well suited to transmit data on a noisy transmission channel.

LDPC thus offers an improvement of the channel-to-noise ratio of up to 5 dB. This allows a higher-order modulation, thereby achieving a higher bit rate with the same bandwidth and transmission power.

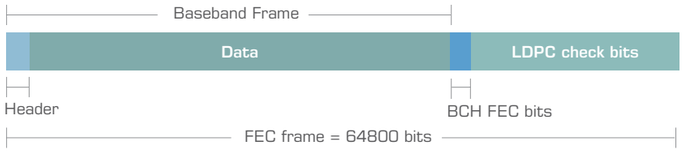

Figure 2-6: DVB-T2, FEC frame.

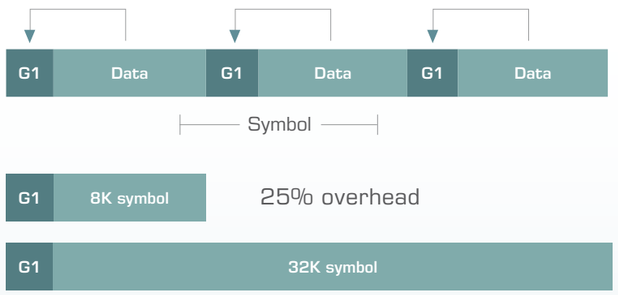

Figure 2-7: DVB-T2, Symbole time

[23] Available from Internet: *www.dvb.org/news_events/press_releases/press_releases/DVB_pr174%20T2%20Final.pdf.*
[24] Available from Internet: *www.dvb.org/technology/dvbt2/a122.tm3980r5.DVB-T2.pdf.*
[25] ETSI time table DVB-T2. Available from Internet: *www.omploader.org/va2Rp*

2.5.6.2 MODULATION

2.5.6.2.1 NUMBER CARRIER

Traditional DVB-T used either 2K or 8K carriers (4K for DVB-H). In DVB-T2, there are numerous carrier options: 1K, 2K, 4K, 8k, 16K, and 32k. The symbol time expands with the number of carriers. If the length of the guard interval is maintained (e.g. based on the distance between SFN transmitters), resulting in a relatively more data with respect to overhead, this will yield a higher bit rate.

2.5.6.2.2 GUARD INTERVAL

DVB-T2 encompasses several options for the Guard Interval: 1 / 128, 1 / 32, 1 / 16, 19/256, 1 / 8, 19/128, 1 / 4. This allows reduced overhead and gives more flexibility.

2.5.6.2.3 256 QAM

It is possible to use 256 QAM instead of the traditional 64 QAM in DVB-T2. This transfers 8 bits per symbol instead of 6 bits per symbol. This is possible due to the improved FEC error correction using LDPC.

2.5.6.3 SCATTERED PILOTS PATTERNS

The amplitude and phase of carrier pilots are known. The carrier pilots are used by the receiver to compensate for changes in the frequency and time domains of the transmission channel. In DVB-T 1 out of 12 data cells are scattered pilots, thus an 8% overhead for pilots.

- DVB-T2 allows 8 different pilot patterns. This minimizes the pilots overhead for a given guard interval
- Pilot cells are amplified up to 7 dB depending on the density of pilots in the pattern.

2.5.6.4 CONTINUOUS PILOTS

In addition to scattered pilots, continuous pilots are used in both DVB-T and DVB-T2.

They entail:
- Frequency locking of the receiver
- Elimination of phase errors due to channel equalization (impact/capping)
- 2.5% overhead on the continuous pilots in the case of DVB-T.

With DVB-T2, the number of continuous pilots depends on the FFT mode:
- Approximately 2.5% overhead for 1K and 2K mode
- 0.7% overhead for 8K, 16K, and 32K.

2.5.6.5 SERVICE SPECIFIC MODULATION/ RUGGEDNESS

Each service in a multiplex can be modulated separately and at different FEC rates. For example, a program could be using 16 QAM - FEC rate 3/4 and another 256 QAM - FEC rate 5/6.

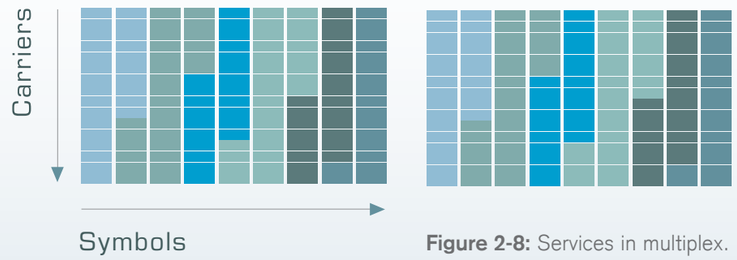

Figure 2-8: Services in multiplex.

Each service will have a slice in a frame. This method also saves energy for the recipient. The same technology (time slicing) is also an essential element in the DVB-H standard.

2.5.6.6 INTERLEAVING

LDPC is especially effective, if bit errors are randomly dispersed. LDPC is not effective against bit errors in bursts or series. The reason is Inter leaving, which is also known from the existing DVB standards. Interleaving in DVB-T2:

- Bit interleaving in a FEC block. This corrects the randomized single errors in the data cells
- Time interleaving. Dispersing data from each FEC block of a frame. Increases signal robustness against impulsive noise
- Frequency Interleaving. Corrects randomized corrupted data cells in a COFDM symbol.

2.5.6.7 GAIN

Preliminary estimates from trials in Britain show a gain of up to 47%. Although this is probably somewhat optimistic, it does show that there is any room for improvement.

2.6 OTHER TECHNOLOGIES

2.6.1 FLASH-OFDM

An alternative technology for using a radio link for data to provide both broadcast services and preserving bandwidth for on-demand services is considered. However, where many data link technologies have problems providing high data rates when moving at high speeds, an alternative technology has been tested in countries like Finland and Germany (the ICE trains) and was tested in Denmark as well at 872 MHz by Butler Networks [Butler]. It has later been applied in Denmark and feeds buses and S-trains with Internet connectivity[26].

This technology developed and marketed by Flarion is called Flash-OFDM (Fast Low-latency Access with Seamless Handoff Orthogonal Frequency Division Multiplexing) also referred to as F-OFDM. It is based on OFDM and has generated interest as a pure IP packet-switched cellular bearer, and 450 MHz frequency bands previously used by NMT-450 and C-Net C450 (now mostly decommissioned) in Europe are being licensed to Flash-OFDM operators. The tests has resulted in data link speeds of >5 Mbps downlink and >1 Mbps uplink at distances of up to 55 km moving a speed of 350 km/h.

No solution like MXtv for WiMAX has been proposed yet, but it can easily be imagined that such a technology will be available, if F-OFDM becomes commercially popular.

3 SERVICES AND CONTENT

This section deals with standards related to the services and content issues.

3.1 ELECTRONIC SERVICE GUIDE

The purpose of the Electronic Service Guide (ESG) is to provide a description of services available from a broadcaster's point of view. The ESG is encoded in an XML-based format and is structured into information units, so-called fragments. These fragments describe:

- The service and program schedule
- The technical details required to tune in and receive the service with optional interactive services
- The conditional access parameters and optional digital rights management
- Additional information for the user
- Purchase and delivery related information.

The service descriptions are dynamically updated, pushed and pulled from a variable number of service providers to different types of terminals using different broadcast and cellular bearer networks. The end-user then freely chooses which service the user would like. The terminal or a personalized service provider can also use the service description to automatically filter services based on data from a user profile. Each broadcaster on a given frequency has its own ESG root. ESG makes it easy for the end user to switch channels, to search for shows, to get detailed descriptions about content and even to set alerts for upcoming content of interest.

There are currently two standards for the ESG. The first version called the multi-standard ESG is using the DVB-CBMS schema and the newer standard proposed by OMA is called OMA BCAST.

The DVB-CBMS structure is based on seven tables:

- Service Guide
- Content
- Acquisition
- Schedule event
- Service bundle
- Purchase
- Purchase channel.

The OMA BCAST includes following functions:

- Service Guide
- File and Stream Distribution
- Notifications
- Service & Content Protection
- Service Interactivity
- Service Provisioning
- Terminal Provisioning
- Roaming and Mobility Support
- Specification on back-end interfaces for each function
- Broadcast Distribution System Adaptations.

DVB-CBMS could be said to satisfy the traditional broadcast business needs and models and not intended for using a return path channel to do interactive services, while the BCAST standard focuses more on convergence with other cellular technologies and specifies the service layers for other cellular bearers such as MBMS over 3G network than only broadcasting using DVB-H.

The main differences between OMA BCAST and DVB IPDC are:

- A single OMA BCAST Service Guide transport supports the marketing messages of several service operators. In the IPDC alternative, a separate ESG is needed for each operator
- The OMA BCAST Service Guide supports dynamic interactivity changes
- OMA BCAST allows the OMA BCAST Smartcard security method to be used in addition to the OMA BCAST DRM profile
- Proprietary conditional access systems vs. Smartcard Profile and DRM in OMA BCAST
- OMA BCAST can send notification using the broadcast transport stream for 3GPP MBMS, 3GPP2 BCMCS and IPDC over DVB-H.

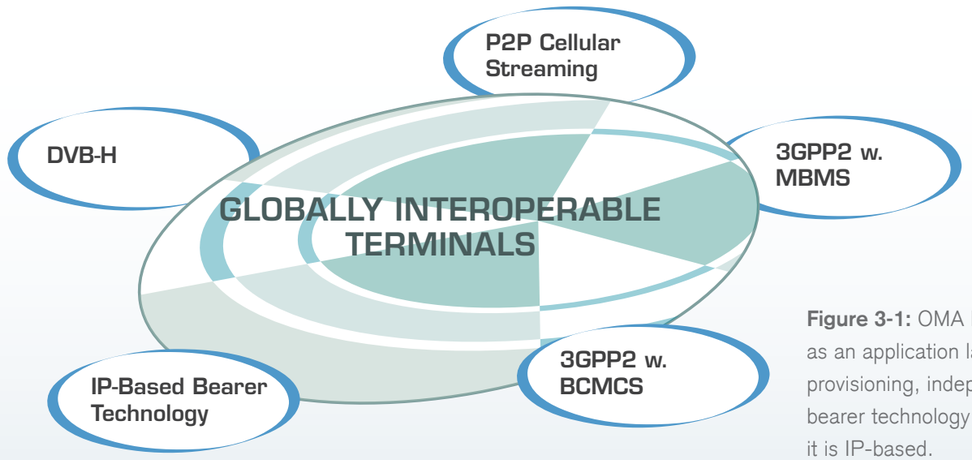

Figure 3-1: OMA BCAST defines as an application layer for service provisioning, independent of the bearer technology just as long as it is IP-based.

[26] Available from Internet (only in Danish): *www.butlernetworks.com/da/teknologi/bMobile/*.

There is a large development on the OMA BCAST specification standard, and mobile vendors like Nokia that has now switched to only support OMA BCAST as well as Samsung and LG are also providing terminals compliant to the standard. Italy started providing DVB-H only supporting the DVB-CBMS standard, but they are now rebuilding the network to support both standards. In Austria when applying the DVB-H network only OMA BCAST ESG was selected. All of these initiatives point in the direction that OMA BCAST in the future is more likely to be selected as the only ESG standard for DVB-H and other mobile broadcast solutions.

3.2 CONTENT AND METADATA DESCRIPTION FRAMEWORKS

Metadata has been defined as "data about data" and is composed of "elements". Metadata elements describe characteristics of the information object or resource, e.g. author, title and subject of the content. Metadata elements have standardized presentation and content in order to facilitate their interoperability and usefulness to the user of metadata. Most elements use rules, standards, or encoding schemas to ensure consistent presentation of their content. For example, the element 'date' is generally standardized to ISO 8601, and the element 'subject' is standardized to a thesaurus, such as the UNESCO Thesaurus, to ensure consistent vocabulary. In other words, metadata imposes a structure on unstructured information (i.e. documents, maps, audio-visual material, etc.) and adds more structure to already structured (i.e. database) information. The metadata structure is then exploitable for the purposes of finding information, administration, record keeping and preservation. MPEG-7 and TV Anytime are some of the key standards, described in the following.

