Service Platform for Converged Interactive Broadband Broadcast and Cellular Wireless

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***Abstract*—A converged broadcast and telecommunication service platform is presented that is able to create, deliver, and manage interactive, multimedia content and services for consumption on three different terminal types. The motivations of service providers for designing converged interactive multimedia services, which are crafted for their individual requirements, are investigated. The overall design of the system is presented with particular emphasis placed on the operational features of each of the sub-systems, the flows of media and metadata through the sub-systems and the formats and protocols required for inter-communication between them. The key features of tools required for creating converged interactive multimedia content for a range of different end-user terminal types are examined. Finally possible enhancements to this system are discussed. This study is of particular interest to those organizations currently conducting trials and commercial launches of DVB-H services because it provides them with an insight of the various additional functions required in the service provisioning platforms to provide fully interactive services to a range of different mobile terminal types.**

***Index Terms*—Broadcasting, multimedia communication, service platform, terrestrial mobile cellular radio systems.**

I. Introduction

ALTHOUGH there have been many Digital Video Broadcast-Handheld (DVB-H) service trials in different cities throughout the world (e.g. Oxford [1], Berlin [2]. Pittsburgh [3]) and DVB-H was launched commercially in Italy in 2006, the services provided have been based on the re-provisioning of existing terrestrial TV programs and have not included fully interactive services to a range of different terminal types. Future evolutions of these systems are expected to deliver over converged broadcast and telecommunication networks a wider range of multimedia services, including interactive and downloadable services, delivered to a wider range of terminal types.

This paper presents a system that was developed to create, deliver, manage and consume converged interactive multimedia content and services to three classes of terminals for services that suited the business interests of the two main categories of converged broadcast and telecommunication service providers. Therefore, two classes of converged broadcast and cellular telecom services were developed, namely: Cellular Telecom operator oriented on a mobile phone; Broadcaster oriented on a tablet PC and Personal Digital Assistant (PDA). A broadcast oriented service is TV program service centric whereas a Cellular Telecom Oriented service is any multimedia service centric. The reason a converged broadcast and cellular telecom solution was developed to deliver multimedia services to mobile devices, was because broadcast services will benefit from the interaction provided by the cellular telecom networks whilst the cellular telecom network services will benefit from ability of the broadcast network to deliver high quality, high bit rate services to large numbers of users.

The system architecture is similar to the overall structure of the system architecture proposed by DVB [4] but crucially includes a unique set of tools for creating and delivering interactive multimedia services and for managing a business framework for the exchange of contracts between all the players in the value chain as opposed to focusing solely on the contract between the end-user and the service provider.

The paper is organized as follows: Section II presents an overview of the system architecture. Section III provides an insight into the motivations behind the design of converged broadcast and telecommunication services from a broadcaster and telecom operator's perspective Section IV provides a high-level view of the interactions between the sub-systems of the overall system architecture. Section V presents the data flows through the various sub-systems. Section VI presents the range of tools required for creating and supporting the range of interactive multimedia services and end-user terminals supported by the system. Section VII presents a discussion on possible technical enhancements to the sub-systems' functionality. The conclusions are presented in Section VIII.

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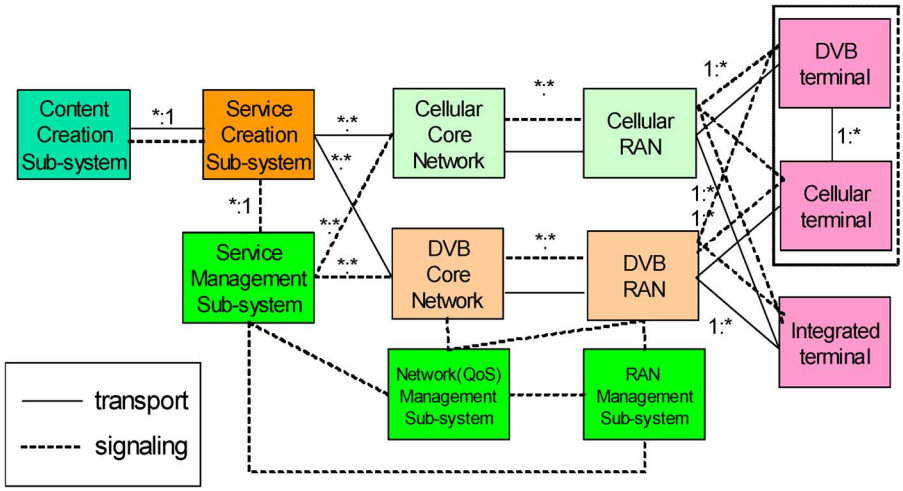

Fig. 1. Converged DVB-H and cellular telecom reference architecture.

