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MODEL OF A DIGITAL VIDEO BASED BROADCAST BASED HOME TELECARE SYSTEM (DVB-HTCS)

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ABSTRACT

The purpose of our study was to develop a generic reference model for home telecare in a digital television environment and to evaluate how this model could be deployed our test village Ikaalinen. In this research work we describe an architecture based on Digital Video Broadcast (DVB) standards, its components, services, and required additional technical solutions to provide a unified home telecare solution. We also defined different user groups according to our reference village and studied the possible service scenarios for these groups. As a general observation it can be stated that digital television provides a flexible and exciting platform for home telecare services.

INTRODUCTION

A Digital Video Broadcast - Home Telecare System (DVB-HTCS) is a provision of Home-Tele-Care (HTC) based on Digital, Interactive Television (digiTV) standards. It focuses on home - health care institution telemedicine, rather than health care institution - health care institution communication and involves several entities of commonly known telecommunication technologies of distance oriented medical applications: distance education, telemedicine, picture archives, communication systems, security aspects, tele-diagnosis, distance biological signal measurement, personalised treatment, etc. Our intention is to introduce and describe a generic reference model as HTC based on digiTV as user-side front end to health care services upon which concrete health care services can be implemented and deployed.

Figure 1: Generic Reference Model for DVB-HTCS.

Figure 1 shows a generic reference model for a DVB-HTCS, compromising four main subsystems: the Patient Unit (PU), the Home-Tele-Care Service Provider (HTC-SP), the Broadcast Service Provider (BSP), and the Interaction Service Provider (ISP).

The ISP provides networking resources between PU-HTC-SP, HTC-SP-BSP, and PU-BSP. The services offered by the ISP limit the bandwidth of transmissions between every involved entity. The bottlenecks are bandwidth limitations between ISP and PU, as only minimal bandwidth (a simple twisted-pair phone line) can be assumed. However, the system should also be capable of faster transmission protocols as already introduced in other home telecare systems. This requires a

sophisticating scalable solution for wireless alarm device management and for applications demanding higher bandwidth.

The BSP has the capability to multiplex in addition to the usual television programmes any entity of multimedia content into a high-bit rate MPEG-2[1] stream. The stream is characterized by its broadband capabilities, push-application schemes, conditional access, and feedback involvement over the interaction network, multiprotocol facilities to multiplex multicast IP packets within which other protocols overlying IP can be transferred, transmission possibility over satellite, terrestrial, cable or the Internet, and synchronizing facilities.

The PU is a service access point for various medical related applications and equipment over either wireless, wired, or manual editing environments. Its essential tools can be categorized as follows:

- Communication Tools allow direct patient-HTC-SP and patient-patient communication and also includes the whole set of Internet communication tools for information retrieval and interchange;
- Automated Measurement Equipment is responsible for remote or online measurement of patient's biomedical signals: e.g. EKG, saturation, blood pressure, etc.;
- Self Measurement Equipment shifts the responsibility of performing measurements and updating the measurement database to the patient side: e.g. blood sugar measurements, point of care, etc.;
- Alarm Devices detect automatically emergencies, such as patient falls etc., and alert the HTC-SP about their origin and reason to involve emergency units;
- Treatment Devices are devices for rehabilitation of all different types: e.g. physiotherapy, medication, training equipment, etc.

- Medication Devices allow medication life-cycle control and their management. This system part represents unified service architecture for medication ordering, subscription, payment, and revenue: e.g. anticoagulation, blood pressure, diabetes, asthma, etc.

MATERIALS AND METHODS

Ikaalinen - the first DVB-HTCS village

The area of Ikaalinen, with about 8 000 people, is 843 square km and it belongs to the health district of Pirkanmaa which has TAUH (Tampere University Hospital) as the reference hospital. From Ikaalinen to Tampere it is 55 km by road. The Ikaalinen health centre employs five GPs and one resident total number of personnel is 97. TAUH is serving 35 municipalities with 21 health centres and about 450 000 inhabitants and it is also a secondary reference centre for 1.2 million inhabitants. Patients have an unlimited access to the Ikaalinen health centre (for a nominal fee of 13 euro for a year). With the exception of emergency, the access to TAUH is limited to doctor’s referral. In both cases the patient fee is subsidized by the municipality and is nominal.