3.2.1 MPEG-7

The main elements of the MPEG-7 standard consist of:

1. Descriptors that define the syntax and the semantics of each metadata element or feature and Description Schemes (DS) that specify the structure and semantics of the relationships between their components. That may also be between the Descriptors and the DS themselves
2. A Description Definition Language (DDL) to define the syntax of the MPEG-7 Description Tools and to allow the creation of new Description Schemes and Descriptors. Also extension and modification of existing Description Schemes can be done by DDL
3. System tools to support binary coded representation of data, which applies to efficient storage and transmission. The tools also include transmission mechanisms (both for textual and binary formats), multiplexing of descriptions, synchronization of descriptions with content, management and protection of intellectual property etc.

To sum up, in principle the MPEG-7 Description Tools allow creating descriptions (i.e., a set of instantiated Description Schemes and their corresponding Descriptors at the users' will), to incorporate application specific extensions using the DDL and to deploy the descriptions using System tools. The descriptions are coded using serialized XML schemas.

An example of an MPEG-7 description of content could be [Wactlar & Christel]:

- Information describing the creation and production processes of the content (director, title, short feature movie)
- Information related to the usage of the content (copyright pointers, usage history, broadcast schedule)
- Information of the storage features of the content (storage format, encoding)
- Structural information on spatial, temporal or spatio-temporal components of the content (scene cuts, segmentation in regions, region motion tracking)
- Information about low level features in the content (colours, textures, sound timbres, melody description)
- Conceptual information of the reality captured by the content (objects and events, interactions among objects)
- Information about how to browse the content in an efficient way (summaries, variations, spatial and frequency sub-bands)
- Information about the interaction of the user with the content (user preferences, usage history).

The MPEG-7 is very broad and is a huge literature study itself. The implementation and use of metadata in MAGNET Beyond related to retrieve audio-visual context could be done by use of the MPEG-7 standard, but only as a subset of the standard, because the full implementation would be too big and contain a lot of unnecessary information. A document describing the API for an MPEG-7 library implementation can be obtained from Joanneum Research [MPEG7 Lib].

3.2.2 TV-ANYTIME

The TV-Anytime Forum (cf. Sect. 1.3) was established in September 1999 to develop open specifications designed to allow all interested parties to exploit the potential of high volume digital storage in digital television platforms. In more general terms the specifications were made to aid the controlled delivery of multimedia content to the users' Digital Video Recorders (DVR), which could be any devicewith an IP stack implemented. This is called a Personal Video Recorder (PVR). The work included the development of a metadata standard that would work for spectators, advertisers and the rest of the stakeholder value chain in digital television. XML was chosen as the common representation format for metadata for the purpose of interoperability.

XML offers many advantages like:

- High-level description (mark-up language)
- Allows for extensibility
- Supports the separation of data from the application
- Widely used (used in many other software components in CAMMP)
- Schemas are used to represent the data model making interoperability easy.

XML is used as the common representation format, but the TV-Anytime descriptions are allowed to be instantiated in other formats. Using metadata defined in the TV-Anytime standard offers the opportunity of providing the user with personalized EPGs and the ability to do service discoveries. This concept is highly relevant to CAMMP, but an alternative technology will be used, focused on mobile terminals yet in many ways similar to TV-Anytime. This technology is defined by Open Mobile Alliance and also uses TV-Anytime in parts of the specification (cf. sect.3.1). The TV-Anytime is in many ways - regarding description of multimedia content - based on the work in the MPEG-7 standard, especially the parts 3-5 [MPEG-7].

Where possible, the TV-Anytime classification schemes use tags identical to those in MPEG-7.

3.2.2.1 CRID

The cornerstone of TV-Anytime metadata is the Content Reference Identifier (CRID) protocol. A CRID refers to a piece of content or one or more other CRIDs. A CRID reference is a URL (adopted by IETF[27]), and the content owner will typically use their own DNS names in a combination with a product specific name to create globally unique CRIDs.

An example of use from DR could be the very popular X-Factor competition. To access content relating to the competition in general, the following line could be a valid query:

crid://dr.dk/dr1/xfactor/

If referring to a specific competitor (e.g. the winner Linda) the following could be a valid query:

crid://dr.dk/dr1/xfactor/competitor/linda

The TV-Anytime specification classifies content related metadata as either **content description metadata** or **instance description metadata**. Content description metadata is defined as the general information about a piece of content that does not change regardless of how the content is published or broadcast [TV-Anytime Phase 1].

It includes information such as:

- Title
- Description
- Genre

Instance description metadata describes a particular instance of a piece of content such as:

- Content location
- Usage rules (pay-per-view, localization restrictions etc.)
- Delivery parameters (e.g. video and sound formats)

The categorization of the two metadata types relates to the way, the content is produced and later handled. When the content is created, the content description metadata is added.

[27] Available from Internet: *www.tools.ietf.org/html/rfc4078* [cited 23rd June 2009; 12.02].

When the content is made ready for distribution, the instance description metadata is added. When the user searches or selects content, both entries from the general content and the instance descriptions metadata can be used as parameters.

The third category of metadata is the **consumer metadata** and includes information such as:

- User history data
- Annotation metadata
- User preferences

The fourth and final type of metadata is called **segmentation metadata** and can basically contain segments of segmented content. In short, it refers to the ability to define, access, and manipulate temporal intervals within an AV stream using metadata. It is then possible to restructure an existing input AV stream to generate alternative navigation modes, insert a summary of the content with highlights or a set of bookmarks that point to important parts within the stream, quite similar to a chapter menu on a DVD. It could also be used to split an AV stream into fragments and insert commercials or simply add advertisements that are to be rendered by the player at specific time codes. This type of metadata is also added to make it possible for a CRID to refer to one or more other CRIDs as mentioned earlier.

The following Figure sums of the four types of metadata, and how the CRID for an individual content item is used to tie all of them together.

The above Figure does not contain a complete list of all TV-Anytime metadata available. The complete list will be considered in the design of CAMMP. In the following subsections, a few of the metadata classification schemes highly relevant to CAMMP are described.

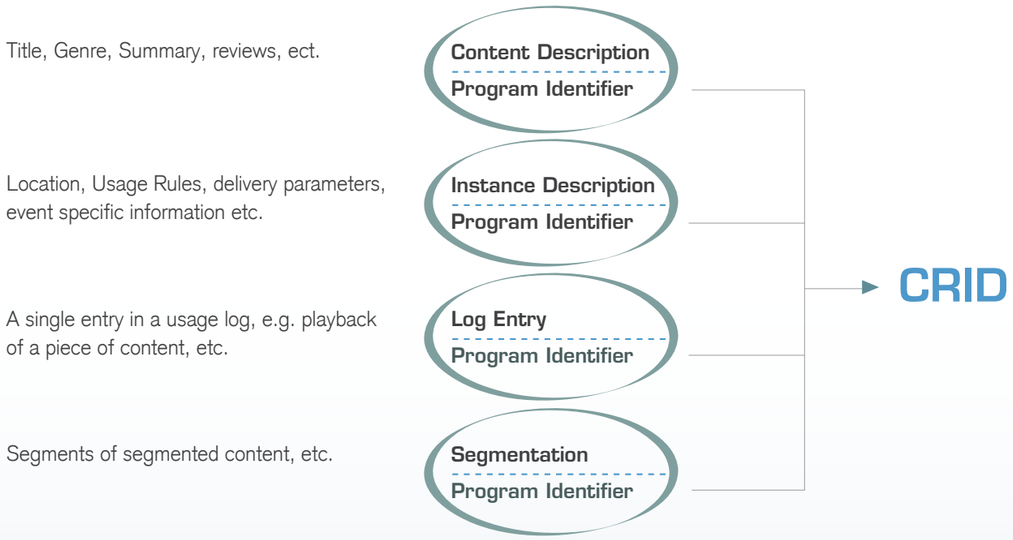

Figure 3-2: An example of how a CRID ties the different types of metadata in the TV-Anytime standard together. This is called a program CRID. The only common data for the four types of metadata is the unique program identifier. Note that this example does not resolve into further CRIDs [TV-Anytime 2001].

3.2.2.2 TV-ANYTIME GENRES

The TV-Anytime content classification is described using a predefined genre dictionary. This is based on an initiative of the European Broadcasting Union (EBU), and the genres are divided into four levels of classification [TV-Anytime 2001]. It is a very thorough description with many subcategories trying to make a complete framework for putting all types of content into one or more categories. Together with the TV-Anytime Metadata XML schemas, it provides a thorough rule-based vocabulary for describing radio and television programmes and also, to some extent, other forms of digital content and services. In short one could say that it is a very powerful platform for personalizable EPGs. The problem, however, is that the specification was originally created for radio and television, making it rather limited compared to the visions of CAMMP. Here, all kinds of media are supposed to be categorized. Therefore, the work of MPEG-7 is reconsidered in the definition of CAMMP multimedia content to ensure a conformance between CAMMP and existing standards.

The original TV-Anytime specification has later been extended to cover games as well. This is defined in the extended metadata documentation with a newtype called GamePerspectiveCS [TV-Anytime Phase 2]. A combination of this and the original genre dictionary from TV-Anytime covers the aspects of categorizing games.

3.2.2.3 TV-ANYTIME USER HISTORY AND PREFERENCES

As described earlier in the document, one of the visions with the TV-Anytime specification was to make it possible to generate personalized EPGs. This would require that the device being used to some extent keeps track of the user and contain the user's likes and dislikes. This has been implemented in TV-Anytime using the full specification from MPEG-7 with the same names. The following figure shows the user preferences scheme and relations between different other classifications schemes.

To accommodate the specifications, usage scenarios have been created by TV-Anytime that are subsets of the possible functionality using the user metadata formats. These following examples are examples of how user history could be used [TV-Anytime Phase 1]:

- Tracking and monitoring the content viewed by individual members of a household
- Building a personalized TV guide by tracking user viewing habits
- Selling viewing history to advertisers
- Tracking and monitoring content usage for more efficient content development
- Selling usage data to service provider
- Compensating the user for making his/her usage history data available to content providers.

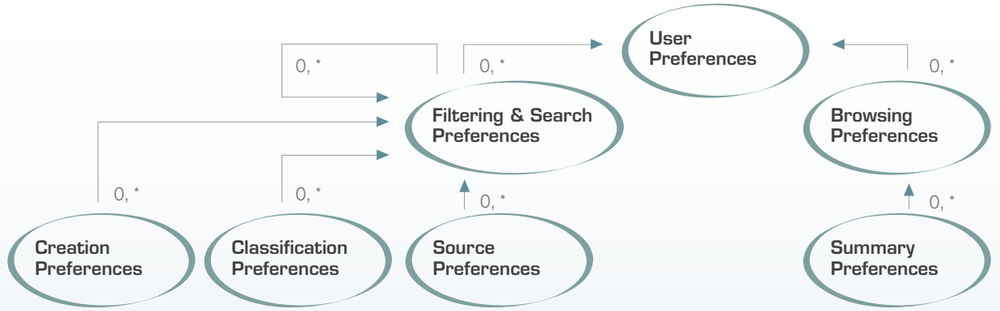

Figure 3-3: Illustration of the user preferences classification scheme as defined in MPEG-7 [MPEG-7 Part 5].