II. System Architecture

Since today's radio networks, such as Global System for Mobile Communications (GSM) [5], General Packet Radio Services (GPRS) [6], Universal Mobile Telecommunications System (UMTS) [7], Digital Video Broadcast (DVB) [8] and Terrestrial Digital Multimedia Broadcasting (T-DMB) [9], operate with fixed long-term spectrum allocations, the allocation of radio spectrum has largely been managed over long time scales through international and national radio regulatory bodies [10]. Although there have been proposals to dynamically allocate radio spectrum to radio services, depending on demand for the various types of service [11], [12], these are currently considered by industry as too complex to implement.

The service architecture developed in this work assumes that there will be fixed long-term spectrum allocations for converged DVB-T/H (Terrestrial/Handheld) broadcast and GSM/GPRS/UMTS cellular networks to allow enhanced and/or new types of services to be provided. The service architecture uses Internet Protocol (IP) as its transport protocol because IP is the common transport protocol of its constituent networks. It uses DVB-H broadcast technology [13], which was developed by DVB group for the delivery of broadcast services to mobile users. DVB-H supports a burst mode of reception using time slicing. This allows the end-user terminal to receive the broadcast signal in a more power efficient way and enables soft handover between broadcast cells as the periods between bursts can be used to take measurements of signals from adjacent cells [14]. The reason DVB-H was selected over T-DMB and Multimedia Broadcast Multicast Service (MBMS) was because DVB-H is more efficient than T-DMB in its use of spectrum [15] and MBMS does not have the capacity to deliver multiple high bit rate TV programs [16].

The service architecture incorporates the interests of all the various types of businesses in the value chain: Content Creation, Service Creation, Service Management, Content Transmission, Core and Radio Network Management, and Content Reception which are represented as sub-systems [17], [18] and clearly identified in Fig. 1.

III. Service Design Motivations

The design of services [19] depends on both the network and terminal physical constraints imposed on the service designer and on the individual business strategies of the service providers and terminal manufacturers. The type, capacity and number of networks delivering the services constrains what can be delivered and how. The processing, storage and display, capabilities of the end-user terminals constrains what and how services can be downloaded, accessed and consumed. The mobile phone manufacturers' business strategy promotes the sale of their terminals by distinguishing them through the branded "look and feel" of their user interface. Broadcasters are interested in promoting viewer loyalty, particularly for novel services, by providing them with a familiar branded "look and feel" and by offering user-friendly services allowing for confident and intuitive navigation oriented along well-established usage patterns.

For terminals that have limited resident storage capacity such as mobile phones, the Electronic Service Guide (ESG) can be interpreted and presented on the terminal by applications that are embedded within the terminal (e.g. ESG manager, service applications). Alternatively, for terminals that have a large amount of resident storage capacity, the ESG can be interpreted and presented on the terminal by applications that have been downloaded onto the terminal. For terminals that have limited screen size, such as mobile phones, there is only sufficient space for an ESG to be presented on one screen whereas for terminals that have larger screen sizes, such as tablet PCs, there is sufficient space for both an ESG and information services to be presented on the screen.

All the terminal types considered have the capability of playing audio/visual content that has been downloaded onto the terminals or streamed across the DVB-T/H broadcast IP network or through the cellular radio mobile phone unicast IP network.

The telecommunication service scenario is directed to streaming audio/visual services using IP over a DVB-H network, since there is not sufficient memory on mobile phones or sufficient IP multicasting capabilities over cellular radio networks to support continuous DVB-T transmissions. Due to the

