Intelligent content personalisation in internet TV using MPEG-21

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Abstract: This paper introduces a novel approach for intelligent content personalisation in internet TV using the new MPEG-21 standard in the framework of an ongoing project, which aims at the delivery of interactive TV (iTV) services to disabled children. The approach includes the development of an authoring tool for a diversity of multimedia resources supporting a metadata model according to MPEG-21. The authoring tool works in conjunction with a simulation platform, acting as an interaction interface between our internet TV architecture and the prospective viewer. Based on that, interactivity in IP Television accessibility services is faced through metadata and adaptation.

Keywords: internet TV; personalisation; MPEG-21; EPG; electronic programme guide.

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1 Introduction

Service provisioning in liberalised, deregulated and competitive telecommunication market is a quite complex process since it involves various diverse actors (e.g., users, service providers, (third party) application (content) providers, brokers, network providers). The following are some key factors for success. First, the efficiency with which services will be developed. Second, the quality level, in relation with the corresponding cost, of new services. Third, the efficiency with which the services will be operated, controlled, maintained, administered, etc. Fourth, the personalisation and tailoring of services and applications to the user needs and preferences. The aim of this paper is, in accordance with cost-effective QoS provision and efficient service operation objectives, to propose enhancements to the sophistication of the functionality that can be offered by service frameworks in open competitive communications environments.

The number of available digital content is increasing over internet and broadcast networks. Such a quantity of documents requires new ways to handle them. Besides, new services need tools to describe and organise these documents in an efficient and extensible way. These issues make metadata an interesting subject of research. Metadata are ‘information about data’ and can include characteristics about the data such as the content, accuracy, reliability and the source. Metadata provide the mechanism to describe data in a consistent form which allows users to gain a uniform understanding of the content and fitness for the purpose of datasets. Metadata have many applications and they can be used to:

- concisely describe datasets and other resources using elements such as the name of the dataset, the quality, how to access the data, what is the purpose of data and other related information
- enable effective management of resources
- enable accurate searching and resource discovery
- provide an online interface to a dataset and link to other information about it
- accompany a dataset when it is transferred to another computer so that the dataset can be fully understood, and put to proper use.

The majority of metadata specifications use the eXtensible Markup Language (XML, 2007). The XML language permits to build hierarchical structures suitable for most types of documents and therefore facilitates advanced search. XML is often used with XML schemas (XML schema, 2007). An XML schema is an XML language expressing rules to create XML documents. Most metadata standards for multimedia content are built on this language, among them MPEG-7 (ISO MPEG-7, 2002), MPEG-21 (MPEG-21-part 1, 2004). The primary goal of metadata is to manage the huge number of digital sources, thus facilitating the search. However, metadata are employed for many other functions. Metadata are useful to give information about multimedia resources. For instance, information can be displayed on the client screen in interactive TV (iTV) while playing the audiovisual content. This can also be applied in all applications of IPTV.

Therefore, metadata are quite useful for building interactive interfaces. Such devices collect multiple mixed multimedia contents inside the same structure. Metadata define the spatial and temporal layout as well as hyperlinks. Examples of such interactive interfaces lie in DVD movies where images, texts, audio tracks and audiovisual sequences are combined. Another example of such interactivity could be when a character appears in a movie, a textual description of this character is displayed and a hyperlink is proposed to see a biography of this actor. Metadata are also used for content protection, which restricts content usage to a particular user or group of users; it is particularly useful for service providers in a pay-per-view scenario. Finally, adaptation can be performed by using metadata; in this case metadata describe terminal capabilities, network characteristics and the way data has to be modified.

In this paper a novel approach for intelligent content personalisation in internet TV using the new MPEG-21 standard is introduced aiming at the delivery of interactive services to disabled children. This is the reason why we also use the term iTV in this paper, which is organised as follows. Section 2 presents the aims and scopes of MPEG-21 which is adopted as metadata schema in our approach. Section 3 describes briefly an authoring tool (Developer21), which supports the MPEG-21 XML schema files. Section 4 shows the architecture of our IPTV simulator. The main characteristics and the scopes of our IPTV simulation platform are described in Section 4. Finally, the last section concludes and summarises this approach.

2 The Multimedia Framework (MPEG-21)

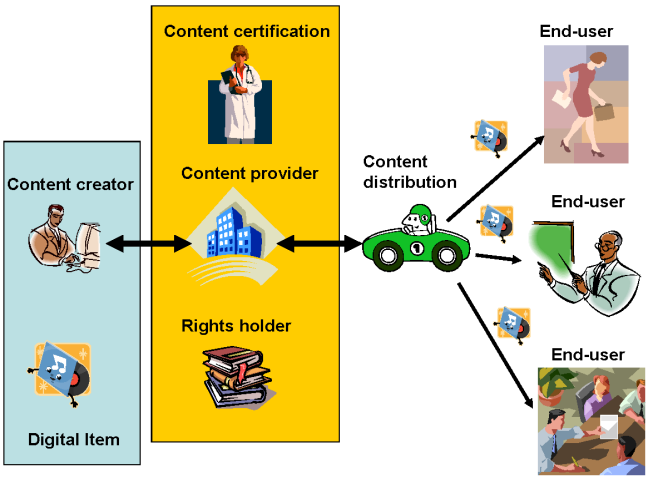
The MPEG-21 Multimedia Framework is based on two essential concepts: the definition of a fundamental unit of distribution and transaction (the Digital Item) and the concept of Users interacting with Digital Items. The Digital Items can be considered the 'what' of the Multimedia Framework (e.g., a video collection, music album) and the Users can be considered the 'who' of the Multimedia Framework.