Adding the user preferences to the standard provides further possibilities to make content even more personalized. user preference descriptions can be correlated with media descriptions to search, filter, select and consume desired content. The following contains examples of the possibilities according to the TV-Anytime forum, when enabling the user preference opportunity from MPEG-7 [TV-Anytime Phase 1]:

- Identification of multiple users
- Filtering according to a rich combination of user preferences on genre, time, date, channel, etc.
- Accurate and effective agent operation by featuring a well-defined mapping between user preferences and media descriptions
- Prioritization of sources of information in combination with other preferences, such as genres, titles, etc.
- Specification of preferences (e.g. for a favourite actor) for a particular time duration
- Specification of preferred keywords in connection with other preferences, such as genre (e.g. news)
- Specification of preferred critics and critic's ratings
- Description of consumer's desire to keep the entire or selected parts of preference data private
- Specification of preferences for genre and source preference combinations
- Descriptions of preferences for particular kinds of highlights (e.g. highlights of certain duration or highlights composed of segments containing certain events)
- Exchange of personal profiles under consumer control
- Specification of profiles for different countries taking all of the above information into consideration, the following Figure can be derived containing the general and various aspects of using the TV-Anytime format.

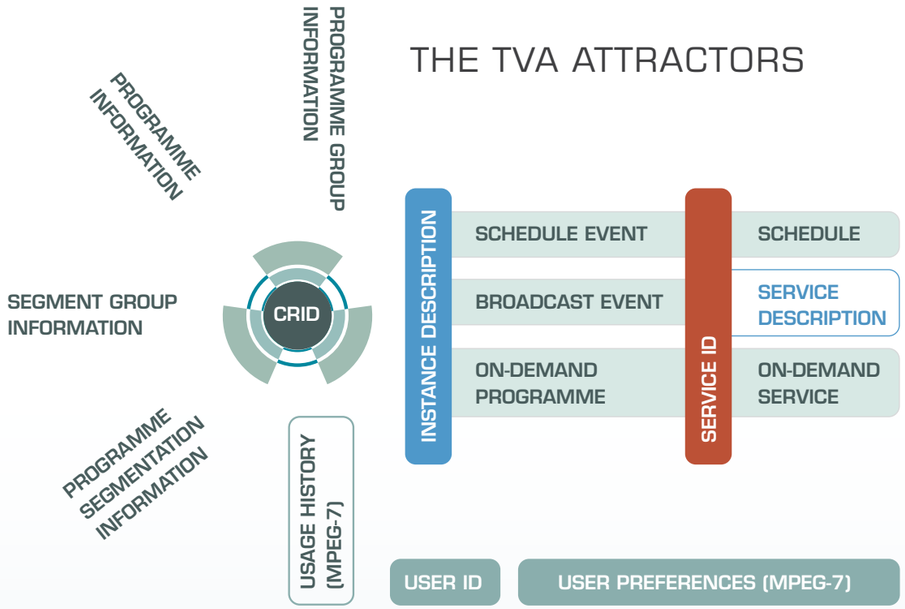

Figure 3-4: Alllustration of the CRID being the integrator to access content. It accesses metadata of different types and delivers the content it to the proper requestor, while keeping track of the user history. These requestors could have used their individual user preferences as well[28].

[28] Available from Internet: *www.ebu.ch/en/technical/trev/trev_295-evain.pdf.*

3.2.3 DIGITAL RIGHTS MANAGEMENT (DRM)

Digital Rights Management and copyright protection is extremely important for content owners and there are huge commercial interests at stake, e.g. for Hollywood movies and music. One of the most important standards for DRM is OMA DRM, which is currently in version 2.1, but version 1.0 is still widely used. Other technologies are Apple's FairPlay[29] and Microsoft's Windows Media DRM[30] and PlaysForSure. An interesting initiative is that of Creative Commons[31], which makes it possible to assign rights anywhere between "All rights reserved" and "No rights reserved".

3.3 USER PROFILES AND IDENTITY MANAGEMENT

User profiles are still predominantly at the stage of research and development. But considering that user identities are closely related to the user profile, there are a number of initiatives in the field of identity management, which may be applied in CAMMP. Some of these are described in the following.

3.3.1 3GPP GENERIC USER PROFILE

Generic User Profile (GUP) is a specification developed by 3GPP, aimed at managing subscriber data within the operators' domain. In order to manage their subscribers the operators need to keep track of subscriber data such as [3GPP GUP], [MBD1.2.1]:

- Authorized and subscribed services information
- General user information
- PLMN specific user information
- Privacy control data of the user
- Service-specific information of the user
- Terminal-related data
- Charging and billing related data.

The Generic User Profile specifications represent a framework for storing and managing this information and controlling access to the information from other stakeholders.

The goal of those specifications is to enable harmonized usage of user-related information originating from different domains. They aim at facilitating user preference management, user service customization, user information sharing, and terminal capability management as well as profile key access. In addition, they have started to develop Personal Network Management (PNM).

The 3GPP Generic User Profile (TS22.240, TS23.240, TS29.240) is the collection of data which is stored and managed by different entities such as the User Environment, the Home Environment, the Visited Network and Value Added Service Provider, which affects the way in which an individual user experiences services. GUP use cases often involve many entities and domains such as user, (3rd party) application servers, GUP server, network servers, and Home Subscriber Server (HSS). The application does not need to know where the user data is stored. In a broader context, 3GPP GUP provides a useful framework for handling access to personal data and requests from 3rd part service providers.

The GUP is composed of a number of **User Profile Components**. An individual service may make use of a number of User Profile Components (subset) from the GUP. The fact of having several domains within the 3GPP mobile system introduces a wide distribution of data associated with the user.

A natural extension of the GUP framework would be to enable user profile data to be shared between different stakeholders in order to facilitate:

- **User preference management**
  Enable applications to read and utilize a limited set of user preference information
- **User service customization**
  Enable applications to read and utilize service information, i.e., individual settings for a particular service
- **Terminal capability management**
  Enable applications to access terminal-related capabilities
- **User information sharing**
  Enable applications to read and utilize application level information, e.g. address book information
- **Profile key access**
  Enable applications to use a unique identity as a key to access profile information, e.g. any public user identity or an alias.

[29] Available from Internet: *www.en.wikipedia.org/wiki/FairPlay.*
[30] Available from Internet: *wwww.en.wikipedia.org/wiki/Windows_Media_DRM.*
[31] Available from Internet: *www.creativecommons.org/.*

e.g. based on an IMS (IP Multimedia Subsystem) approach [3GPP GUP].

3.3.2 LIBERTY ALLIANCE FRAMEWORKS

The Liberty Alliance key concepts are:

- **Federation** – The act of establishing a relationship between two entities, an association comprising any number of Providers and Identity Providers
- **Principal** – a person or "user", a system entity whose identity can be authenticated
- **Identity Provider** (IdP) – a service which authenticates and asserts a Principal's identity
- **Single Sign-On** (SSO) – the Principal's ability to authenticate with one system entity (Identity Provider) and have that authentication honoured by other system entities, often Service Providers.

The GUP server and data repositories are aligned with LA as an instance of the LA data Service template. LA standardizes functions for authentication, authorization, security/privacy control and discovery services that can be used in GUP.

The Liberty Alliance architecture is built upon:

- Liberty Identity Federation Framework (ID-FF)
- Liberty Identity Web Services Framework (ID-WSF)
- Liberty Identity Services Interface Specifications (ID-SIS)

The ID-WSF part has four core components, Authentication Service, Identity based Service Discovery, Service Invocation (SOAP Binding), and User Interaction Service. Specifically the Identity-based Service Discovery component is relevant for the MAGNET project investigating similar approaches for Personal Networks (PNs).

The ID-SIS part is investigating Geo-location, Presence and Gaming service aspects. The Liberty enabled identity-based Presence service and Identity-based specification will help products to realize presence service using existing protocols.

One issue is the interaction for information exchange between a Service Provider with Presence capabilities and other SPs (e.g. location, contact book, game). Mobile operators can confirm a user's request to exchange private data securely (e.g. presence, geo-location) with services that use the information.

The PrimeLife project has produced a comprehensive survey of ongoing work and initiatives in the field of identity management and privacy control, see [PrimeLife report].

3.3.3 OPENID

OpenID is an open source decentralized, lightweight protocol for single sign-on and portable identity with more than 25,000 web sites accepting OpenID. An OpenID is basically a URL and can be a domain name or the URL of an OpenID Identity Provider (IdP)[32]. This could be a URL like "littleimp.myopenid.com", and when asked to sign in to an OpenID-enabled site "littleimp.myopenid.com" is written as the user name. When you log in with an OpenID, the system logs in to the IdP for validation. This is in line with the specification from Liberty Alliance. This means that on OpenID-enabled sites, web users do not need to remember traditional items of identity such as username and password, but instead simply register with any OpenID IdP. Since OpenID is decentralized, any website can use OpenID, and OpenID does not require a centralized authority to confirm a user's digital identity and just like email addresses, the user can have more than one OpenID for work, at home or for any other use. However, unlike email, the web sites cannot send spam or access the user's data unless the user allows it.

OpenID operates with the following terms:

- **End-user** – The person who wants to assert his or her identity to a site
- **Identifier** – The URL or XRI chosen by the end-user as their OpenID identifier
- **OpenID Identity Provider** – A service provider offering the service of registering OpenID URLs or RIs and providing OpenID authentication
- **Relying party** – The site that wishes to verify the end-user's identifier referred in Liberty Alliance as a Service Provider (SP)
- **Server or server-agent** – The server that verifies the end-user's identifier. This may be the end-user's own server (such as their blog), or a server operated by an IdP
- **User-agent** – The program (such as a browser) that the end-user is using to access an identity provider or a relying party
- **Consumer** – an obsolete term for the relying party.

There are two modes in which the relying party can communicate with the IdP:

- **icroso_immediate** – The relying party requests that the provider not interact with the user. All communication is relayed through the user's browser without explicitly notifying the user
- **icroso_setup** – The user communicates with the IdP directly using the same browser used to access the relying party site.

The method of authentication may vary, but normally an OpenID IdP prompts a user for a password and then asks, if the user wishes to trust the relying party web site to receive his credentials and identity details. If the user declines, the browser is redirected to the relying party with a message indicating that authentication was rejected. The site in turn refuses to authenticate the user. If the user instead accepts, the browser is redirected to the designated return page on the relying party web site along with the user's credentials. That relying party must then confirm that the credentials really came from the IdP. If they had previously established a shared secret (see above), the relying party can validate the shared secret received with the credentials against the one previously stored. OpenID does not provide its own form of authentication, but if an IdP uses strong authentication, OpenID can be used for secure transactions such as banking and e-commerce.

An example of a bigger OpenID provider is the company Verisign, who is one of world's biggest providers of secure

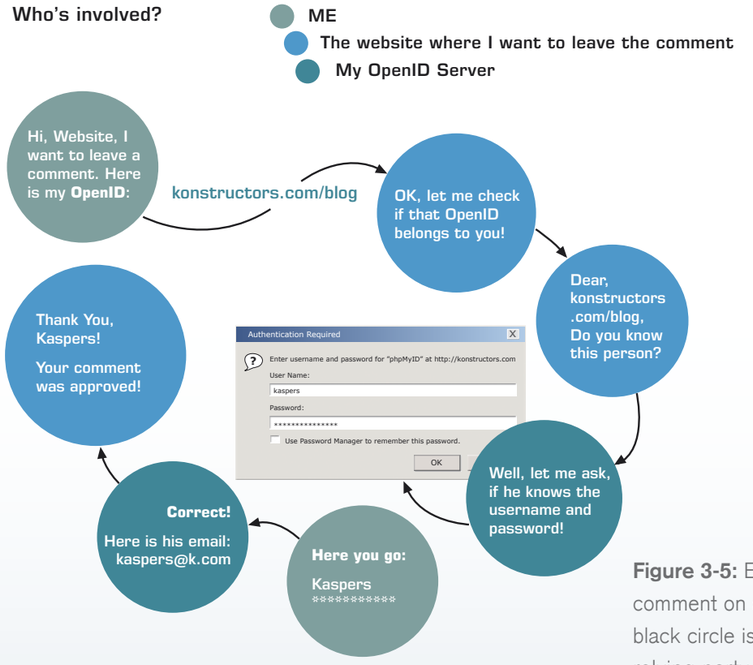

Figure 3-5: Example of a user wishing to leave a comment on a website using his OpenID. Here the black circle is the end-user, the beige circle is the relying party and the red circle is the IdP [Konstruktors].