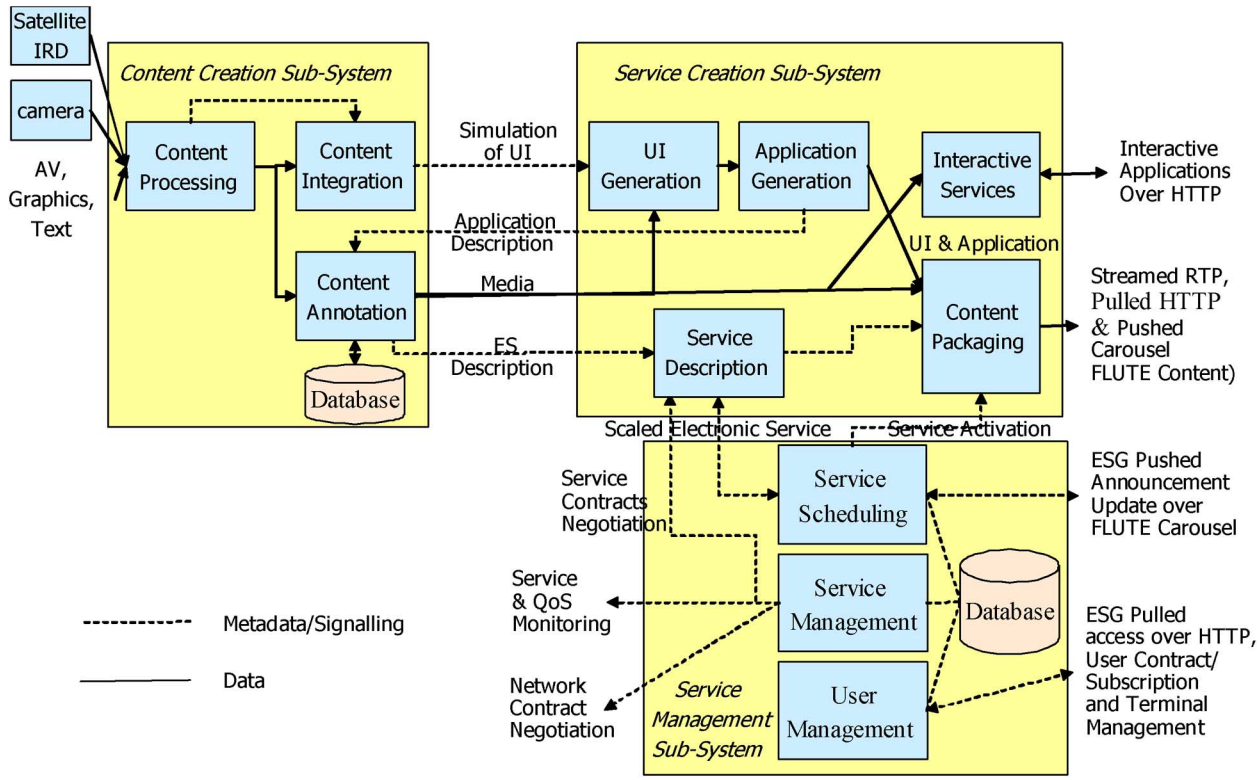

Fig. 2. Content and service creation and management sub-systems.

screen size, a streamed or multicast downloaded TV program using IP over DVB-H can only be presented on a mobile phone by using its entire screen.

The broadcast service scenario combines existing TV programs streamed over DVB-T with additional multimedia information services where content is either downloaded or streamed using either IP over DVB-T/H or the unicast cellular radio network. A TV program broadcast on IP over DVB-H to a Tablet PC can be presented on the entire screen. Alternatively it can be simultaneously displayed with additional information services streamed that had been delivered using IP over the unicast cellular telecom network. However, user validation studies have shown that viewers find it disturbing to have TV programs running on a screen with additional audio/visual information.

All the terminal types considered have the capability of pushing or pulling additional text, image or graphical content over the broadcast DVB-T/H or the cellular radio mobile phone unicast IP network.

The telecommunication service scenario is directed to pulling content snippets since mobile phones do not have the processing power or storage capability to support a full Internet browser. Due to the small size of mobile phone screens, each media snippet, for example an image service, pushed over the IP multicast cellular network can only be shown on the screen a snippet at a time. The broadcast service scenario pushes core content via the DVB network and uses the IP cellular network to pull special types of additional content according to user's individual wishes/interests. Internet page services were provided that were pushed over an IP broadcast network on which there are hypertext URLs to access further media over the unicast network. The tablet PC is able to archive services as it has sufficient storage capacity to save the services in persistent storage.

All the terminal types considered have the capability of receiving alert services pushed to them from which additional pushed or pulled AV, Internet, image or graphical content can be accessed over the DVB-T/H or cellular radio networks. An alert service broadcast to a mobile phone can only be presented on one screen at a time whereas an alert service to a Tablet PC can be presented at the same time as other information services.