The goal of MPEG-21 can be phrased as: defining the technology needed to support Users to exchange, access, consume, trade and otherwise manipulate Digital Items in an efficient, transparent and interoperable way. This Technical Report gives an overview of the technologies that have been identified to enable this goal (and that are consequently being reflected into the different parts of the MPEG-21 standard).

In the context of the MPEG-21 multimedia framework, the main entities are Users and Digital Items, see Figure 1:

- An MPEG-21 User is any entity that interacts within the multimedia framework: it can be a content creator, a content distributor, or a content consumer (end user). Users include individuals, consumers, communities, organisations, corporations, consortia, and governments. Users are identified specifically by their relationships to other Users for a certain interaction. From a purely technical perspective, MPEG-21 makes no distinction between a 'content provider' and a 'consumer' as both are Users in the MPEG-21 multimedia framework.
- On the other hand, the Digital Item is the fundamental unit of distribution and transaction among Users in the MPEG-21 multimedia framework. It is a structured digital object with resources (the content), unique identification and corresponding metadata (e.g., MPEG-21 XML schemas). The structure relates to the relationships among the parts of the Digital Item, both resources and metadata. Once the content (in the form of Digital Items resources) will be exchanged in the defined framework, there will be entities that will offer content customisation functionalities to achieve an optimal end-user experience. Therefore, MPEG-21 sets the trail to create a complete system, where such entities will play the role of the "bridging element between the parts that have to be matched/bridged", which are the multimedia content and the usage environment (Magalhaes and Pereira, 2004).

Figure 1 Main entities in MPEG-21 (see online version for colours)



2.1 MPEG-21 and its accessibility role

MPEG-21 is, from our research view, an attempt to provide the IPTV designer a framework that can offer a big – integrative picture of an IPTV system. Based on that, an indicative scenario has been devised, including production, delivery and consumption of the digital content, aiming at identifying the primary entities and the way these are involved in the overall design outcome (see Figure 2). According to that:

- The Content Designer (CD) identifies the target groups. CD in our research works with the authoring tool called Developer21.
- Developer21, supported by MPEG-21 metadata, describes the target groups using their characteristics (e.g., blindness) and associates interaction modes (e.g., auditory description).
- The CD develops the required content components (digital items) based on the above-decided interaction modes. These are integrated into the metadata using the authoring tool.
- End user A (e.g., blind) wants to consume developed content providing his or her profile that was already stored. The context of use is accomplished with attributes like access device capabilities, audio configuration, time and location of the end user.
- The context of use is delivered to the serving system accompanied by the user request.

Even if MPEG-21 addresses considerations for adaptation and specifically accessibility by including several relating XML elements into its schema, it seems that on its own this cannot ensure the accessibility of delivered content. Instead, this is a fundamental condition for providing accessibility output of the systems involved. In other words, it should be able to provide the required infrastructure so that a digital content would be able to obtain the requisite variety for both the CD, to be able to design accessible content, and the involved systems, to have the required information to deliver an accessible result. Figure 3 presents the stakeholders from a DAWIS framework's prism (Vlachogiannis, 2008). From such a point of view, the content provider, the author (also referred to as CD), the authoring tools, the systems of the content provider and of course the consumer with her accompanied interaction profile (i.e., preferences, device capabilities) are identified and all play a major and cascading role to the iTV accessibility.

Briefly, the role of the MPEG-21 towards the accessibility of iTV is revealed through the following dimensions:

Alternative content. MPEG-21 offers metadata (MPEG-21-part 7, 2004) that allows content providers to provide the content in one or more alternative ways. The ways often refer to different modalities and thus they can include captions, audio descriptions, etc.

Digital Content Navigation. In iTV environments, navigation facilities within available content are provided by an Electronic Programme Guide (EPG). This is actually the interactive portion of the system that offers the required functionality to the user including service (channel) selection/retrieval, programmes information and scheduling, profiling/personalising, rating/or even acting upon the content.