[32] An IdP is defined as a computer system that issues credentials to a user and verifies that the issued credentials are valid. An IdP may operate one or more credential services, each of which issues end user credentials based on standards for identity verification and operations defined by the National Institute of Standards and Technology (NIST). A user can hold credentials from multiple IdPs and a "Federation" of IdPs is also possible.

digital infrastructure. Among other roles Verisign is acting as a Personal Identity Provider (PIP) and has adapted and enabled the OpenID technology also. Verisign does not release software, as most of the software is fully proprietary. However, a PIP portal enabling OpenID [Verisign] and a list of OpenID enabled sites [OpenID sites] are available online.

3.3.4 OPENSOCIAL TECHNOLOGY

The idea behind the OpenSocial technology from Google is in many ways comparable to application development in Facebook. However, where Facebook uses a known formats in proprietary formats called FBML, FBJS and more, OpenSocial is largely based on open standards and is fairly easy to develop to. It uses XML, HTML, Javascript, and the data formats are all ATOM and RESTful/WOA and even Flash content and functionality can be applied inside the OpenSocial application. Popular development platforms like Ruby on Rails[33] can support the server-side API. The concept of OpenSocial development is illustrated in **Figure 3-6**.

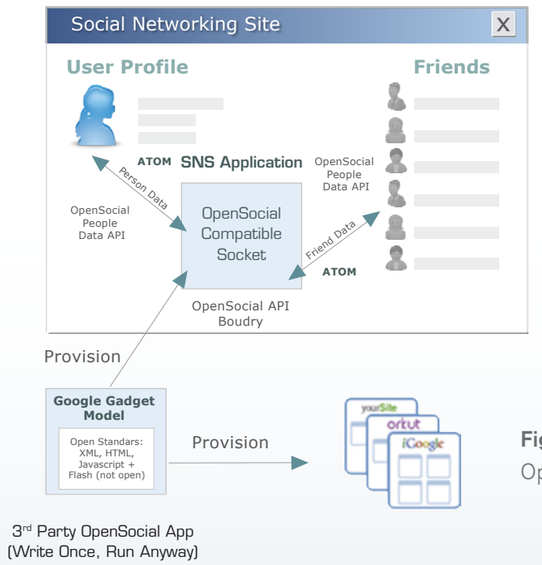

Figure 3-6: Conceptual diagram of the OpenSocial development platform [WEB2].

A site that supports OpenSocial applications can – if allowed – import or export information about a user and the friends of the user's to create a sort of a social profile of the user for a 3rd party application compliant with OpenSocial. These services can then be personalized based upon the information retrieved. There are many web sites already implementing OpenSocial, including Engage.com, Friendster, hi5, Hyves, imeem, LinkedIn, MySpace, Ning, Oracle, Orkut, Plaxo, Salesforce.com, Six Apart, Tianji, Viadeo, and XING[34].

3.3.5 FEDERID

Many initiatives on the web work with specific parts of standardization organizations and communities implementing open source solutions compliant to the standards but not necessarily made for an end user. While work has been done on implementing Liberty Alliance standards to enable identity provisioning and management, others have focused on online access to user content in a standardized AAA[35] way. On open source project called FederID has gathered the best of these initiatives and implemented a full-blown solution with graphical user interfaces [GUI] as well.

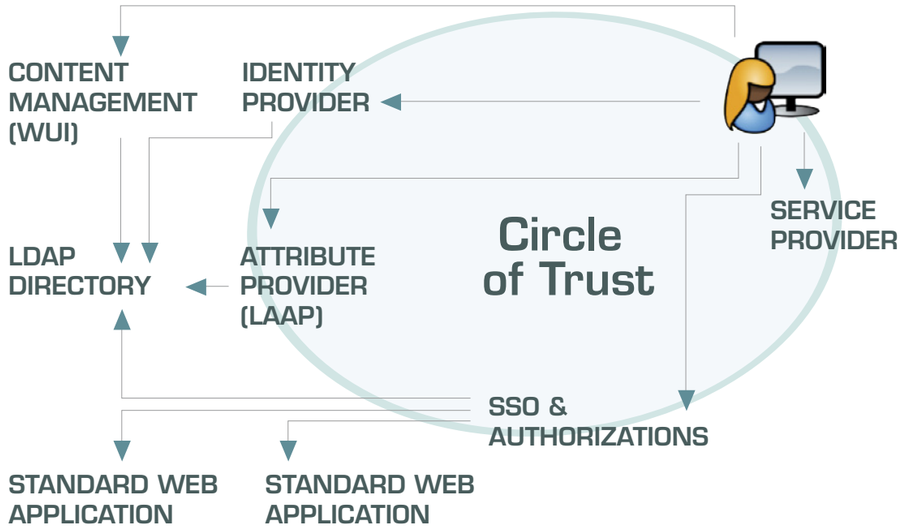

Figure 3-7: Schematic overview of the FederID system [FederID by OW2 (www.ow2.org.)].

The principle of FederID is in line with principle of Liberty Alliance's specifications. A user logs on to authenticate himself to an IdP and can then be automatically authenticated to all service providers or other IdPs that have been trusted by this IdP (a "circle of trust"). The different service providers, however, are not allowed to communicate any information about the user between each other. They can exchange information relating to this user only with the IdP that can access the user's credentials for relevant data, if it is available. Overall, LA standardizes functions for authentication, authorization, security/privacy control and service discovery. In other words, LA can grant access for a service provider to offer services to an identified user or a representative of the user, if this service provider is accepted by either the IdP or the user.

The FederID project has released software and a demo is available online.

3.3.6 THE BANDIT PROJECT

Based on the open source Higgins framework[36] that enables users and applications to integrate identity, profile, and relationship information across multiple data sources and protocols the Bandit Project has implemented a bunch of other technologies to handle any digital identity from other vendors. The implemented technologies are in summary:

- CASA – Common Authentication Services Adapter[37]
- OpenXDAS[38]
- DigitalMe[39]
- Higgins Framework

The major outcome of the project has until now been the Bandit Cards compatible with Microsoft Windows Live[40] and the Bandit Role Engine. Bandit Cards provides a consistent

[33] Available from Internet: *www.rubyonrails.org/.*
[34] Available from Internet: *www.code.google.com/apis/opensocial/.*
[35] Authentication, Authorization and Accounting mechanisms.
[36] Available from Internet: *www.eclipse.org/higgins/.*
[37] Available from Internet: *www.novell.com/.*
[38] Available from Internet: *www.openxdas.sourceforge.net/.*
[39] Available from Internet: *www.code.bandit-project.org/trac/wiki/DigitalMe.*
[40] Available from Internet: *www.login.live.com/beta/managecards.srf?wa=wsignin1.0&wreply=http://www.live.com@vv=500.*

way for web sites to request information from a user, let the user manage this person's information from a central location and to review card information before send it. Bandit Cards supports two types of cards:

- Personal Cards
- Managed Cards

Personal cards are like business cards and include information such as a user's name, birth date, phone number and address. The personal information that is entered on a card is stored encrypted on the user's computer. Managed cards are created and stored by a managed card provider on a user's behalf. Some managed card information is stored encrypted on the user's computer. This information includes the card name, the date that the card was installed, a "valid-through" date, and a history of the sites where this card was used. When the user enters a website that accepts a Bandit Card, that site indicates what type of card it is willing to accept. Bandit Cards show the user, which cards in the collection meet the site's requirements. The user can review the card's information before submitting it to a site.

The Bandit Role Engine is a role-based system that uses the Bandit Common Identity. The Role Engine comprises:

- An open source component that can be integrated into any application.
- A consistent role calculator that unifies authorization across diverse systems and services.
- An emitter of Bandit audit records (Audit Record Framework).
- Based on the open standards: RBAC and XACML.

The idea behind a role-based system is illustrated in **Figure 3-8**.

The idea is that users or computers are assigned roles that contain specific access rights to different resources. A user with administrator role can access everything but a simple user might only be able to use one specific printer or so. This idea is kept in the Bandit Role Engine, where all resources are assigned an ID based on Higgins Identity Attribute Service (IdAS).

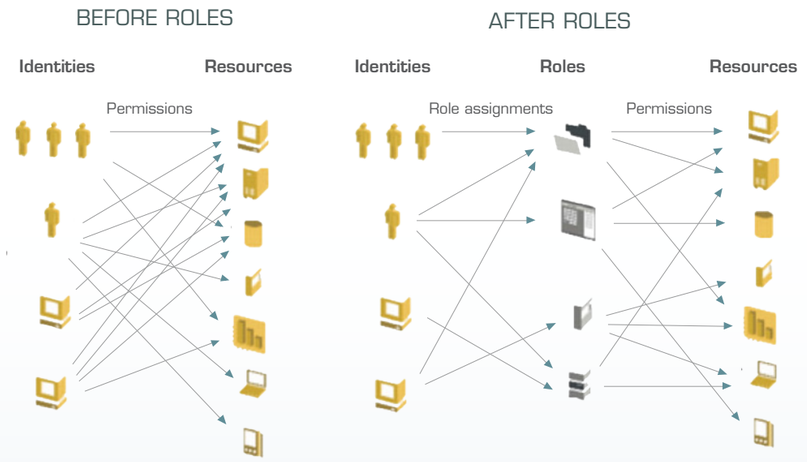

Figure 3-8: Illustration of the difference between a normal authentication system for resources and a role-based system [BANDIT].

The engine can be called from any application and based on the queried identity the engine provides the role information to the application from the Role Store along with the role policy defined. From the policy role membership the access control can be calculated.

3.3.7 MICROSOFT CARDSPACE

Microsoft CardSpace is built on the concept of the identity metasystem based on "The Laws of Identity" proposed by Microsoft[41]. The identity metasystem can in many ways be compared to the Liberty Alliance with words like IdP, relying parties and service providers. CardSpace basically provides a way to represent secure digital identities for the users. It was originally called "InfoCard" and it lets an application like Internet Explorer (and with a plug-in also Mozilla Firefox) in a consistent way work with digital identities regardless of the kinds of security tokens the different web sites and applications uses. The user can create and manage different digital identities and also choose from a group of identity providers as the source of the digital identity presented to the relying party.