IV. System Operation Overview

The overall system architecture is similar to the overall structure proposed by DVB CBMS. It consists of the Content Creation, Service Creation, Service Management and Quality of Service Management sub-systems as shown in Fig. 1. Any original equipment manufacturer (OEM) is free to subdivide each sub-system into components and define their functionality in whatever way it chooses. Fig. 2 shows the content and service management sub-systems at component level as interpreted in this work to provide the service creator with the means to design multimedia services according to the constraints discussed in the previous section. A description of the functionality of these components is provided in this section.

A. Content Creation Sub-System

The Content Creation sub-system is responsible for providing content for services in a single "base" format to alleviate the need to adapt content to different types of network and mobile terminals It is also responsible for generating the graphical components of the end-user terminal's graphical user in-

terface (GUI) to cater for mobile terminals that require some or all parts of the UI to be downloaded. The audio-visual (AV) base format is MPEG-2 [20] and the GUI base format is Extensible Markup Language (XML) with 'Joint Photographic Experts Group (JPEG)/Portable Network Graphics (PNG) for the representation of images. The process of integrating content is achieved using a simulation tool that allows a fast prototype of the service to be generated for testing with the organization commissioning the service and with potential consumers. This tool allows services that have the same look and feel as the final service to be simulated on target end-user terminals without going through the expensive process of commissioning the service on the broadcast and cellular network delivery platform [21]. The Content Creation sub-system then generates descriptions of the service and content in base format and delivers this to the Service creation sub-system.

B. Service Creation Sub-System

The Service Creation sub-system first negotiates a Service Contract with the Service Management sub-system that defines the terms of the contract, namely: which services to deliver and when; over which combination of networks; to which network areas; to which terminals classes; etc. This provides the Service Creation sub-system with sufficient data to semi-automatically generate scaled versions of the GUI for each terminal class and applications targeted to various end-user terminal operating systems (e.g. Linux, Windows etc.) and APIs (e.g. Java MHP (Multimedia Home Platform [22], Java MIDP (Mobile Information Device Profile) [23] etc.). The semi-automatic application generation tool possesses information on the capability of each end-user terminal type (e.g. players, alert and archive manager applications etc.) and these functions are semi-automatically mapped onto the leaf nodes of the GUI [21]. A scalable service description is generated from the base service description that targets different terminal types by defining coding formats, terminal profiles, network areas, schedules and sessions for each service as agreed in the Service Contract. The Service Creation tool organizes the off-line transcoding/transrating of MPEG-2 video into appropriate formats (e.g. MPEG-1 [24], MPEG-4 [25], Windows Media [26]) for file download. It then configures the FLUTE IP carousel server [27] for downloading these files using Session Description Protocol (SDP) [28] and File Description Table (FDT) [27] files. It then configures the video encoder/transcoder/transrater to process live video (e.g. from cameras, satellite receivers etc.) into contractually agreed formats for streaming on Real-Time Protocol (RTP) [29] over IP. FLUTE is a protocol for the multicast/unicast unidirectional delivery of files over the Internet using User Datagram Protocol (UDP) over IP, which is particularly suited to multicast networks. It provides reliability through retransmissions and Forward Error Correction. At an appropriate time the service descriptions are delivered to the Service Management sub-system.

C. Service Management Sub-System

The Service Management sub-system incorporates a Commerce Management component, which negotiates Service Contracts with the Service Creation sub-system, Network Contracts with the network operators and User Contracts with the end-users. Since the Service Management sub-system keeps a record of all the types of terminals sold by manufacturers, this information is used to draft Service Contracts designed to target a particular group of terminal types. Although a Commerce Management component has been designed to incorporate Customer Account Management, Service Pricing Management, Billing, Invoicing/Collection/Remittance, and Service Rating functions, these have not been built. The Service Management sub-system receives electronic service descriptions from the Service Creation sub-system and integrates these into an ESG. The complete ESG and any subsequent updates to the ESG are then broadcast to the end-user terminal using the FLUTE IP carousel (pushed broadcast portal) or pulled by the end-user terminal from a Web server (pulled portal). A personalized ESG may be accessed from the pulled portal since the Service Manager is able to compile this on establishment of the User Contract. The Service Management sub-system activates the pre-configured transcoders and transraters in the Service Creation sub-system before the start times of services.