Figure 2 MPEG-21 involvement in IPTV: a possible scenario

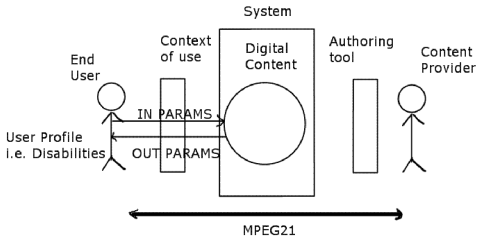
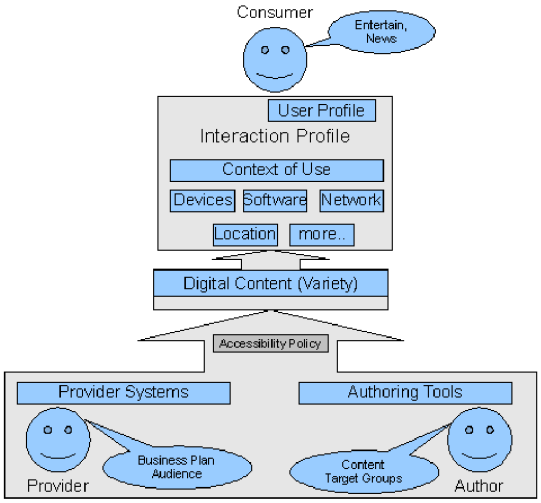


Figure 3 Multimedia delivery stakeholders (see online version for colours)



Description of context of use (IN PARAMS). The usage context actually refers to all the information that needs to be taken into account to adapt digital content according to the user's requirements.

Description of presentation parameters of digital content (OUT PARAMS). This determines what technical characteristics need to be adapted. An important implementation consideration was the transformation of MPEG-21 to SMIL as an intermediate solution to ensure media players' compatibility. This involved the mapping between those two infrastructures realised using XSLT.

Device accessibility. This refers to the accessibility of the involved hardware including remote controls and set-top boxes (TIRESIAS, 2007).

Content provider accessibility policy. Probably, an important contribution to the field of accessibility of MPEG-21 is the capability of applying and claiming for an accessibility policy. In other words, content providers need to be capable of applying a kind of accessibility policy

based on the target consumer group and the former's requirements for quality assurance. For instance, such a policy could provide for digital content to be accompanied by subtitles of two languages (e.g., English, Greek) and every image with an alternative text between 2 and 10 words. Applying such policies requires a mechanism for validating a digital content to a policy description and could be for instance implemented based on Schematron (Schematron, 2007), an XML structure validation language for making assertions about the presence or absence of patterns in trees.

3 The authoring tool

3.1 Literature and market review

Surprisingly, very few authoring tools based on the MPEG-21 standard are present in the market as well as in the literature. In contrast, several metadata authoring tools based on the MPEG-7 standard have been exhaustively described and presented in the market (Martinez, 2002; Lee et al., 2003; Bulgarelli et al., 2006; Lay and Guan, 2000).

Enikos DI Creator (2007) designed an MPEG-21 authoring tool, called DIEditor, allowing users to link multiple resources inside an MPEG-21 structure. In addition, in the framework of ENTHRONE project (Rousseau et al., 2005), the M-Tool was created combining and unifying TV-Anytime and the MPEG-21 standard. In the latter work, MPEG-21 provided content protection, network adaptation, client terminal adaptation and a structure to link several multimedia contents while TVAnytime provided content-descriptive metadata and temporal segmentation.

MPEG-21, as described briefly earlier in this paper (MPEG-21-part 1, 2004) aims at defining an open framework for the delivery and consumption of multimedia contents in heterogeneous conditions. In other words, the goal of MPEG-21 is to define a metadata model to support users to exchange, access, consume and manipulate Digital Items in an efficient, transparent and interoperable way. MPEG-21 is based on two essential concepts: the definition of a fundamental unit of distribution and transaction (called the Digital Item or DI) and the concept of users interacting with Digital Items.

The MPEG-21 specification is flexible and enables higher-level functionality and interoperability by allowing the connection of the several parts of MPEG-21, the inclusion of other description schemes, etc. The Digital Item Declaration (DID) (MPEG-21-part 2, 2005) represents a complete separation of metadata from its associated media resource. The DID specifications encompass the following features:

- the DID Model
- the DID Representation in XML
- XML schemas comprising grammars for the DID representation in XML.

The Digital Item Identification (DII) schema (MPEG-21-part 3, 2003) uniquely identifies Digital Items and parts thereof, relationship between Digital Items (and parts thereof) and relevant description schemes. MPEG-21-part 4 (2006) defines an interoperable framework for Intellectual Property Management and Protection (IPMP). The framework includes standardised ways of retrieving IPMP tools from remote locations, exchanging messages between IPMP tools and between these tools and the terminal.

MPEG-21 IPMP manages rights and intellectual property of a specific resource. It also addresses authentication of IPMP tools, and has provisions for integrating Rights Expressions according to the Rights Expression Language (REL) (MPEG-21-part 5, 2004) and the Rights Data Dictionary (RDD) (MPEG21-part 6, 2004), which are MPEG-21 parts 5 and 6, respectively.

MPEG-21 REL specifies whether a given group of people can perform a given right upon a given resource under a given condition. Finally, MPEG-21 Digital Item Adaptation (DIA) (MPEG21-part 7, 2004) has recently been finalised as part of the MPEG-21 Multimedia Framework. DIA specifies metadata for assisting the adaptation of Digital Items according to constraints on the storage, transmission and consumption, thereby enabling various types of quality of service management.