The concept behind CardSpace is based on the identification process a user experiences in the real world when using physical identification cards. In the CardSpace system an IdP issues virtual information cards to users called InfoCards, and the user can then later use them to identify himself or herself to any service provider who trusts the identity provider. The InfoCard is stored in the user's machine and does not contain any security-sensitive information. CardSpace does not compete directly with other Internet identity architectures like OpenID and Liberty Alliance's SAML. The three approaches to identity management and SSO can be seen as complementary. To give an example InfoCards can be used for signing into OpenID providers and SAML IdP to access different service providers that could be or become a part of the user's circle-of-trust. The idea about the InfoCards can be compared to the DAIDALOS concept of Virtual ID's (VID) in many ways. However, a VID also contain security-sensitive information that has to be security enforced by another system. This could be a

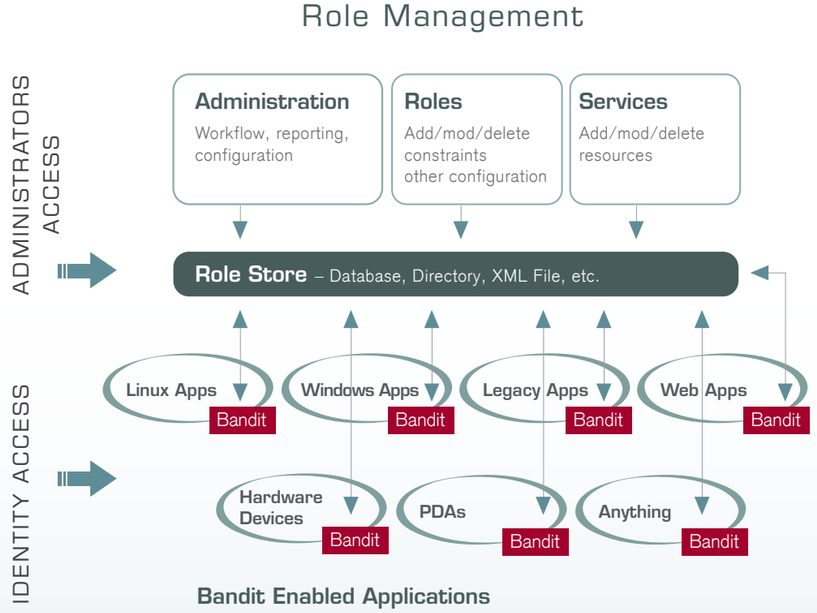

Figure 3-9: Illustration of the Bandit Role Engine [BANDIT].

[41] Available from Internet: *www.msdn.microsoft.com/en-us/library/ms996456.aspx.*

system based on Liberty Alliance (e.g. FederID) or simply by applying policies and a policy enforcer mechanism to all parts of the user profile as proposed in the MAGNET Beyond project.

3.4 CONTEXT INFORMATION

There are many types of context information that might be considered for service adaptation in CAMMP. Here we only give details about a couple of them, dealing with device profiles and location information.

3.4.1 DEVICE PROFILES

Device profiles are – in a narrow sense – not really personal, but rather express in a standardized manner the capabilities of a device: Communication interfaces and other connectivity; display resolution; sound, image and video capabilities; operating system and installed software (if applicable); etc.

However, the user profile should contain information about the specific personal devices of the user and personal settings such as, e.g., tailored user interface, colour themes, language setting, and preferred dictionary. Hence, the combination of settings and the basic device profile could be stored in the user profile – or the user profile might contain a pointer to another location, from where the device profile may be retrieved.

Two of the main specifications for device profiles are briefly described in the following.

3.4.1.1 W3C CC/PP

The W3C CC/PP defines a Composite Capabilities / Preference Profile (CC/PP) as a description of device capabilities and user preferences, often referred to as a device's delivery context, which can be used to guide the adaptation of content presented to that device [W3C CC/PP]. The CC/PP Structure and Vocabularies 2.0 (abbreviated to CC/PP in the following) define a client profile data format and a framework for incorporating application- and operating environment-specific features.

It should be noted that in [W3C CC/PP], the term "profile" does not refer to a subset of a particular specification, but rather to the document(s), which describe the capabilities of a device. The Resource Description Framework (RDF)[42] is used to create profiles that describe user agent capabilities and preferences.

A CC/PP profile is broadly constructed as a 2-level hierarchy: a profile having at least one or more components (e.g. the hardware platform, the software platform, an application such as a browser), and each component having at least one or more attributes (that is, a sub-tree whose branches are the capabilities or preferences associated with that component). A CC/PP profile basically describes client and device capabilities and includes user preferences in terms of a number of "CC/PP attributes" for each component.

3.4.1.2 OMA UAPROF

The User Agent Profile (UAProf) specification [OMA BC], [OMA UAProf], is concerned with capturing capability and preference information for wireless devices. It includes the hardware and software characteristics of the device as well as information about the network to which the device is connected. This information can be used by content providers to produce content in an appropriate format for the specific device. UAProf is a part of Open Mobile Alliance WAP 2.0 specification [OMA UAProf].

The User Agent Profile (UAProf) specification enables the end-to-end flow of a User Agent Profile between the WAP client, the intermediate network points (proxies and gateways), and the origin server. It seeks to interoperate with the emerging standards for Composite Capability/Preference Profile (CC/PP) distribution over the Internet. It uses the CC/PP model to define a robust, extensible framework for describing and transmitting user agent profile about the client, user and network that will be processing the content contained in a WSP/HTTP response. UAProf and CC/PP have a common ancestry. In accordance with CC/PP, UAProf schema is defined using an RDF schema and vocabulary. The specification defines a set of components and attributes that WAP enabled devices may convey within the UAProf. The UAProf specification may include, but is not limited to:

- hardware characteristics (screen size, colour capabilities, image capabilities, manufacturer, etc.),
- software characteristics (operating system vendor and version, list of audio and video codecs, etc.),
- application/user preferences (browser manufacturer and version, markup languages and versions supported, scripting languages supported, etc.),
- WAP characteristics (WML script libraries, WAP version, WML deck size, etc.),
- network characteristics (bearer characteristics such as latency and reliability, etc.).

Servers, gateways, and proxies can use UAProf to ensure that the user receives content that is particularly tailored for the environment, in which it will be presented. Moreover, this specification permits the origin server to select and deliver services that are appropriate to the capabilities of the requesting client. Finally, it is expected that this specification will be used to enhance content adaptation based on user preferences, and other factors, as specified by the Platform for Privacy Preferences Project of W3. The RDF schema of UAProf can be used as a template to build a device profile specification.

4 MOBILE OPERATING SYSTEMS

This chapter gives an analysis of the mainstream operating systems for mobile terminals. Not all of the available mobile operating systems on the market have been analysed. Only the most active and company driven variants have been selected, based on market analysts' facts and predictions [Gartner, 2009], [DigiTimes, 2009]. One common factor is that all of the operating systems are targeted for smartphones.

In the following, the most prominent available mobile operating systems are described. The different operating systems are typically based on older and well-known operating system architectures. The most prominent types of architectures are the monolithic kernel type and the microkernel. A kernel is commonly defined as the code that is directly responsible for the tasking model (the part of the operating system that controls how tasks are executed and in what order). In the Figure below the basic concepts of the two types of architectures are illustrated.

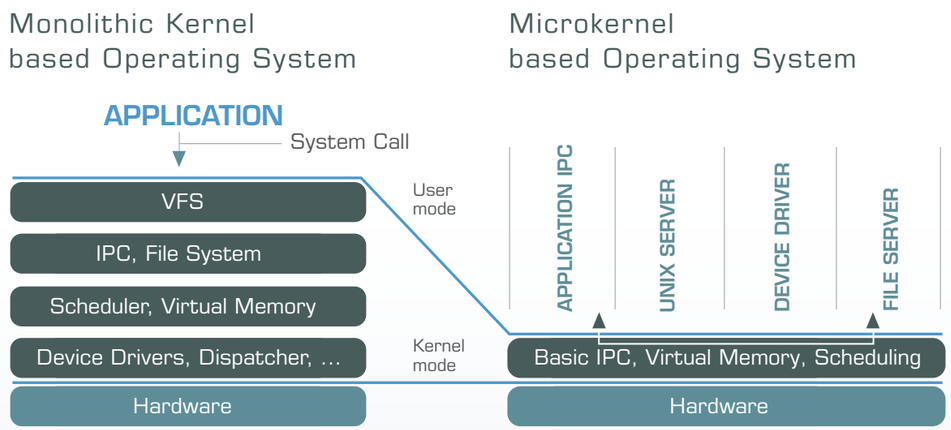

Figure 4-1: The two most popular types of operating system architectures. The left figure is an example of the monolithic kernel e.g. used in Linux, and the right figure illustrates a microkernel e.g. used in Symbian.

[42] Available from Internet: *www.w3.org/RDF/.*

Originally a microkernel, by definition, was a kernel that was about 50 kB or less. Today, a microkernel is usually meant as a systematic design, where the device drivers, programs, and system services run outside of the kernel memory space. The only functionalities in the kernel are mechanisms to somewhat tie the external OS components together and make them work. A monolithic kernel is an architecture where a large portion of the OS components are part of the kernel, and they are all executed inside the kernel address space. There is also another type of the monolithic design, where some of the OS components are modules that have their own address space to run in. This variant could arguably also be called a microkernel, but it is however still defined as being a monolithic kernel.

4.1 IPHONE OS (IOS 4)

Courtesy of Apple Inc. Photographer Frederick Lieberath

This is the iPhone (and iPod Touch) OS developed by Apple. The newest version is 4 and it now supports simulated multitasking, which so to speak "freezes" the current application in focus, when switching to a new application. This is unlike real multitasking, where all executed applications have access to the processor. All of the iOS versions are based on a variant of the same Darwin operating system core (heavily modified version of the Mach microkernel[43]) that is found in Mac OS X, which is a Unix-like operating system by nature. The newest version is also compatible with the iPad. A notable add-on software feature is the possibility to use a Wi-Fi connection to do video calls in high quality.

The newest iPhone 4 has a so-called "Retina Display", which is a 3.5-inch (89 mm) LED backlit liquid crystal display with a 960×640 pixel resolution and more processing power and RAM than all of its predecessors.

The new design incorporates an un-insulated stainless steel frame that acts as the device's antenna. Users of the iPhone 4 have reported a signal reduction, when the phone is held in certain ways, especially in the left hand, as the antenna problem is in the bottom left corner of the phone's side casing. This problem has been confirmed by some of the CAMMP partners. It can be solved by adding a special frame around the metal to prevent short-circuiting of the antenna.

Application development for the iPhone OS is mainly done using objective C, but C/C++ development is also possible. Effort has been put in supporting widgets as well. Development of the iPhone OS is controlled by Apple in all aspects. However, the short learning time to start building applications to it, that even takes advantage of the hardware possibilities, together with the large community around it, are the main drivers.

4.2 ANDROID

The Android OS is a result of the Open Handset Alliance (OHA) with Google as one of the very active partners in the implementation. Other notable partners in OHA being handset manufacturers are HTC, LG, Samsung, Sony Ericsson, Motorola – but not Nokia, Palm (now HP) and Apple – as well as NTT DoCoMo. Android is designed with the intention of working fast on even small devices (with the ARM hardware architecture) and being as much open source as possible. The current version of Android is 2.2 called Froyo (abbreviation for Frozen Yoghurt), but a new terminal from Google and Samsung will feature the newest version 2.3 of Android called Gingerbread.

Android OS isn't made in Java, but the application development for Android is Java. However, C/C++ and ARM Assembly can also be used, when using a native Android development kit.

[43] Available from Internet: *www-2.cs.cmu.edu/afs/cs/project/mach/public/www/mach.html.*

Figure 4-2: The Android OS is built on the Linux kernel with the proper drivers and a built-in Java Virtual Machine (JVM) for Android. Therefore, Android is not Linux, but instead the Android OS uses Linux to run.

Android is based on a Linux kernel with the user space and the JVM for Android (Dalvik) being written in C. The Java implementation is based on a custom profile with a lot of own-developed functionality, especially regarding the graphical components and processing.

As the OS is open source, everyone is allowed to create Android terminals. The left figure is an example of a Danish Android mobile phone called Lumigon with the unique B&O designed ICEpower sound[44]. Even though Android is open source, the actual development is Google-controlled only. Also applications created by Google to access existing Google web services are not open source and not allowed to be distributed without permission from Google. The operating system is in rapid development, and version 2.2 has improved on several functionalities, especially when accessing the SD card and speed in general. Multi-tasking functionality is an important and powerful feature of Android. The OS is implemented with the vision of being always on, and most processing will happen online making this OS a suitable choice for developing widgets, enabling cloud computing and taking advantage of social communities applications. Android does support the full Adobe Flash.