The primary health care centre in Ikaalinen employs seven nurses for home care. The seven nurses make 6,119 house calls a year. One of them does also administrative work and one doe’s part of his work timework among children and pregnant women. Five nurses office are located in the centre of Ikaalinen and most of their visits are fairly close to their office. Two nurses exist in rural office, which is located 25 km from the centre. All the visits were included to the study in the test period what these four nurses made.

Issues in Designing DVB-HTCS

This chapter compiles some general requirements in the design and realization of a home-telecare system based on digiTV solutions. Especially the STB implementation has to provide a scalable and portable solution, as its computational performance is limited. A software layer architecture introduced within the scope of this research paper shall provide a sophisticated solution.

Generic Information Representation Standards

A converged and multiprotocol driven environment requests high demands in content transmission, representation, and presentation for categorizing, schematising, correlating, and standardizing patient information. A suitable solution for frameworks, services, and electronic documents is XML, as defined by W3C and refined in HL7[7], XML-EDI[6], X12[16], ASN.1[2], and ASTM[5].

Frameworks are standardized definitions for the XML syntax of communication between two trading partners. Frameworks for information exchange include efforts by HL7 and XML-EDI. The framework category includes using XML as the syntax for messages, transactions, and SGML/XML architectures to request and send healthcare information. Services for healthcare information are object models from which the interfaces and interface definitions are derived. Services specify a mechanism to find request, send, filter, and query distributed healthcare information that may be represented in XML. Efforts include standardization efforts by CEN, HL7, and CORBAmed. Electronic documents in health care may be generated by many sources such as transcription, scanned from paper, created by and structured reporting software systems. Document types found in health care include paper-based forms and documents, which include regulatory forms. Deriving such an electronic representation for the paper-

based documents in healthcare requires developing standard formats for different document types (Document Type Definitions)[14].

Categorisation of Customers

In the area of Ikaalinen health centre home care customers can be divided to two groups: controlled and non-controlled customers.

Controlled customers typically need help from home care personnel on a regular basis and a nurse visits each customer at least twice a month. The typical needs of controlled customers are medication dispensation and the treatment of lesions, which always require a visit from a nurse. In addition, controlled customers usually have many health conditions requiring attention. In Ikaalinen there were 82 controlled home care customers in December 2000 and most of them were over 70 years old. As a result of the high average age over ¾ of the customers were women, most of the widows.

Non-controlled customers need help from home care personnel only occasionally and are not regularly visited by home care personnel. Typical reasons for visiting a non-controlled customer are the collection of blood samples for laboratory tests and various physiological (e.g. blood pressure and blood sugar) measurements. In Ikaalinen the number of non-controlled customers was about the same as the same as the number of controlled customers in December 2000. However, the age structure of the group was different from the controlled customers as the average age was lower. Non-controlled home care customers typically have only one health condition needing attention.

The two home care customer groups need individualised care and customer grouping allows us to differentiate the home telecare services and the realisation of them for the two groups.

Broadcast Service Provider

The responsibility of the BSP is to encode and multiplex video, audio, and services into a MPEG2 data stream, for terrestrial or satellite broadcast, or transmission by cable or the Internet [8]. Depending on the quality of the transmitted programme and the included data services, the utilized bandwidth consumes approx. 4-6 Mbps. To obtain those services from the broadcast stream at the PU side various solutions exist: object and data carousel functionality, multiprotocol decapsulation of all-over-ip multiplexed protocols, video- and audio decoder, personal data recorder, etc.

The multiplexed can be categorized into those provided for any DigiTV STB, and context dependent ones. The first include Electronic Programme Guides (EPG), Enhanced Service Guides (ESG), Conditional Access (CA) facilities, etc. For the HTCS platform these context dependent services can include e.g. informational services about different diseases and other health conditions, personalized medical information, pay-per-service, etc. For advanced services, the PU is mandatory connected to a feedback network, described in the following section.