3.2 Developer21 description

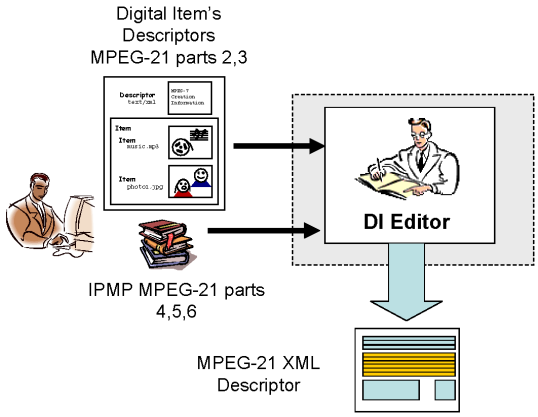
Developer21 for MPEG-21 serves as a multimedia authoring tool adding or extracting MPEG-21 descriptors and metadata in various multimedia assets as shown in Figure 4. Once created, these descriptors (in XML schema files) are locally stored and its list is displayed to the user. The user is then allowed to select one or more descriptor schema which can be further processed and visualised using the respective Graphical User Interface (GUI). Users have the possibility to create a new MPEG-21 Digital Item, edit, delete, convert or send this metadata document to a specific (local or external) metadata database.

MPEG-21 enables the hierarchical representation of multimedia contents which is useful to create advanced and interactive multimedia contents. Every resource is described using the MPEG-21 standard and more specifically through the relevant XML schema, which is provided by MPEG-21 standard. Developer21 is designed to support six different XML schemas, each one dedicated to the respective MPEG-21 part. The MPEG-21 descriptors that are provided by Developer21 are the following:

- DID
- DII
- IPMP
- REL
- RDD
- DIA.

DID was almost totally covered in Developer21 as it is the core definition part of the MPEG-21standard, including all the necessary architecture for the creation, the exchange and the manipulation of the DIs. However, special emphasis was given to the protection of the Intellectual Property Rights and therefore important parts of MPEG-21 IPMP, REL and RDD schemas are supported.

Figure 4 The operation of Developer21 for authoring XML descriptors (see online version for colours)



Developer21 is a prototype that provides all the necessary operations to create or manage metadata or descriptors relevant to multimedia assets. The main scope is to provide the end-user and content provider with a reference tool that enables annotating, browsing, maintaining, monitoring and querying multimedia descriptors.

According to MPEG-21, a user is anyone that interacts with Digital Items. Hence, a User can be an individual, an organisation, corporation, any community, consortium or even a government. Moreover, Users act in various roles including creators, consumers, rights holders, content providers, distributors, etc. Therefore, it is designed to help them in annotating and authoring multimedia resources. In other words, this application allows users to create objects' relationships to each other to enrich multimedia resources with metadata both formatted and stored in XML or in a relational database. This type of service is useful for applications that present a mixture of textual, graphical, and audio data.

3.3 Modules of Developer21

Developer21 is composed of two modules, namely the Digital Item editor (DI editor) and Digital Item Manager (DI manager). It is a DID model editor, Digital Item generator and Digital Item Browser. A DI is edited or generated by inserting, deleting or modifying metadata on account of the DID, DII, IPMP, RDD, REL and DIA specifications.

When a user requests to create a new Digital Item, DI editor is invoked to create the MPEG-21 structure according to the respective part of this standard. For example, if the user intends to create a very simple DI, only MPEG-21 part 2 and the relevant XML is sufficient. However, if Intellectual Property Rights need to be specified, the user should use the respective protection model which is defined in MPEG-21 part 4. In any case, the DID generation is achieved through a graphical representation of the MPEG-21 structure in explorer-like panel as shown in Figure 5. New elements are simply added by performing a drag and drop from the desktop to the MPEG-21 structure. These elements consist of MPEG-21 structure elements (Container, Item and Component) and Descriptor elements (REL, RDD and DIA metadata).

The MPEG-21 DI editor is composed of four areas as represented in Figure 6,

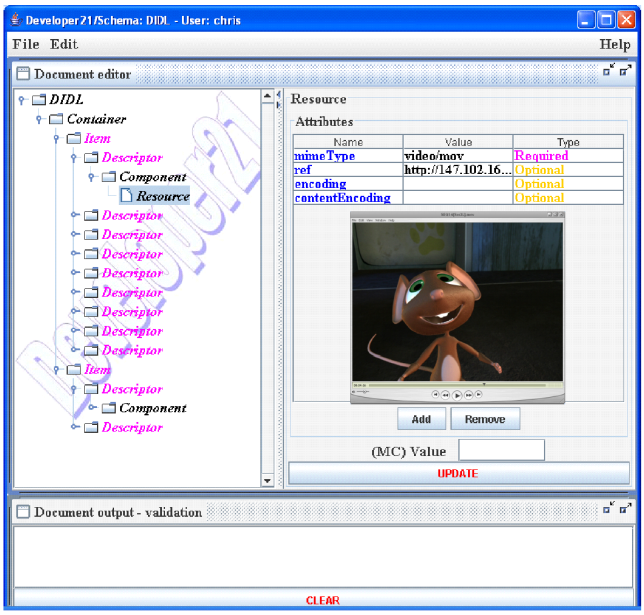
1 the Menu choices

2 the relevant hierarchy and tree visualisation

3 the editor desktop where the manipulation of elements takes place

4 the user–tool interaction line where messages generated from the software appear.