The newest version 2.3 of Android comes pre-installed in the mobile phone called Nexus S[46] from Google and Samsung is expected to have access to Google's upcoming music store, be better integrated with social networks like Twitter and Facebook and also support for front-facing video chat, probably inspired by Apple's "FaceTime" introduced on the iPhone[45]. The most notable difference is the support for near field communication (NFC), which Google's CEO Eric Schmidt thinks will eventually replace credit cards[46].

[44] Available from Internet: *www.lumigon.dk/products.*
[45] Available from Internet: www.*gizmodo.com/5676008/hands-on-the-nexus-two-by-samsung?skyline=true&s=i.*
[46] Available from Internet: *www.engadget.com/2010/11/15/eric-schmidt-shows-off-a-nexus-s-at-the-web-2-0-summit/.*

4.3 SYMBIAN/MAEMO/MEEGO

Symbian is one of the oldest mobile operating systems and is still by far the most common OS on phones today. At the end of 2009, according to Gartner, 46.9% of all mobiles phones used Symbian[47]. But that goes for all kinds of phones released (not only smartphones), and Nokia's big success is due to the huge amount of low-end phones being shipped every day. Looking only at high-end smartphones, Nokia has released the N8 with the Symbian version called Symbian^3[48] and the upcoming smartphones called X7 and E6 are based on the newest version of Symbian called Anna[49].

Symbian has a microkernel OS architecture and originates from the old Psion graphical OS called EPOC, which was primarily designed for PDAs back in the 1980s. It was, and is still, a great multi-tasking OS, and the newest release provides the developer with the opportunity to implement applications in Qt, Python Mobile, J2ME, Flash Lite (not standard Flash), Ruby, .NET, WRT Widgets, Symbian C++ and Standard C/C++.

The look of the desktop and menus in Symbian are generally old-fashioned and lacks some of the innovative control like webOS, Android and especially iPhone. Symbian^3 has taken Nokia smartphones into a new generation mobile terminals, especially regarding the hardware specifications, but the OS seems to be at least a generation behind competing mobile OS. However, the performance of the OS has really improved compared to earlier versions. With the newest update especially the responsiveness has become significantly better, and the kinetic scroll of the screen is now mapped to the actual finger movement instead of the first version of the Nokia N8 device with Symbian^3, which only recognized and responded to a complete gesture[50].

Nokia has not been the only partner developing on the Symbian platform. Sony Ericsson and especially Samsung have been very active in the past[51]. However, both have stated that they will no longer support the development of the operating system. Samsung will start phasing out Symbian from 2010 to focus on Windows Mobile, Android and their own developed Linux-based mobile OS called Bada. The statement was later officially denied by both Nokia and Samsung. But it was in late 2010 official that Samsung would no longer develop or use Symbian in their products. The Symbian development lab in Samsung would be closed, and the support forum removed from Dec. 31, 2010[52].

Latest news from the Symbian foundation, the organization behind Symbian, is that the foundation will be changing to become a legal entity responsible for licensing software and other intellectual property, such as the Symbian trademark. Nokia will lead the future development of the Symbian platform and make it available to the foundation in an alternative way compared to earlier. The foundation will in phases reduce both operations and staff numbers. The "new" Symbian Foundation will be governed by a group of non-executive directors tasked with overseeing the organization's licensing function[53]. All the software development for the Symbian platform will be outsourced to Accenture in a strategic collaboration with Nokia. The final agreement that also contains plans for Accenture to provide software services to the Windows Phone 7 platform[54] (see section 4.5). Nokia has announced that their future high-end smartphones will be based on the Windows Phone 7 platform with releases in the end of 2011[55].

Windows Phone 7 and Symbian are not the only OS that Nokia has and still works on. An open source Linux-based OS called MAEMO was released in 2005 by Nokia for a special type of small internet enabled tablet PCs. This work has led to a new OS developed in collaboration with Intel called MeeGo[56]. The first MeeGo-enabled devices have been released, but they are not devices created by Nokia[57, 58]. MeeGo will not only focus on supporting netbooks and smartphones. It is designed to be implemented for in-Vehicle, Connected TVs and Media phones as well.

4.4 WebOS

WebOS was originally developed as open source from Palm in 2009. Palm was bought in 2010 by HP, and the mobile operating system, focusing solely on web runtime (WRT) widgets, is now entering version 2.0 (released on 19th October 2010) and the market of tablet PCs as well. WebOS is the classic PDA maker Palm's latest version of a mobile OS. It is very different from older versions. It is solely based on applications using WRT widgets that are implemented in HTML, JavaScript and CSS. No versions of Flash were supported in the initial versions. WebOS is closed source with partly open source software components[59]. It is based on a Linux 2.6.24 kernel with proper patches and hardware driver support, together with a WebKit implementation that is the main engine for the web applications. In WebOS terminology applications are composed of one or more distinct scenes, rendered on a stage in a card. A stage can be compared to a window or tab in a browser, and each scene as different web pages. Each scene is composed of underlying JavaScript code that provides the functionality of the scene. Within a scene, the application presents graphical widgets to the user that the user can interact with. This conforms to the W3 Document Object Model (DOM)[60], providing access to all elements on a web page that can by dynamically updated or manipulated.

Version 2.0 of WebOS introduces notable new functionalities such as[61]:

- True multitasking, meaning that apps stay open in the background and continue their processes. This is unlike the "simulated" multitasking (e.g. on iPhone 4) that instead "freezes" the app and continue, when returned to
- JustType, where the user can write a text and then decide how to ship it by SMS, e-mail, Facebook, Twitter etc. Developers can also interface to this
- Full support for C/C++ plug-ins. This is in order to mix the best from lightweight web technologies with the processing power of native OS support from C/C++ components and in one app. In the initial versions of WebOS this functionality never left beta stage
- HTML5 support. At least part of the upcoming standard
- Preinstalled Skype client
- Flash 10 browser support.

Ari Jaaksi resigned as head of Nokia's MeeGo division, and joined the WebOS team starting November 2010 as senior vice president of WebOS at Hewlett-Packard's Palm division[62]. Also, Victoria Coleman, who was the head of Samsung's R&D Centre in San Jose, has joined the WebOS team with the responsibility to oversee the platform and application development. This has definitely raised the expectations for the future of WebOS.

[47] Available from Internet: *www.gartner.com/it/page.jsp?id=1306513.*
[48] Pronounced: "Symbian to the third"
[49] Available from Internet: *www.conversations.nokia.com/2011/04/12/announcing-symbian-anna-aka-pr2/.*
[50] Unlike the normal touch phones the movement of the finger had to finish its path before the device responded to it. This is called a gesture. For a user it feels like the device does not respond properly compared to an Android or iPhone device
[51] Available from Internet: *www.press.nokia.com/2008/06/24/nokia-to-acquire-symbian-limited-to-enable-evolution-of-the-leading-open-mobile-platform/.*
[52] Available from Internet: *www.innovator.samsungmobile.com/bbs/tech/view.do?boardName=technology&messageId=99534.*
[53] Available from Internet: *www.symbian.org/news-and-media/2010/11/08/symbian-foundation-transition-licensing-operation.*
[54] Available from Internet: *www.press.nokia.com/2011/04/27/nokia-announces-plans-to-transfer-symbian-software-activities-to-accenture-accenture-to-provide-future-smartphone-ecosystem-services-to-nokia/.*
[55] Available from Internet: *www.press.nokia.com/2011/02/11/nokia-and-microsoft-announce-plans-for-a-broad-strategic-partnership-to-build-a-new-global-ecosystem/.*
[56] Available from Internet: *www.engadget.com/2010/10/21/nokia-refines-development-stategy-adopts-html5-in-qt-and-ends-s.*
[57] Available from Internet: *www.wetab.mobi/en/product-details.*
[58] Intel's version is called: "Intel's Moorestown Quanta Redvale tablet". Available from internet: *www.allaboutmeego.com/news/item/11614_Intels_Quanta_Redvale_tablet_s.php.*
[59] Some of the software implementations are available from Internet: *www.opensource.palm.com/1.4.5/index.html.*
[60] Available from Internet: *www.w3.org/DOM/.*
[61] Available from Internet: *www.hp.com/hpinfo/newsroom/press/2010/101019a.html.*
[62] Available from Internet: *www.digitaldaily.allthingsd.com/20101014/high-profile-hires-for-palm-nokias-ari-jaaksi-and-samsungs-victoria-coleman/?mod=ATD_rss.*

4.5 WINDOWS MOBILE (AND PHONE 7)

Windows Mobile OS is a proprietary and not open source OS originally created to be a mobile version of Windows with a user interface compliant to the current Windows version. It is originally based on the Windows CE v5.2 kernel, which most hardware specific components are offered as open source. Windows CE is a minimalistic real-time multi-tasking OS that can run in less than a megabyte of memory. Windows Mobile was updated to version 6.5 in October 2009 as a sort of a consolation prize for the delayed Windows Phone 7 that was said to be the real iPhone-killer. With the update to 6.5 a new user interface inspired by trends from smart-phones user interfaces was introduced. The update also included access to the new application store from Microsoft called Windows Marketplace. The amount of applications available was very limited and they were not as fancy as iPhone and Android applications. A number of programming languages were supported for Windows Mobile and CE development. This includes J2ME, Qt, Visual Basic, .NET, Visual C++ and a lot more. Together with support for WRT widgets (JavaScript, CSS and HTML) and Flash Lite as well, Windows Mobile was considered a very versatile platform for application developers. However, the look and feel still felt generations behind webOS, Android and iPhone. A major brush-up was expected with the new version of the OS.

Windows Phone 7 was introduced in October 2010, and even Microsoft called the Windows Phone 7 "a complete reboot for their mobile strategy". It is very different from any earlier version of a Windows phone OS. The graphical user interfaces are very modern and are heavily inspired by the Microsoft developed Zune music player. All development for the platform is done in either Microsoft Silverlight for web services or XNA for game development. Also, development using .NET Compact Framework 4 is possible. Some games for the existing gaming console XBOX 360 will also be available for the OS. The functionalities of the first generation are somewhat limited. Among the features that were not present in the first release were:

- Cut, copy, and paste
- Full multitasking
- Adobe Flash
- Does not support user-removable SD cards supports removable SD cards[63]
- Cannot connect to hidden Wi-Fi hotspots
- Windows Phone 7 only supports a small subset of Microsoft Exchange Server features,

and unfortunately even other features as well. Microsoft has, however, promised to implement support for most of the issues (some have been already), whenever the platform reaches enough critical mass. The look and feel of Windows Phone 7 is very different from the competitors, and it looks really promising. Microsoft has said that it is issuing "tough, but fair" hardware requirements to manufacturers. Therefore, all of the Windows Phone 7 devices, as a minimum, must comply with the following specifications:

- Capacitive, 4-point multi-touch screen with WVGA (800x480) resolution
- 1 GHz ARM v7 "Cortex/Scorpion" or better processor
- DirectX9 rendering-capable GPU
- 256 MB of RAM with at least 8 GB of Flash memory
- Accelerometer with compass, ambient light sensor, proximity sensor and Assisted GPS
- 5-megapixel camera with an LED flash
- FM radio tuner
- 6 dedicated hardware buttons - back, Start, search, camera, power/sleep and Volume Up and Down.

This is very unlike most of the other mobile OS (iOS not included), where various versions of the OS exist, capable of supporting many different hardware specifications. The first phone manufacturers to launch Windows Phone 7 devices are Samsung, LG and HTC. Later 2011, as earlier stated, Nokia will launch their smartphones based on the OS.