Interaction Service Provider

A DVB based HTCS requires a mandatory minimum of one interaction channel connected to the ISP or HTC-SP. Telecommunication can be based on wired technology as utilized as OSI physical layer protocols, where the most important are: twisted-pair phone lines, ISDN, ADSL and Ethernet; or

wireless technology such as UMTS, GSM, etc. To provide a scalable solution and the capability of carrying various multimedia and medical protocols an All-IP solution is to aim at, though not all wireless protocols support currently packet switching. A minimum bandwidth of 1.5 Mbps is required for the interaction channel, for real-time video information transmission using protocols such as MPEG1. For the digital audio signal, protocol MPEG1 layer 2 audio, a bandwidth of 32-256 kbps is required which is comparable to CD quality. Currently running wireless solution do not provide this facility, therefore mostly wired technology will be required in the first phases. Urgently required services need a certain bandwidth reservation scheme to allow prioritisation for urgently required services such as alerting or medication information.

To consider, current solutions of transmission protocols do not guarantee bandwidth reservation, quality of service, and secure transmission. To perform those substantial tasks adequate application layer protocols are required. Especially for transmitting biomedical signals and providing enhanced security strategies for authentication, security, and data protection.

The Patient Unit (PU)

Figure 2 shows the PU as access point to multiple medical services over arbitrary communication channels and interconnecting devices. The major integral and most resource-limiting device in the system is the STB making up the main integral graphical presentation of services. Interconnection between devices is arbitrary and scalable over wireless or wired solutions shall also be provided by the system. This allows converging multiple paradigms and multimedia standards under one unified architecture.

Figure 2: The Patient Unit as Access Point to Medical Home Services.

For the communication between medical devices and the service access point multiple technical solutions exist: serial bus, wired, IRDA, USB, and in the near future also wireless solution will exist for transmitting biomedical signals to the service access point. The latter will mainly involve Bluetooth and WLAN technologies, which seem to be a promising transmission protocols between devices and wireless AP. Still for the most of distributed system, data has to be collected by hand and typed in by the patient himself, which requires a minimum on discipline.

As the PU is the central access point, it has to fulfil the following requirements:

- In-House Communication Infrastructure
- Data Security
- Local Data Storage
- Medical Devices and Connections to those
- Easy to use User Interface
- Solutions for Bed-Laying Patients
- MHP/DVB Compliant Services

The PU is the key element in the system as it provides the interface between the end-user and the other parts of the system to provide unified health care home equipment.

Software Reference Model

The system software layer compromises mainly of the MHP reference implementation as defined by EBU/ETSI[15] available in all compliant STB devices. Several basic operating system tasks are performed by this layer: application-, resource-, security management; broadcast- and interaction channel access; driver management and low-layer resource access; interoperability support etc. PersonalJava[10] technology is the major integral technology as application environment and provides a portable, scalable, and unified basic architecture for multiple Java, multimedia, and medical transmission based services. PersonalJava represents a hardware resource optimised version of the Java application environment and is an excellent lightweight solution for consumer devices such as STBs, PDAs, InternetTV, or mobile phones. It provides networking, security, reliability, platform independence, multithreading, dynamic software un- and loading, small sized code, and simplicity. The environment requires less than 8 MB of flash memory, 16 MB of RAM, and a 32-bit RISC processor as defined in[11]. To guarantee complete compliancy additional Java packages such as standard APIs delivered from SUN, HAVi's user-interface implementation, DAVIC APIs, and DVB specific APIs have to be integral part of the system software. An accurate stream access for visual communication between HCSP and patient is provided by the Java Media Framework JMF[9], which utilizes the Real-Time Transfer Protocol (RTP)[12] together with RTSP[13] as transmission protocol.

Figure 3: Software Architecture of the STB as element of the PU.

Additional software APIs are required to enhance this platform to an integrated medical home service point:

- Database System: A database system is essential for storing patient related data. Data has to be frequently transmitted to the HCSP due to patient status check, alerting, centralizing data at the HCSP

side, and backup strategies. It should be capable of storing objects, pure data, and multimedia data and secure data access.