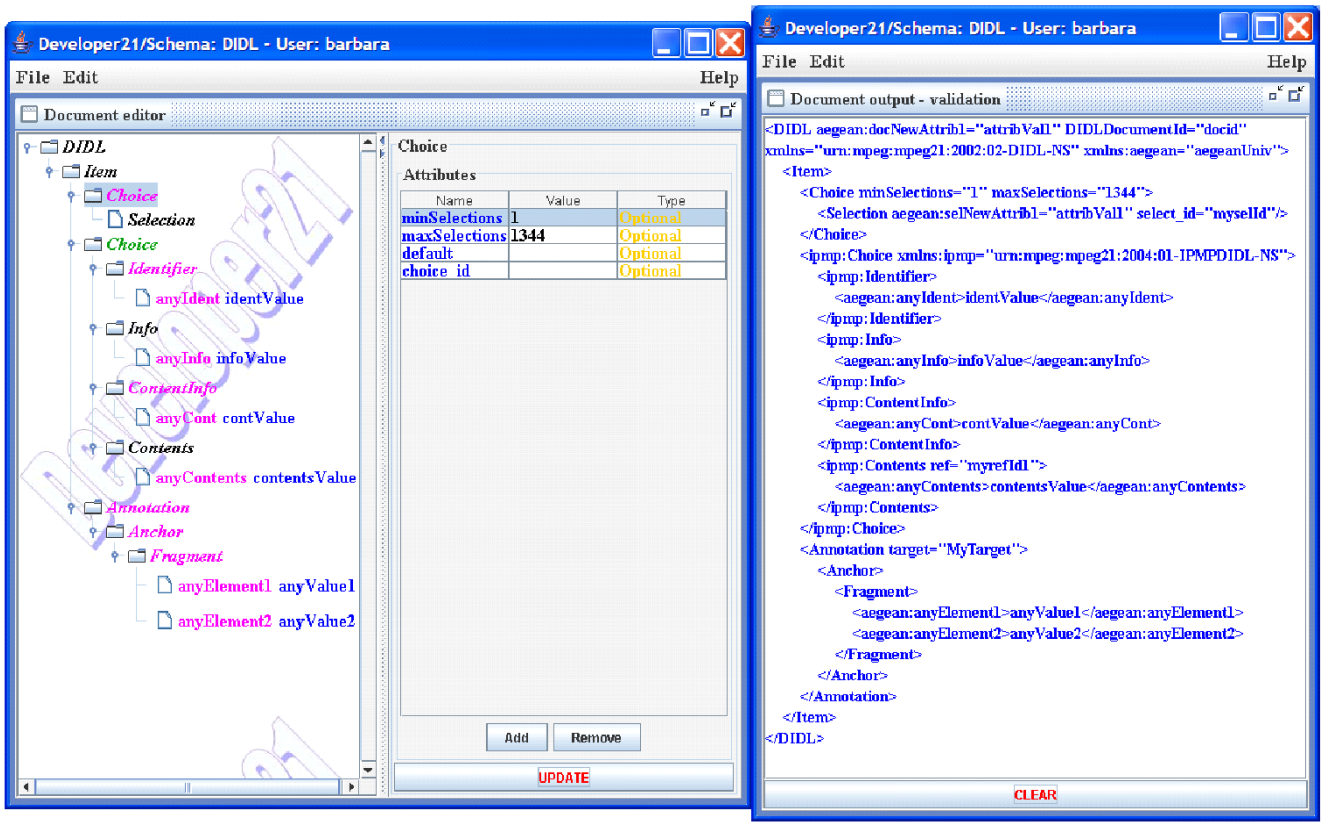
Figure 5 A screenshot of Developer21 editor panel (see online version for colours)



Similarly, to create of a new MPEG-21 document, updates to the current document are achieved by dragging and dropping different icons from area 3 to area 2. The tree view in area 2 gives the XML structuring components while area 3 gives the details of each selected component. Selecting the fields in the top tree displays its full content in the bottom tree.

Basic information about descriptors is provided by the graphical representation: the type of descriptor (DID, DII, IPMP, RDD, REL, DIA), the type of programme information (general information or only audio and video attributes). The schema file can be selected from a pull-down menu in the menu bar. Selecting a particular MPEG21 part triggers the appropriate XML schema for edition and visualisation.

Figure 6 A screenshot of Developer21 manager panel (see online version for colours)

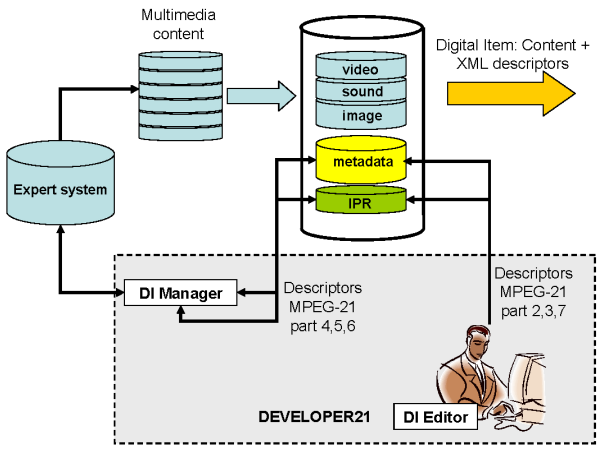


3.4 Increasing interactivity in IPTV with Developer21

In parallel with the editing and browsing capabilities of theDeveloper21 tool, metadata management is also supported. Binding of metadata and XML descriptors with the actual multimedia content is performed to create the integrated Digital Item that contains the actual content and the descriptive information. The manager is able to control, refresh and synchronise metadata files in conformance with their content including detection and elimination of XML metadata (sub-) item (or component) duplicates, and checking freshness and consistency of both metadata associated to distributed digital resources.