D. Quality of Service Management

The Service Management sub-system then monitors the end-to-end availability of the service from the end-user terminal and the quality of service provided by the core and access networks at the network edges. The Core and Access Network Managers are used to ascertain whether contractual obligations have been met according to the user contract and whether the constituent core and access networks have met their contractual obligation according to their network contracts.

Service data is delivered as IP traffic from the Service Creation and Management sub-systems to the DVB-H/T Radio Access Network points through multi-domain networks including Asynchronous Transfer Mode (ATM), Synchronous digital hierarchy (SDH), Gigabit, asymmetric/symmetric/High-data-rate/Very high-data-rate digital subscriber lines (xDSL).

For the purposes of the demonstrator, one network contract was drafted with a single network operator [30] that had the responsibility of drafting further Service Level Agreements between domain operators as required to provide the required terrestrial coverage. Network simulations were used to model these multi-domain networks and the performance results of the simulations were used to emulate the outcome of traffic flows through these networks using NISTNET [31] to ascertain the effect of traffic degradation on the quality of service (QoS).

The purpose of the end-to-end service monitoring is to determine if services are delivered to end-user terminals successfully or not. This is typically required by sections of the Service Management sub-system organization that is concerned with the provisioning of services.

The purpose of the end-to-end quality of service monitoring is to determine if the Core and Access Networks are delivering the QoS agreed within the Network Contracts. If this QoS is not achieved then it is tasked to ascertain which network component (core or access) has violated its contractual obligations and to either renegotiate the contract or find another network provider. After the Service Management Sub-System has negotiated network contracts with the core and access broadcast network providers, it provides to the Core and Access

(Broadcast) Network Manager the Network Contract and an end-to-end service level specification based on the different classes of User Contracts that have been offered (e.g. Platinum, Gold and Silver).

The first task of the Core and Access (Broadcast) Network Manager is to use the Network Contract to configure its routers or gateways to route the contractually agreed IP services and to configure the broadcast Radio Access Network (RAN) to map IP streams onto DVB-H bursts. Once service delivery has commenced it then gathers QoS data from network edge probes that report on the measured quality of service at strategically positioned points in the core and access delivery networks. This data is gathered at the Broadcast (Core and Access) Network Management sub-system to generate quality assurance reports that are typically required by sections of the Service Management sub-system organization, which is concerned with organizing the provisioning of network resources.

This report simply lists whether the end-to-end service level specification is being provided according to Platinum, Gold and Silver quality or not. If the required quality is not being provided then it is the responsibility of the Service Management sub-system to notify the network operator to seek financial compensation and remedy this situation by reallocating network resources to meet the service level specification or to renegotiate a new contract with another network operator.

E. End-User Terminals

Three classes of terminals were targeted for consumption of services: Tablet PC with MHP; PDA with MHP; Mobile Phone with MIDP. Each can use Linux or Windows as their underlying operating system. All the terminals considered have interfaces to a DVB-H/T radio receiver and a GPRS/UMTS radio transceiver, which is configured using a delivery session configuration function. Subsequent data access can be managed using a (Stream and File) Delivery Management function. A Storage Manager function is used to make transparent to any application the method and route of data delivery from the various networks. A Metadata Management function is used to allow any application to easily extract data from the delivered ESG. A Service Management function establishes a User Contract and a Profile Management function at the end-user terminal allows the end-user to define a user profile for filtering services. A Personal Service List Management function at the Service Management sub-system allows this process to be undertaken by the service provider.

V. Data Flows Through System

The data flows through the system are broadly subdivided into content flows and metadata flows. The metadata flow is divided into the service and contractual frameworks. The service framework is concerned with the description of service providers, services and content. The contractual framework is concerned with the description of contractual agreements between the actors.