- Medical Java APIs: Medical Java APIs provide functionality specific to medical services. These include, e.g., personalization and rule based decision-making features for the medical services.
- Imaging APIs: Image processing and powerful implementations of 2D/3D APIs do hardly exist in the MHP standard. To provide healthcare solutions for displaying medical material it is obvious to include some basic image displaying and computer graphic possibilities.
- XML Parser: A generic XML parser is required to handle various forms of XML based data. For most applications, XML is the general information representation standard.
- HL7 Layer: A mechanism to find, request, send, filter, and query HL7 information that may be presented in XML.
- Secure Data Access Layer: The security layer is responsible for the de- and encryption of each database access, assigning and granting access rights, login strategies, in-house security, patient data access control, electronic identification (EID). The medical services utilize the MHP APIs and the additional software APIs as described in this section providing a comprehensive solution as an element of the PU. The following section describes services that can be based upon this reference APIs.

Home-Tele-Care Service Provider (HTC-SP)

The HTC-SP involves several entities of a health care system - such as health insurance, doctors, hospitals, administrative institutions, social institutions, food bank, etc. - with additional features for extending its service to an integral solution for home-telecare. The following services shall be provided:

- Alarm Management allows the handling of any alarm call coming from the patient side. Involved communication protocols must guarantee privacy, data security, elaboration of the patient's biomedical signals and data records, and patient location determination;
- Resource Management is a complex task for all involved entities, and involves human- and equipment management;
- Patient's Data Databases allow the retrieval and storage of patient records that can be accessed either locally or from a centralized health care database. Data sets should comprise personal data, medical records, location data, patient impairments, biomedical signals; services required, patient group, etc.;
- Patient Communication comprises direct communication between patient and HTC-SP by utilizing video/audio conferencing tools, phone calls, and data exchange between both entities. Those services should be scalable, as bandwidth limitations offered from the local ISP have to be taken into account;
- Distance Treatment is very ambiguous and depends highly on the patient and its illness type and shall provide a scalable solution for binding hardware resources: telemedication allows remote medication, medication reminders, automated medicament ordering and delivery, and monitoring of currently at home available medicaments; another idea is telediagnosis and teletreatment, where medical equipment can be controlled remotely from the HTC-SP side with or without assistance from the patient; based on position sensoring or smart fall sensors home-behaviour-monitoring provides a possibility for the HTC-SP to remote monitor human behaviour at home during his malady; How a HTC-SP should be organized depends on current local infrastructure. Usually a health care institution, such as hospitals or physician compounds, and local social welfare offices, composes it.

Value Added Services on a DVB-HTCS Platform

The following services are among the most promising ones for implementation on the DVB-HCTS platform. They represent a large spectrum of novel service types for different user groups:

- Medication Service: Compromises every life-cycle step from ordering, controlling, taking, remote notification of medicines.
- Treatment Follow-Up Service: Provides the capability for the customer to transfer medical follow-up measurement results for review by the treatment personnel. In addition, the service allows the patient to receive, for example, treatment guidelines, etc.
- Home Monitoring: Patients can be remotely monitored to observe changes in their physiological parameters. For example, blood pressure monitoring.
- Automatic Home Equipment: Automatic home equipment helps the customer in his daily functions, e.g., for disabled customers.
- Rehabilitation Service: In this service type we combine video broadcast with a value added application to provide enhanced rehabilitation to the patient. In practice, this could mean that we have a television broadcast for physiotherapeutic exercises, which we combine with application motivating the patient in doing this exercise.
- Communication Service: Allows the customer to contact the treatment personnel or the other people with similar a health condition.

After we introduced the technical solutions, we examine how this can be applied to our test-village.