When a Digital Item is processed with DI Manager (see Figure 6), it is in the appropriate form to interact with an expert system that is currently implemented in the IPTV simulator for increasing the interactivity in IPTV. The expert system will be able to assign a TV viewer to a specific social category and then match the appropriate audiovisual content according to the respective MPEG-21 descriptors. The whole architecture is depicted in Figure 7. In general, personalisation allows users to browse programmes much more efficiently according to their preferences. On the other hand, personalisation also enables to build social networks that can improve the performance of current IPTV systems considerably by increasing content availability, trust and the realisation of proper incentives to exchange content.

Figure 7 The operation of Developer21 for authoring XML descriptors joined with an expert system for content personalisation (see online version for colours)

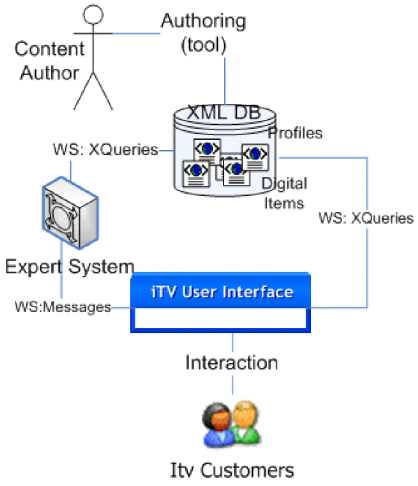


4 The IPTV simulation platform

Under the umbrella of our research project, the need for designing and developing of a simulation platform, acting as an interaction interface between our iTV architecture and the prospective viewer, was evident. It should be noted that the iTV simulator operates with IP technology and therefore, our work could be applied in any internet TV (IPTV) case. In other words, a user interface prototype has been implemented to enable users to effectively browse,

search, download and consume the provided audio-visual content. In the case of disabled people, 'effectively' means that both the content and the value-added services need to be accessible to the user, as already discussed. Such an interface is actually a sub-system of the overall system architecture as briefly presented in Figure 8, consisting of an authoring tool, an expert system, storage (native XML database) and the user interface, referred to as itvSimu. Developer21 allows content providers to easily author a diversity of multimedia resources supporting an MPEG-21 compliant metadata model (Anagnostopoulos et al., 2007). The expert system uses an algorithm originally devised for clustering web documents (Tsekouras et al., 2007), to classify digital items and user profiles based on their attributes and enable intelligent TV programme recommendations. The aforementioned systems communicate through web services under a flexible and distributed architecture. One of the aims of this paper is to present also the design and the implementation of the itvSimu system.

Figure 8 iTV adaptation architecture (see online version for colours)



4.1 Design approach

In effect, the developed User Interface comprises an EPG simulator. It should be noted that the choice of the implementation technologies has not been straight-forward considering the plethora of available standards and technologies like MHP4, GEM-IPTV, TV-Anytime, DVB-IP, Java-TV and more. Given the requirement for incorporating networking functionality into the EPG subsystem, a web-based approach instead of a standalone application has been adopted. This approach ensures the execution of the EPG through a standard browser interface.

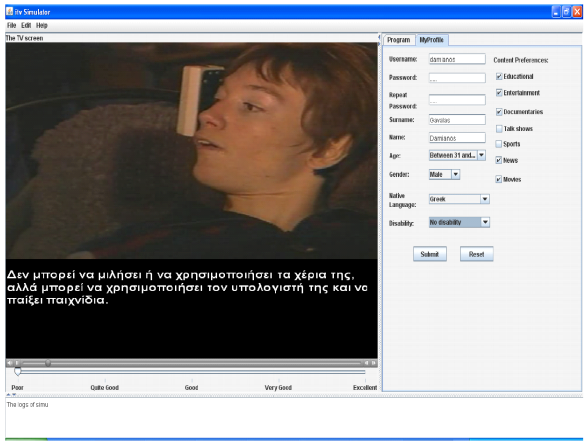
The design approach follows. During the early faces of the design of the prototype system an identification of the stakeholders took place:

- *The end user*: He or she interacts with the ITV interface browsing and consuming digital content. The end user is associated with an XML-based user profile which includes personal data, preferences upon the audiovisual content (e.g., sports, news, movies) and potential disabilities (hearing problems, visual impairments, etc.).
- *The Service Provider*: The analogous of the traditional TV channels.
- *The TV Guide Provider*: A service that informs end users about the offered services and their availability of time schedule.