A. Contractual Framework

The contractual framework, shown in Fig. 3, provides an agreement on the nature of all data interactions between the actors of the DVB-H system, namely: service metadata, multimedia content data and quality assurance metadata. It consists of two business-to-business contracts and a business-to-end user contract:

- Business-to-business
  - Service Contract—between the Service Management and Service Creation Systems. This defines the services that should be delivered by an individual Service Provider. It defines the schedule of the services, the network over which the services should be delivered and the class of end-user terminals the services provision.
  - Network Contract—between the Service Management and Network Management Systems. This defines the bit rate, packet loss, bit error rate, packet latency and delay variation through a network over time.
- Business-to-end-user:
  - User Contract—between the Service Management System and end-user. This describes different types of contracts that could be created such as a service where users have x hours a month of service to consume. It also describes packages of services where several levels of packages can be defined. It also consists of user preferences. Default user preferences are set when the user buys a contract with the DVB-H Service Manager. User preferences are based on keywords available on the service description and this information can be changed by users using the return channel

The contractual framework is supported by the Terminal Profile that is provided by terminal manufacturers, as shown in Fig. 3. The business contract between the Service Creation system and the Content Creation system is not considered.

All business contracts consist of the ContractParty element, which describes the actors in the contractual agreement and a Terms element, which describes the terms of the contract between them. The business-to-end user contract has an additional Preferences element that describes user preferences for offered services. All contracts cannot be dynamically renegotiated and are designed as medium to long-term commitments between the actors.

In the case of a broadcast service manager the user contract takes the form of a license fee which end-users are obliged to purchase if they own a TV receiver. In the case of a telecom service manager the user has the option to purchase a subscription of a defined set of services, which can be pre-paid or post-paid, or to pay for services on-demand. The User Contract, User Profile and dynamic Terminal profile data uses the unicast cellular network to communicate contractual information.

B. Electronic Service Guide

The purpose of the Electronic Service Guide (ESG) is to provide a description of the services to reflect all the permutations and combinations discussed. These multimedia service descriptions are dynamically updated, pushed and pulled from a flexible number of service providers to a flexible number of different terminal types using a flexible number of different (broadcast and cellular) bearer networks. These service descriptions are delivered and presented to the end-user who is then free to choose which service s/he wishes to consume. The end-user terminal or

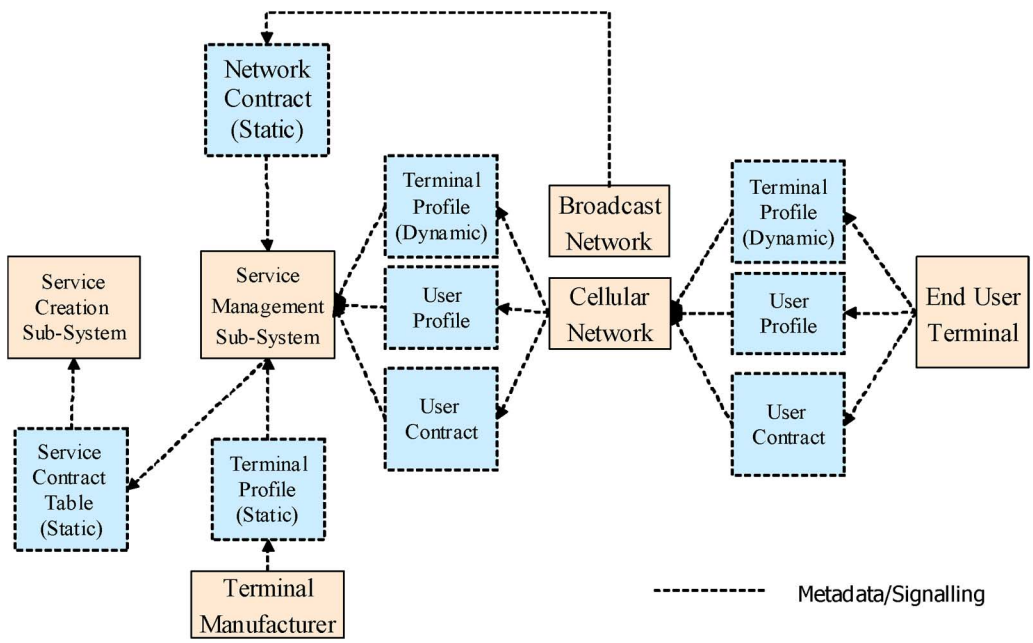

Fig. 3. Contractual framework.