DISCUSSION

How these techniques can be applied in our test village

For the controlled home care customers the possibilities of the HTCS system are relatively limited as they are typically elderly people unfamiliar with IT technology. However, automated home monitoring and automatic home equipment, which don't require any interaction from the customer, are potential applications for the customer group. Also, medication services (as the most needed home care for the controlled customers) are a possible application area for the group. It should be noted that medication services, which necessarily require interaction from the customer, will be, depending the sophistication of the actual implementation, difficult to realise for some of the potential customers due to old age or disabilities common in the customer group. In general home telecare solutions should reduce the workload of the home care personnel as some functions could be automated or remotely controlled.

Non-controlled customers could utilize most of the value-added services available on the HTCS platform. For example, treatment follow-up services, such as blood sugar measurements could, are performed by the patients. In addition, services requiring extensive interaction from the user should be easier to implement for this user groups for which the average age is lower and severe disabilities are rarer than in the controlled group. Examples of services requiring extensive interaction from the customer include e.g. rehabilitative and communication services. For the non-controlled home care patient group the workload of the home care personnel could be dramatically reduced as the occasional visits related to e.g. blood sugar or blood pressure measurements could be eliminated.

Conclusion

Interactive digital television provides an exciting platform for a home telecare system. The television as a media is well known for the entire population which makes the move to an IT based home care solution easier. This is especially important as home care customers are typically among the elderly

who are not familiar or hardly are familiarized with IT and their complicated usage. It is projected, that costs overall can be reduced with a move to a home-telecare system based on the HTCS platform. Traditional home care solutions do not provide the possibility for a unified data transfer capability, advanced use of self-measurement equipment, and the ability to shift workload and responsibility to the patient. The future work related to the use of digital television in health care is to be done in the HCTV (Health Care Television) project studying the possibilities of digital television in health care. The described HTCS system will be only used as basic reference solution as the HCTV architecture represents a more advanced and generic solution for the implementation of health care services.