[63] When a user replaces the SD card, all of the data on the phone is lost and the device defaults back to factory settings.

4.6 BLACKBERRY/QNX

The Blackberry OS and development platform is developed by the Canadian company Research-In-Motion (RIM) and was released in its latest version 6 in August 2010. The OS is providing a platform for doing application development supporting solely J2ME the profile CLDC based on the profile MIDP. The Blackberry Java Virtual Machine (JVM) is based on Sun's implementation of the J2ME being written partly in C, C++ and assembler. It is a native implementation located in the actual firmware of the device, making it very hard to hack or in any way alter. The two greatest advantages of this are that: 1) the OS doesn't have to be compiled to the CPU type of the device, and at the same time 2) it provides a hardware abstraction layer to other hardware functionalities of the device like button control, sound, radio communication etc. On paper this gives a better device performance eliminating many bottlenecks in hardware access.

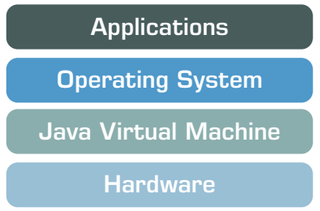

Figure 4-3: A conceptual and generalised model for a Java based operating system. Applications are executed in the OS using a JVM with a specified profile and configuration.

The above Figure illustrates how the Blackberry platform is placed in a data layer model. This is, however, not entirely the truth. The actual Blackberry OS is written as native along with the JVM and all Java libraries as well as the internal implementation of the Java libraries is made native. However, for simplicity the OS is placed on top of the JVM as all development and the preinstalled applications support J2ME. The operating system is implemented to support true multi-tasking without noticeable performance lack, and due to the implementation of the OS the applications load fast and perform really well on slow devices. The general layout and browsing through menus feels classic, but it works smoothly. Multi-touch is supported in the newer versions of the OS. Blackberry OS does not support any Flash versions (but should do in a future version) and the use of the Internet seems to be intended for surfing, e-mail and traditional client server calendar synchronization.

The Blackberry was originally adopted by business people due to especially the clever e-mail handling, and it feels like this is still the case. RIM solely controls the development for the OS, and it will probably be around for years to come. But especially Android, iPhone and the Windows Mobile 7 enabled smartphone are hard competitors. In order to still keep their good market share, RIM has introduced a Blackberry tablet PC called BlackBerry Playbook. This tablet PC has a totally new operating system called QNX, which is the result of RIM purchasing the technology and company behind in 2010. QNX is a microkernel-based Unix-like real-time OS that is aimed primarily at the embedded systems market. The new Blackberry QNX adds support for Adobe Flash and provides lots of functionalities[64].

4.7 LIMO

The LiMo OS is created by the Mobile Linux handset trade group called LiMo Foundation. The OS is based on a Linux kernel. The LiMo foundation consists of many telecom stakeholders from various handset manufacturers, telecom operators and software developers. The OS is now in the second version called R2. This version has as the first industry handset support for the Open Mobile Terminal Platform (OMTP) BONDI specification, which is a standard set of secure APIs for mobile browsers or WRT. It provides a consistent and secure Web services interface that can be used by developers across multiple device platforms. BONDI can be said to

[64] Available from Internet: *www.devblog.blackberry.com/2010/09/blackberry-tablet-os/*.

expose key handset features to 3rd party developers creating mobile applications, while at the same time not compromising the security. BONDI-compliant WRT co-exist with other runtime environments in a device, such as the native operating system, JVM etc.

Key technologies supported by the R2 platform are said to include location-based services, multimedia, personal information management and especially improved security applications. The main application development is intended to be created using web technologies CSS, JavaScript, HTML etc. like WebOS. However, it supports running applications in a JVM along with native code.

Looking at the lack of openness of the OS, even though it is Linux with great support from industry, it is assumed that LiMo will have a chance to get its share in the smartphone market, but the much more open Android and MAEMO, based on Linux kernels as well, are hard competitors. This is also indicated by the Gartner analysis (Gartner, 2009).

5 TERMINALS AND GADGETS

When mobile TV in Denmark was mentioned, a lot of focus was put on smartphones with DVB-H support. The available devices had the typical characteristics that the screen sizes were small. When changing focus to support various IP-enabled wireless technologies for services provisioning, it also expands the amount of compatible devices.

These, however, have very different specifications and this introduces other issues to be considered regarding support for CAMMP-enabled services. The introduction of a new breed of tablet PCs from Apple called iPad has had a huge impact on the market for small PCs. It is expected that 10 million total tablet devices will be sold in 2010[65], with the purpose of browsing and viewing mobile media on a larger screen than a traditional smartphone. **Figure 5-1** illustrates some of the available and soon to be released devices. Developing apps for the various devices is not trivial, as they all support different kinds of native programming languages like Apple's objective C, Android Java, WebOS native C/C++, Qt and many more. When services do not need to be developed in the native language of the platform, another way is to develop web services or so-called widgets. These services are implemented using HTML, Javascript and CSS3 and enable the Internet browser of the devices. It is then up to the browser to render the content. New trends in developing widgets show the use of upcoming standard HTML5, JavaScript and CSS3. As HTML5 and CSS3 are not yet standards, some changes can be expected until the finalization of the standard. Also the different browsers on the various platforms do not yet support all of the functionality of the upcoming standards, the same service might not work on all platforms, even though it should in theory. But using widgets where possible for the various devices like the ones in **Figure 5-1** and different smartphones as well, it seems as the right choice of technology in order to prevent writing the same service for every single device.

This will, however, not solve the problem of providing video in the right format to the right device. iPhone/iPad operating systems uses one kind of technology, while Android uses another etc. Then there is the question of providing video content in various qualities depending on the network QoS and screen size of the actual devices. As a possible solution for solving this problem, a transcoder called xSTREAME has been developed in CAMMP. This software is responsible for transcoding video and audio into the right format (H.264, AAC) at various bit rates and the desired container format (TS, FLV, MP4, 3GP) for either live or on-demand content. xSTREAME has been tested and confirmed working with Nokia, Android and iPhone/iPad devices besides netbooks, laptops and traditional computers.

When carrying out a state-of-the-art analysis in new trends in multimedia, the new generation of 3D stereoscopy is soon in all kinds of devices.

Figure 5-2 contains examples of new trends in viewing multimedia. 3D stereoscopic video cameras, televisions and display glasses are just some examples. Most of the solutions require the viewer to wear special glasses to be able to view 3D, but a new generation of smaller screens, just released on the marked, does not require glasses. Also the next version of the gaming console Nintendo 3D does not require glasses, but with all of these screens until now, their possible viewing angles are somewhat limited, and as stated the screens are typically small. A way to provide a person on the move, e.g. sitting in a train, with a good viewing experience is to project the picture close to their eyes with the use of display glasses. These low power glasses typically have one screen per eye and give the wearer an illusion of sitting about 2

Figure 5-1: Different versions of tablet PC with various operating systems: Upper left corner is an example of an Asus EEE Pad with Windows Embedded Compact 7 tablet. Also depicted in the same figure is an example of Windows Phone 7 OS that has been released with a fundamentally revised user interface, and tablets could be expected with this as well in the future. In the upper middel/right corner is the Apple iPad 2 (and iPad 2 Smart Cover) using Apple's own developed mobile OS called iOS (the picture used is courtesy of Apple). In the bottom left corner is an example of an Asus Android tablet with a customised version of the Android OS. In the bottom middle is an example of an Intel tablet with the new OS MeeGo and to the right is HP's WebOS tablet. Blackberry's Playbook running the new OS QNX is not depicted in the above figure.

[65] The amount of tablet PCs stated in the article is the expected total amount to be shipped in 2010. Not only the iPad: *www.appleinsider.com/articles/10/03/04/apples_ipad_expected_to_be_part_of_10_5m_tablets_shipped_in_2010.html* .

Figure 5-2: An overview of new trends in viewing multimedia. The figure to the left is an illustration of new 3D stereoscopy hardware. The figures to the right are two different examples of mobile video glasses that can be used to view multimedia content from e.g. a mobile device. The left glasses are from German company Carl Zeiss called Cinemizer. The right glasses are originally created by the Danish company Mobintech but acquired by German company Novero and relased under the name: "MADISON by Novero."

meters from a 60" screen. The two screens make it technically possible to display 3D in the glasses, if the glasses are compatible, and the user terminal supports it. The upcoming version of the Cinemizer video glasses from Carl Zeiss in 2011 has a resolution of 720p, OLED screens and is 3D-compatible. A Danish company called Mobintech did also create a version of video glasses based on OLED screens. This company was later acquired by the German company Novero, and the glasses have been released under the name: "MADISON by Novero."

5.1 GOOGLE TV

Many other projects besides CAMMP are working with the concept of converging television services with Internet VOD and even mobile terminals. Google has launched their project called Google TV, which is a proprietary platform especially designed for set-top boxes (STB) and high-end HDTVs based on Android. It is developed by Google, Intel, Sony and Logitech and was officially announced on May 20, 2010.

Some of the features are[66]:

- Unified search for content on both internet and the TV at same time
- Has Google Chrome to do web browsing
- Built-in dedicated apps for YouTube, Netflix, Amazon VOD, Twitter, Flickr, Picasa, Napster, Pandora (most of them unfortunately only works with a US IP address today)
- Smartphone integration to allow transferring current activities to and from the TV (called "to fling")
- Able to use an Android or Apple terminal as a remote control
- TBS, TNT, CNN, HBO, Cartoon Network and Adult Swim are the first real Google TV channels available
- Access to the Google app store will be available in 2011 (also the non-free apps)
- Adobe AIR enabled meaning that Adobe flash widgets can be executed
- Supports HDMI input from Cable or Satellite box to be able to still view existing channels

Some different Google TV enabled products have been released from Logitech and Sony. These products are TVs, STBs and Blu-ray players. They are rumoured to be powered by Intel Atom based CE4100 consumer electronics system-on-chip.

The products are:

- Sony Internet TV - 24", 32", 40" and 46" models (NSX-24GT1, NSX-32GT1, NSX-40GT1 and NSX-46GT1)
- Sony Internet TV STB with Blu-ray (NSZ-GT1)
- Logitech Revue STB

All hardware supports H.264 and 1080p HD video playback at up to 30 fps. There does not exist a Google TV API as such. Instead Google has provided a guide for developers to optimise their websites for Google TV. This includes how to style the site, optimising Flash video, implement proper site navigation and some hints on site architecture and URL structure etc.[67]

Google TV was launched October 2010, and shortly after the launch there was talk of a rift between Google and TV networks, which has resulted in three major TV networks blocking key programs on Google TV[68]. Google is now in negotiation with these three TV networks in order to make them unblock the access[69]. Prior to the Google TV launch, Google released "YouTube LeanBack" or "YouTube TV", which is a version of YouTube optimized for watching content on a TV, or on the desktop computer, if the user is sitting some meters away from the screen. When the site is opened in the browser, it immediately starts playing videos from a feed of suggestions. The functionality requires the user to be logged in to YouTube. The suggestions are then based on videos liked by the user or recommendations from social sites such as Facebook. If the user is not logged in, it will play the most currently popular videos on YouTube.

5.2 APPLE TV

Courtesy of Apple Inc.

Apple TV is a STB by Apple Inc. with a small form factor network appliance designed to play (and possibly rent) content from the iTunes Store, Netflix, YouTube, Flickr, "Apple's MobileMe"or any Mac OS X or Windows computer running iTunes. It provides the possibility to view photos, play music and download or streaming podcasts. The newest version of the STB was released in September 2010 and is the second generation of Apple TV. The second generation was not shipped with a hard drive, so users would need to buy content on a computer and stream it to the Apple TV or simply get access to a cloud computing Personal Video Recorder (PVR). Apple TV is able to stream content from up to five different iTunes libraries, and five Apple TVs can be linked to the same iTunes library.