Occasionally, the Service Provider and the TV Guide Provider coincide; for simplicity reasons we have made such assumption while designing our prototype. Our focus has been on the interaction of the end user with the iTV interface, since that will affect the overall functionality of a personalised system, with particular emphasis on disabled users.

Figure 9 illustrates the three elementary sub-systems of the iTV user interface: the player, the EPG and the logger. These subsystems are supported by auxiliary services for enhancing the functionality of the iTV simulator. Bellow, we analyse the functional and interactivity requirements of the above-mentioned subsystems and discuss the solutions adopted in our prototype.

Figure 9 A screenshot of the iTV user interface: selection of TV programme through the EPG selection service (see online version for colours)



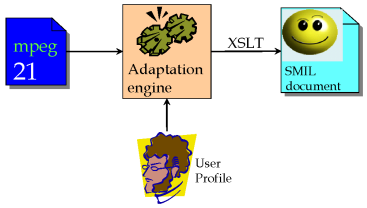
4.2 itvSimu subsystems

Logger subsystem. This is the simplest, yet, a crucial software module as it provides feedback to the user for the 'hidden' operations. It records and displays all (implicit or explicit) user actions (e.g., profile modification, starting/pausing/resuming a TV programme, etc). It has been implemented through Java Observer pattern whose actions activate the logger.

Player subsystem. it reproduces iTV programmes (digital items) as well as recording the user's interaction history. Its elementary module is the digital content player. Such a player should support more than basic functionality (play, pause, rewind, etc.), such as subtitles, and audio descriptions. Given that no MPEG-21 player is currently available, we have chosen to use SMIL as intermediate technology mainly due to the numerous available SMIL players as (X-Smiles SMIL player, 2007) and QuickTime player. In particular, the MPEG-21 DIDs are transformed to SMIL format through an appropriate XSLT transformation and subsequently the SMIL markup code is parsed by the SMIL player. That approach ensures the iTV interface's interoperability since SMIL is now considered a mature web technology. In our prototype, the SMIL player has been implemented using the QuickTime for Java (QTJ) API (QuickTime for Java, 2007). QTJ is a software library that allows software written in Java to provide multimedia functionality, by making calls into the native QuickTime library. QTJ offers SMIL support and can also handle a larger variety of multimedia formats than the 'traditional' Java Media Framework (JMF) API.

As illustrated in Figure 10, the XSLT transformation of MPEG-21 digital items to SMIL documents depends on the user profile, taking into account the potential user disabilities. An example of such DID and its SMIL representation is given in Table 1.

Figure 10 XSLT transformation of MPEG-21 digital items to SMIL documents (see online version for colours)



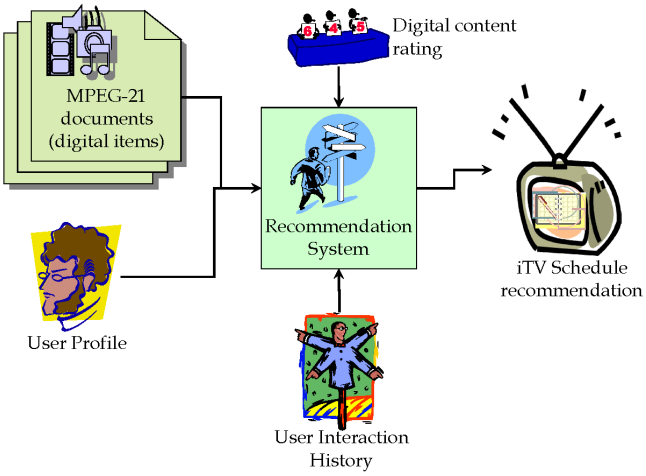
The second function of the Player subsystem is the provision of user interaction information to the expert (recommendation) system. An XML-based description of the user interaction is first stored into an XML native database located on the iTV's server and retrieved by the recommendation system to enable more effective and reliable reasoning. In effect, the user interaction history comprises a function $f(x, y, \ldots, z)$, wherein $x, y, \ldots, z$ are the values of 'interaction parameters'. Such parameters are either explicitly provided by the user or implicitly inferred by the player. Examples of implicit parameters are the playing time of a video over the overall video duration ratio, while the rating of a TV programme (in a 0–10 scale) could be explicitly provided by the viewer. The interaction history function could be expressed as $f(x) = aX + bY$ where a, b represent weights based on the designer's priorities, which could either be static or dynamically specified (through training). As shown in Figure 11, the user's interaction history and the TV programmes ratings posted by users that belong to the same 'users cluster' (e.g., the same disability group) comprise the input of the recommendation system. The latter recommends – among the available digital content – those programmes that suit the user's profile.