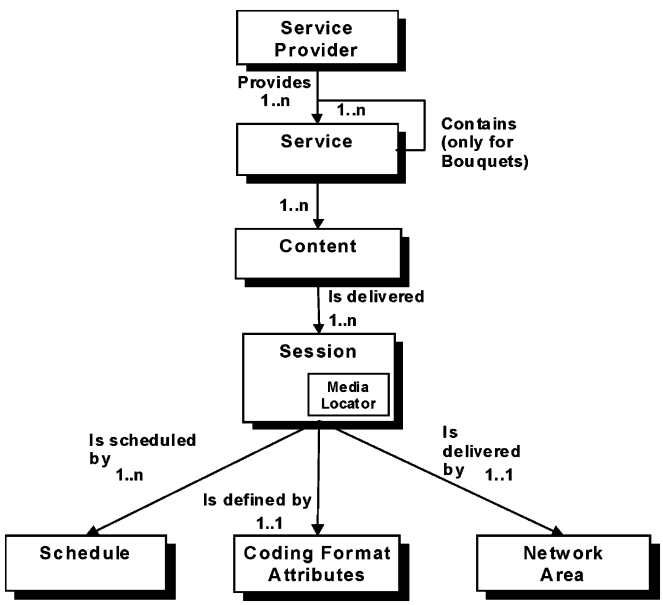

Fig. 4. Hierarchical table view of ESG.

a personalized service provider portal can also use the service description to automatically filter services based on pre-defined user preferences. The structure of the ESG schema is based on seven tables and was submitted to the DVB Technical Module (TM) Converged Broadcast and Mobile Services (CBMS) call for technologies [32]. It is illustrated in Fig. 4.

The ServiceProvider table describes the main features of the distinct possible service providers.

The Service table gives the list of contents that are provided while subscribing to a given service. Different types of services exist according to usual classification (TV services, offline browsing services, audio services, etc). The way to subscribe to each service is described. The services may be filtered through user preference keywords.

The Content table describes the contents themselves, independently from the way they are provided and delivered. Different types of contents exist: text, A/V, images, application. As far as possible, the content description syntax refers to existing standards like MPEG-7/TVAnytime (TVA) (for A/V contents) [33], Dublin Core [34], etc. Note that the list of content attributes is not intended to be exhaustive.

The Session table describes the instances of delivery of the distinct contents provided by given service providers. In particular, it describes the mechanisms of delivery (such as compression, encryption, etc) and the network features, as well (IP addresses, port, etc). Note that a given content may be delivered using several media (e.g. audio and video media delivered separately for A/V content).

The Schedule table is a very light table that provides the delivery time of a given session. This table can then, with the low bandwidth consumption and only a few terminal parsing operations, be updated if a session delivery is deferred.

The CodingFormat table provides the description of media coding formats that are expected to be used often. Information like Mime types (for files) and A/V codecs are given in this table.

The NetworkArea table describes network location elements that are often used by content media (type of network, identification of cells, and optionally IP flows description).

Each element of each table is given a segment_id (e.g. a given content within the ContentTable) and a version number. This information provides the means to identify in an expected transport stream, the elements and their current version.

The DVB-CBMS schema that was finally standardized [35], shown in Fig. 6, is very similar to the schema that was proposed as a result of this research [36] with Service, Content, Acquisition and ScheduleEvent easily mapped from the Service,