Apple TV only supports video H.264 up to 720p at 30 frames per second and therefore cannot play 1080i or 1080p HD content typically from a HD camera, unless it is converted to a lower-resolution format. This is possible by using the "Apple TV export" option in QuickTime, which allows content in various formats that the device does not support to be easily re-encoded.

Apple TV can be controlled by virtually any infrared remote control or paired with the included Apple Remote to prevent interference from other remotes. Either kind of remote can control playback volume, but for music only. Apple also has a free app called "Remote" that allows the iPhone, iPod Touch and iPad to control the iTunes library and Apple TV using Wi-Fi[70].

As stated earlier, YouTube videos can be viewed directly on the Apple TV, but a YouTube account is not necessarily required. With the account the user can set different personalized options, such as favourite clips. Apple TV automatically bookmarks video content midstream to continue playback at a later time.

5.3 BOXEE BOX

A new player on the market in STBs is D-Link that has teamed up with the company Boxee to provide a competitor to Google TV and Apple TV. Boxee provides multimedia centre software compatible for most common desktop OS to enable watching movies, TV shows and clips from the Internet on the TV in a simple way. The Boxee Box is simply a device with Boxee preinstalled to avoid using a PC for running the software. It uses Linux on an Intel Atom CE4100 system-on-a-chip hardware platform and is bundled with a QWERTY remote. Boxee can also use an Apple Remote or one of several other PC-remotes available on the market.
Finally there exists an official Boxee Remote application made for the Apple iOS, which allows for remote controlling of an installed and concurrently active Boxee session on another computer. Some third-party developers have released the Boxee remote control apps for Android and webOS as well.

Boxee supports video playback in H.264 in resolution of 1080p up to 30 fps in virtually any format. It goes for all types of multimedia, as long as they are not DRM protected. The STB automatically fetches metadata using a built-in web scraping mechanisms for various web services (IMDb, TV.com, Freedb, AMG and Discogs). It then arranges all content with cover art, complete with descriptions and user ratings. This functionality could lead to some legal issues in

[66] Available from Internet: *www.google.com/tv/features.html.*
[67] Available from Internet: *www.code.google.com/tv/web/docs/implement_for_tv.html.*
[68] Available from Internet: *www.reuters.com/article/idUSN2111296920101021.*
[69] Available from Internet: *wwww.reuters.com/article/idUSTRE69K5QS20101022.*
[70] Available from Internet: *www.itunes.apple.com/us/app/remote/id284417350?mt=8.*

some countries due to the Terms of Use policy of many websites. However, the enforceability of these terms is unclear.

Boxee provides a login functionality allowing the user to store favourite TV shows and apps. Being logged in also makes it possible for the user to recommend movies to friends in the social network (Facebook, Twitter, and the Boxee network). Users can simply follow the activity of other Boxee users, who were added as friends, and can publicly rate and recommend content. Users can also control what media appear in the activity feed in order to maintain privacy. If a user recommends something that is freely available from an internet content service, then Boxee will let others users stream it directly. If a user recommends something that is not freely available, Boxee will try to show metadata and movie trailers, if it is a movie that the user recommends. Boxee can also export a user's media activity feed to other social networking services such as FriendFeed, Twitter, and Tumblr. This feature is one-way only, not yet making it possible to monitor e.g. Twitter feeds from within Boxee. Boxee furthermore has an integrated BitTorrent client with torrent links to legal BitTorrent trackers download sites. One big limitation with Boxee is that it cannot receive TV signals. Not even from a TV tuner device attached to a computer solution not being the Boxee Box. You can therefore neither watch nor record live TV programs unless it is streamed using an internet technology supported by Boxee.

Boxee has an app store called "AppBox" that serves add-on apps and plug-ins that provide online content to Boxee. Boxee has extensibility and integration with online sources for free and premium streaming content. AppBox offers content including commercial video, educational programming, and media from individuals and small businesses. Users can make and their own add-on apps and plug-ins to add additional content accessible from within Boxee. The Boxee app development features a Python Scripts Engine and WindowXML application framework, which is an XML-based widget toolkit for creating GUIs for widgets. This can be compared to Apple Mac OS X Dashboard Widgets and Microsoft Gadgets in the Windows Sidebar. Boxee recently also introduced an additional plugin architecture based on the XUL (XULRunner) framework[71], which enables any web-based application to be integrated into Boxee as an app. This plugin architecture uses Mozilla core base architecture. Since this is the same core architecture that Firefox uses, any website will see Boxee as any other Mozilla-based web-browser.

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Abbreviations

3G	3rd Generation
3GPP	3rd Generation Partnership Project
AAA	Authentication, Authorization and Accounting
AKA	Authentication and Key Agreement
API	Application Programming Interface
AS	Application Server
ASP	Application Service Provider
AUC	Authentication Center
CC/PP	Composite Capabilities/Preference Profile
CRC	Cyclic Redundancy Check
CRID	Content Reference Identifier
DHCP	Dynamic Host Configuration Protocol
ETSI	European Telecommunications Standards Institute
FEC	Forward Error Correction
FLO	Forward Link Only
FP6, FP7	The European Union's 6th (7th) Framework Programme
FTP	File Transfer Protocol
GI	Guardian Interval
GPS	Global Positioning Satellite
GUI	Graphical User Interface
GUP	Generic User Profile
HSS	Home Subscriber Server
HTML	HyperText Markup Language
ID-FF	Liberty Identity Federation Framework
IDP	Identity Provider
ID-SIS	Liberty Identity Services Interface Specifications
ID-WSF	Liberty Identity Web Services Framework
IMS	IP Multimedia Subsystem
IP	Internet Protocol
ISO	International Organization for Standardization
ISP	Internet Service Provider
LA	Liberty Alliance Project
MAGNET	My Personal Adaptive Global NET
MAP	Mobile Application Protocol
MIMO	Multiple-input and Multiple-output
MISO	Multiple-input and Single-output
MMS	Multimedia Messaging Service
MPEG	Moving Pictures Expert Group
NGH	Next Generation Handheld
NGN	Next Generation Networks

NSP	Network Service Provider
OMA	Open Mobile Alliance
P3P	Platform for Privacy Preferences
PCCC	Parallel Concatenated Convolutional Codes
PDA	Personal Digital Assistant
PN	Personal Network
RDF	Resource Description Framework
RS	Reed-Solomon correcting code
SAML	Security Assertion Markup Language
SMS	Short Message Service
SOAP	Simple Object Access Protocol
SP	Service Provider
SSO	Single Sign-On
UAPROF	User Agent Profile
UICC	A removable IC card containing a USIM
UNESCO	United Nations Educational, Scientific and Cultural Organization
UPNP	Universal Plug and Play
USIM	Universal Subscriber Identity Module
VID	Virtual Identity
VOD	Video on demand
W3 (W3C)	World Wide Web Consortium
WAP	Wireless Application Protocol
WML	Wireless Markup Language
WSP	Wireless Session Protocol
XML	eXtensible Markup Language
XSLT	eXtensible Stylesheet Language Transformation

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The Autors

Allan Hammershøj holds a master degree in electric engineering with a thesis in modelling new types of dynamic neural networks in hardware. After finishing his master, Allan started a company with three fellow students with expertise in designing and implementing new types of neural technologies. This led to a demonstrator project in implementing an artificial vision system for an underground robot. Allan also worked in the EU funded project MAGNET Beyond modelling user profiles to enable context aware personalised services. The work also included designing demonstrator services with new types of innovative user interfaces. Allan has been technical project coordinator on a pilot project implementing a local DVB-H demonstrator running on open source components. This work has led to the involvement in the CAMMP project, where Allan has been active in the design of the platform and personalised context aware demonstration services based on the experience from the earlier projects. Other tasks in CAMMP included analysis of various IP data link technologies and compatible devices to be used with the platform. Allan has written various articles on the above topics and was co-writer on a book in robotics and artificial intelligence and is currently active in giving public lectures about new trends in brain science related to engineering.

Emil Heinze holds a master's degree in electric engineering with a thesis in modelling new types of dynamic neural networks in hardware. After finishing his degree, he started a company with three fellow students with expertise in designing and implementing new types of neural technologies. This led to a demonstrator project in implementing an artificial vision system for an underground robot. EH also worked in the EU funded project MAGNET Beyond modelling user profiles to enable context aware personalised services. The work also included designing demonstrator services with new types of innovative user interfaces. Through his involvement in CAMMP, Emil has focused on dynamic personalisation of mobile media services. Apart from CAMMP, EH also works on innovative use of mobile technologies in new ways of learning in the Danish educational system. Apart from scientific articles, EH was co-writer on a book in robotics and artificial intelligence.

Reza Tadayoni is associate professor at CMI (Center for Communication, Media and Information Technologies) at Aalborg University. He holds a M.Sc.E.E. from DTU (Danish Technical University) specialized in broadband communication, and holds a PhD from DTU in the field of media convergence. His main research focus is on the ICT development and media convergence and he has published a number of scientific papers and research reports. Reza Tadayoni has broad teaching experiences, he has contributed to development of new education programs and courses within ICT and he has been giving course at bachelor, masters and PhD level in a number of years. Reza Tadayoni has also been working in the industry for a couple of years, as a hard-ware development engineer. Reza Tadayoni has since beginning of 1990s been involved in developing research and education in the field of ICT first at DTU and later AAU; he has authored 100+ international journal and conference papers and a number of research reports, and participated in a number of research projects.

At the moment he is technical manager of the CAMMP project, and is the coordinator of the continuing educations program, mICT (master of Information and Communication Technologies). mICT is a continuing education program developed for the professionals in the ICT industry.

Henning Olesen is an associate professor at AAU (CMI) since 2008. He holds MSc EE and PhD degrees from the Technical University of Denmark (DTU). From 1980-1995 he did research in the area of optoelectronics and optical communication, first at DTU and from 1984-1995 at TFL / Tele Danmark Research. From 1996-1999 he was with Tele Danmark R&D and a member of the core team for Tele Danmark's Media Centre. From 1999-2008 he was an associate professor at DTU. His main research interests are mobile services and service architectures, user requirements, and new solutions for personalization, privacy and identity management. In 2004-2008 he was leading tasks on "User requirements" and "User profiles" in the IST projects MAGNET and MAGNET Beyond. He has authored or co-authored about 100 international journal and conference papers and is a co-editor of two WWRF whitepapers on service creation and user profiles. He is also the coordinator for the MSc program on Innovative Communication technologies and Entrepreneurship at AAU.

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The CAMMP Project:

CAMMP (Converged Advanced Mobile Media Platform) is a research project funded by the Danish Advanced Technology Foundation, led by center for Communication, Information and Communication technologies (CMI) at Aalborg University. The research focus of the CAMMP project is identification of the potentials of the convergence between the Internet, digital TV and radio, and 3G mobile technologies.

The aim of the project is to investigate and outline the new converged infrastructures; develop new services and service architectures; and define new business models and new value chains for the next generation rich media mobile services to users not only on the move, but also in the home. The aim is, further, to enable technological innovations in the industry and strengthen the connections between the industry and the research and education institutions in Denmark.

The vision of the project is to build a proof of concept service infrastructure on top of the converging technologies to identify new types of personal mobile services that combines traditional push broadcast with user generated audiovisual content and shared immersive experience in an economic viable environment. The vision is, further, to create firm conditions for a Danish value complex in an international, standardized environment based on a unique university-industry competence cluster.

The project budget is 41 million DKK of which the Danish Advanced Technology Foundation (Højteknologifonden) has granted 22 million DKK. The project period is 4-years (starting in June 2008). The project includes the main research institutions and companies in Denmark dealing with converged mobile media platforms and services.

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DR

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