Table 1 A Digital Item Declaration document transformed to SMIL format which synchronises a video with captions (appropriate for hearing impaired individuals)

```
<DIDL xmlns="urn:mpeg:mpeg21:2002:02-DIDL-NS">
  <Container id="Movie1">
    <Item>
      <Descriptor id="Resource">
        <Component>
          <Resource mimeType="video/mpeg" ref="videos/ratatouille.mpg"/>
        </Component>
      </Descriptor>
      <Descriptor id="Title">
        <Statement mimeType="plain/text">Ratatouille</Statement>
      </Descriptor>
      <Descriptor id="Director">
        <Statement mimeType="plain/text">Brad Bird</Statement>
      </Descriptor>
      <Descriptor id="Protagonist">
        <Statement mimeType="plain/text">-</Statement>
      </Descriptor>
      <Descriptor id="Country">
        <Statement mimeType="plain/text">USA</Statement>
      </Descriptor>
      <Descriptor id="Language">
        <Statement mimeType="plain/text">English</Statement>
      </Descriptor>
      <Descriptor id="Duration">
        <Statement mimeType="plain/text">111 min</Statement>
      </Descriptor>
      <Descriptor id="Category">
        <Statement mimeType="plain/text">Animation</Statement>
      </Descriptor>
      <Descriptor id="Video_resolution">
        <Statement mimeType="plain/text">1250x840</Statement>
      </Descriptor>
      <Descriptor>
        <Statement mimeType="plain/text">1</Statement>
      </Descriptor>
      <Descriptor id="Subtitle_language">
        <Statement mimeType="plain\text">Greek</Statement>
      </Descriptor>
      <Descriptor id="Captions">
        <Statement mimeType="plain/text">1</Statement>
      </Descriptor>
      <Descriptor id="Caption_language">
        <Statement mimeType="plain/text">Greek</Statement>
      </Descriptor>
      <Descriptor>
        <Statement mimeType="plain/text">1</Statement>
      </Descriptor>
      <Descriptor id="Audio_description">
        <Statement mimeType="plain/text">1</Statement>
      </Descriptor>
      <Descriptor>
        <Statement mimeType="plain/text">Greek</Statement>
      </Descriptor>
    </Item>
  </Container>
</DIDL>
```

```
<?xml version="1.0" encoding="UTF-8" ?>
<smil xmlns:qt="http://www.apple.com/...." time-slider="true">
<head>
        <layout>
          <root-layout width="320" height="350" background-color="black" />
          <region id="captions" backgroundColor="yellow"
          top="250" height="100" left="1" width="310" />
          <region id="movie" left="0" top="0" width="620" height="740" />
          </layout>
</head>
<body>
        <par>
          <textstream src="captions.txt" region="captions"
          systemCaptions="on" />
          <video src="movie.mov" alt="Movie title" region="movie"
          begin="00:00.0" dur="00:14:02.000" />
        </par>
</body>
</smil>
```

Figure 11 TV schedule recommendation (see online version for colours)



EPG subsystem. This is the most 'interactive' subsystem in our IPTV approach since it is used by the user to browse, navigate and download audiovisual content. In the context of our research project we have identified several use cases according to which the iTV end-user may use EPG to:

- navigate within iTV available services (zapping)
- personalise the audiovisual content based on her potential disabilities and content preferences
- schedule a reminder for a TV programme.

An important consideration task during the EPG's development has been the representation and retrieval of the TV schedule. To satisfy this design requirement we have used TV-Anytime Programme metadata (TV-Anytime, 2007) along with TV-Anytime Java API of BBC (TV ANYTIME API, 2007). The overall functionality of the EPG has been based on the specifications of the JAVA TV API (JSR-000927) in a non strict manner. The result of the BBC TV schedule retrieval on the iTV interface is shown in Figure 9.

The most important part of content personalisation has been the modelling of user characteristics (e.g., disabilities) and preferences. To address this issue, we have adopted the Interaction Profile of DAWIS framework for the design of adaptive web information systems (Vlachogiannis, 2008). The most abstract layer of the DAWIS Interaction Profile consists of the Service Interaction Profile, the Delivery Context Interaction Profile, the User Interaction Profile and the Platform Interaction Profile. Based on that, an itvProfile schema has been developed and serialised in XML syntax including elements like Language Native, Languages, ContentPreferences, Disabilities, Subtitles, Captions, AudioDescription and SignLanguage. The itvProfile instances are stored in a separate collection into the XML database storage through XQuery (XQuery, 2007).

5 Conclusions

So far, the developed system is at a prototype level and all systems (i.e., expert system, authoring tool, iTV simulator) have not been evaluated as a whole. This paper actually is a first attempt to disseminate the scientific results of a Greek national project that aims at the delivery of iTV services to disabled children. Among the goals of our research, special emphasis was given to a novel authoring tool implementing MPEG-21 XML schemas for modelling and managing content descriptive metadata associated to audiovisual resources. The functionalities of the authoring tool have been presented and associated with content personalisation and improvement of interactivity in IPTV. The novelties introduced by this work is also highlighted as to our knowledge Developer21 is the only MPEG-21 authoring tool capable to produce and manage DI that support IPMP, REL and DIA schemas. Moreover, at this stage, itvSimu seems to offer an interesting and simplified architecture that can realise a primitive IP-TV platform and further serve as benchmarking software for further research in the field of content adaptation and accessibility. Currently, the prototype fulfils the needs of only a portion of user groups. This is because that for the evaluation of behaviour and content adaptation requires a considerable number of users with diverse profiles, and an analogous number of digital items. Such an evaluation is considered as future work. In addition, as a future work, it would be interesting to consider that more runtime parameters (implicit profile) and more effective models for multiplexing them maybe through AI techniques in the expert system and simulation.

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