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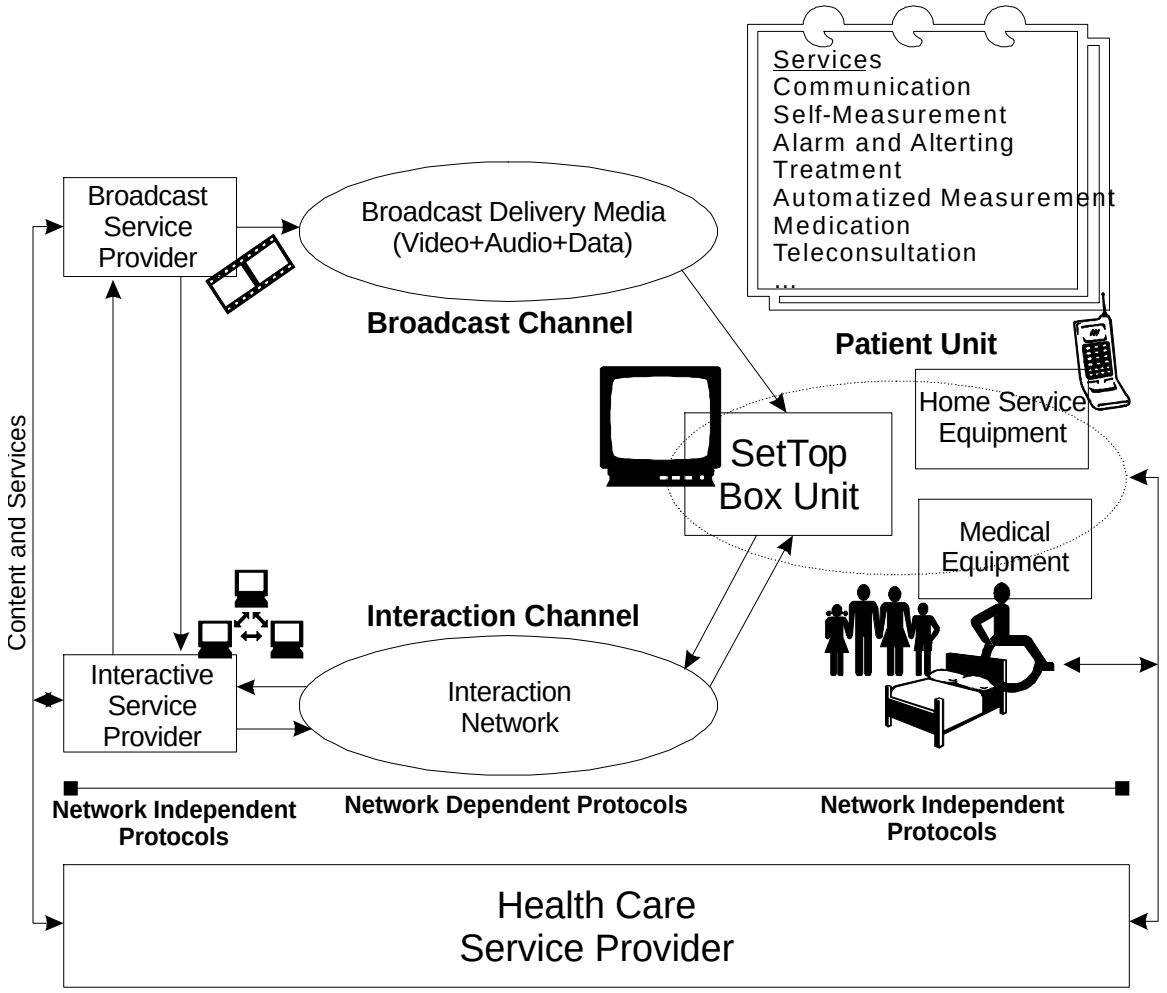
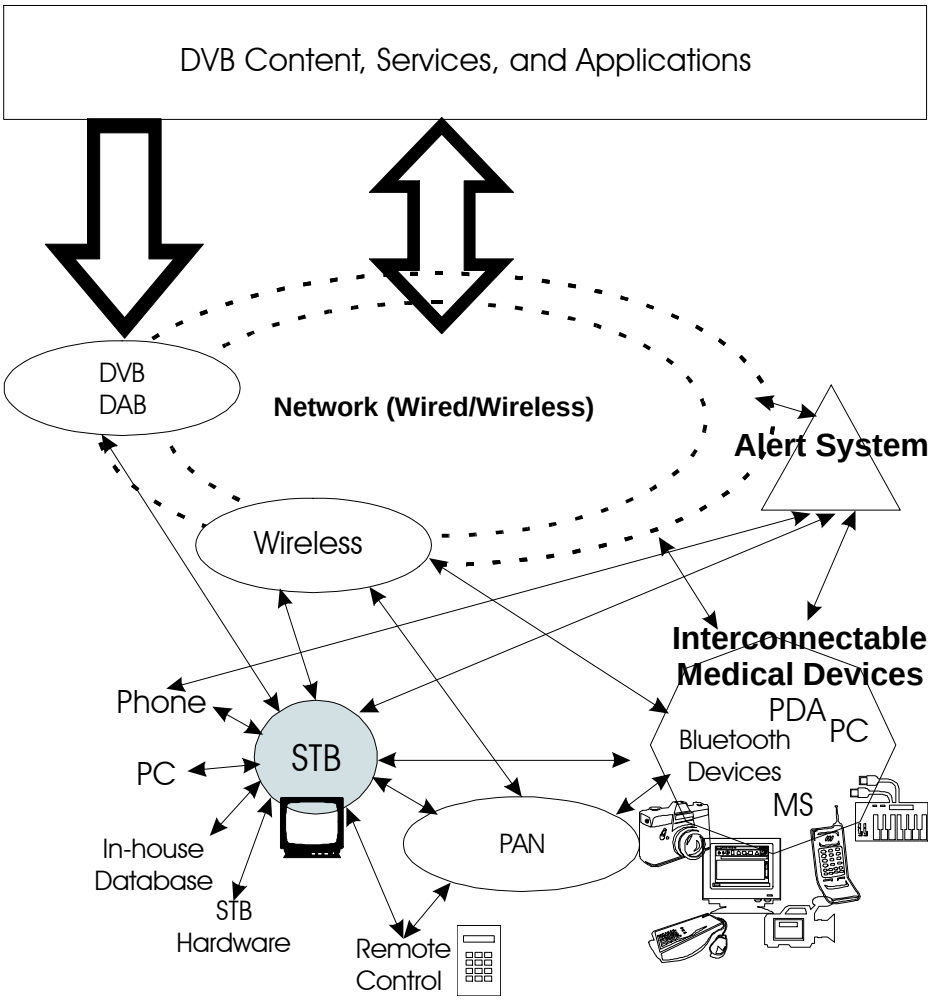


Figure 1: Generic Reference Model for DVB-HTCS.



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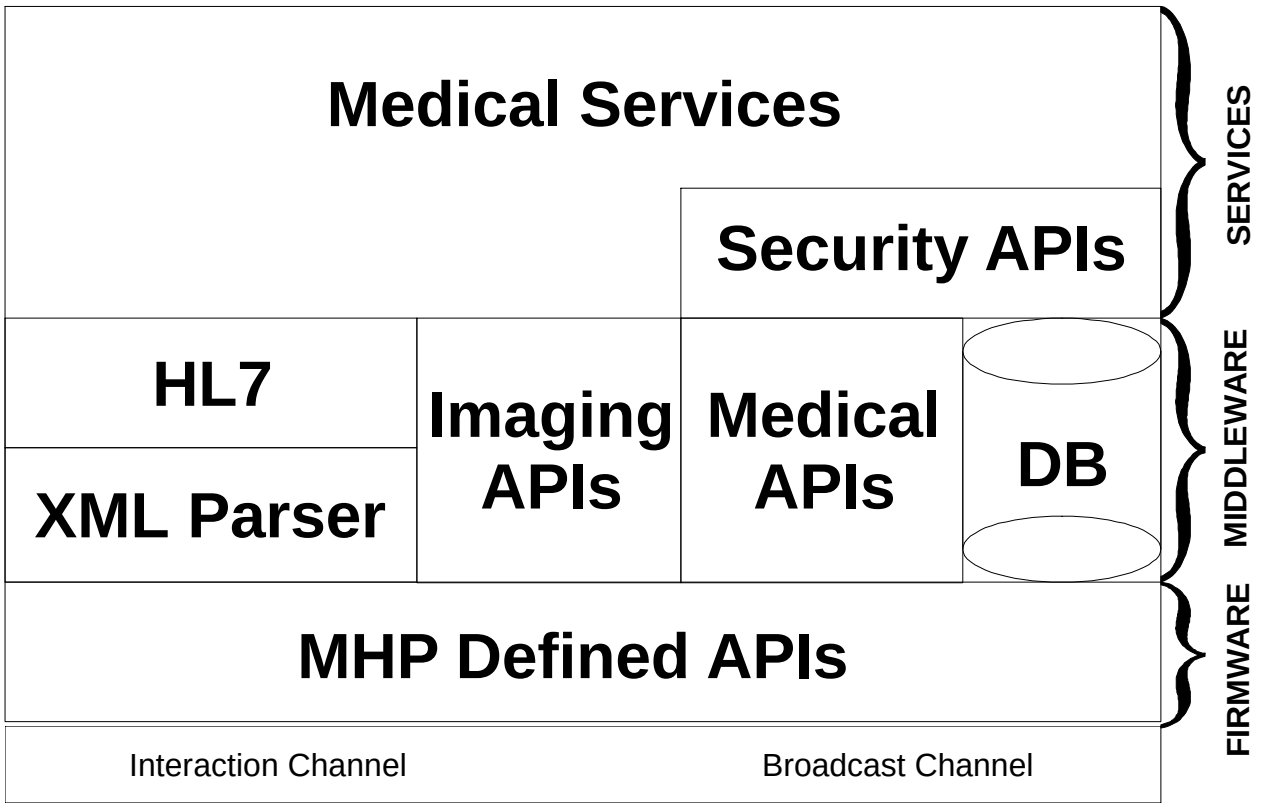

Figure 3: Software Architecture of the STB as element of the PU.

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