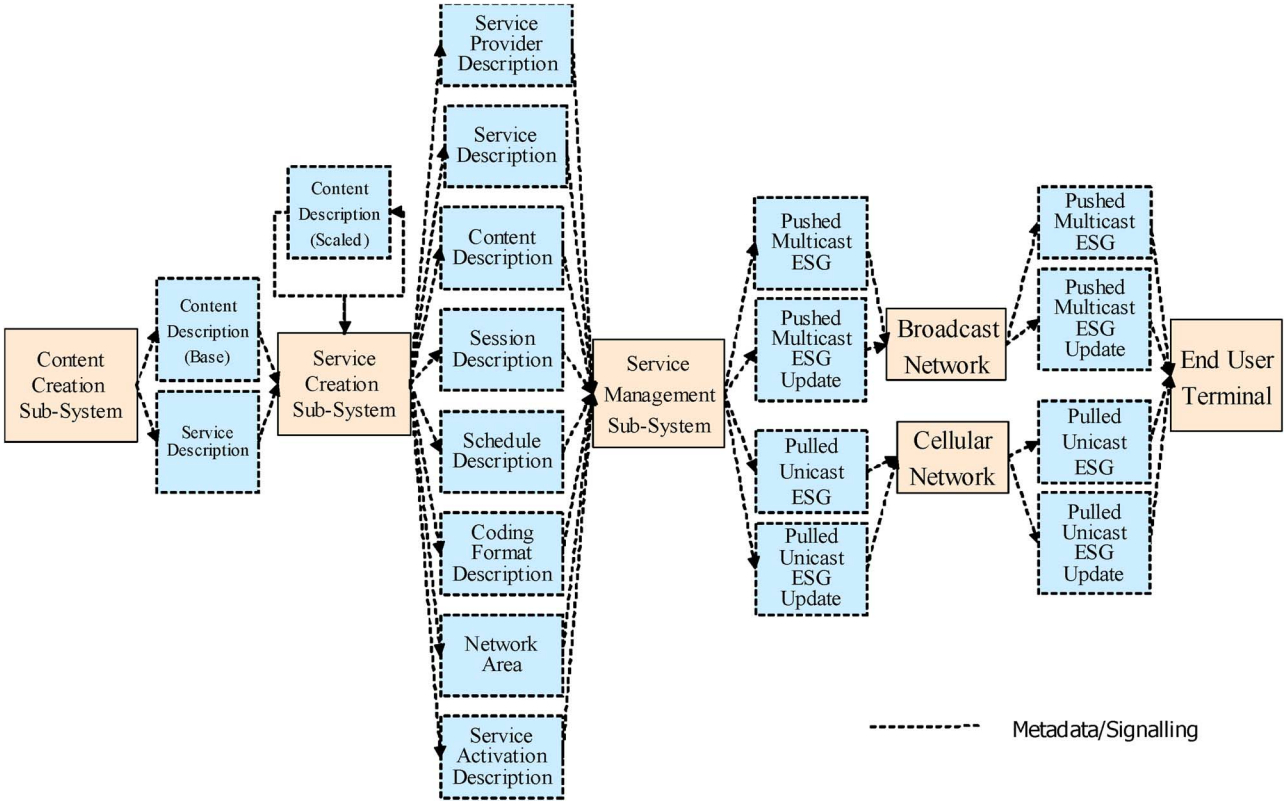

Fig. 5. Service framework metadata.

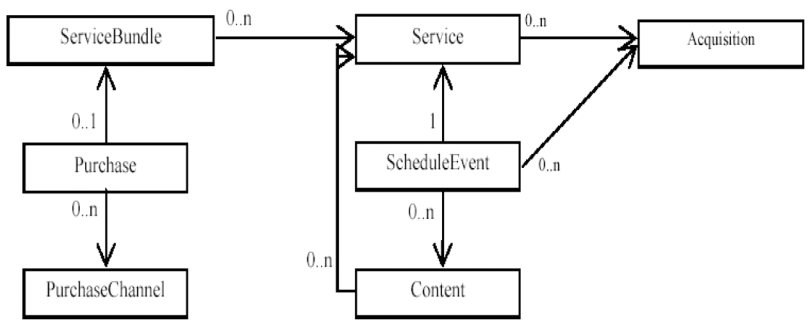

Fig. 6. DVB-CBMS ESG.

Content, Session and Schedule tables. The proposed Coding-Format was inserted into the DVB-CBMS's Acquisition and NetworkArea fragments were not in the DVB-CBMS phase 1 ESG but could be incorporated in the phase2 version. Furthermore, DVB-CBMS has incorporated the commercially relevant tables: ServiceBundle, Purchase and PurchaseChannel; that could be managed by an additional Commercial Management sub-system.

At about the same time as the DVB CBMS ESG standard was published, the OMA BCAST ESG standard [37], [38] was also published. Studies of these two standards conclude that they are very similar [39].

C. Service Framework

The Service Framework describes the services and their related content from inception to delivery, as shown in Fig. 5. At the point of inception, the Content Creation sub-system creates content and service descriptions that are related to a particular service (e.g. sports-football, news-current). At the Service Creation sub-system the service provider descriptions are added, service descriptions are embellished with Session, Schedule, Coding Format and Network Area descriptions and content descriptions are extended to include scaled content descriptions according to the terminal profiles that have been agreed in the Service Contract.

D. Media Flows

The media flows through the DVB-H system deliver multimedia services to the end-user terminal and are shown in Fig. 7. The media services consist of audio-visual, Internet, text and graphics media. Pushed media is delivered over the DVB-T or DVB-H networks from the Service Creation sub-system whilst pulled media is accessed over the cellular network from the Service Creation sub-system. Multimedia services consisting

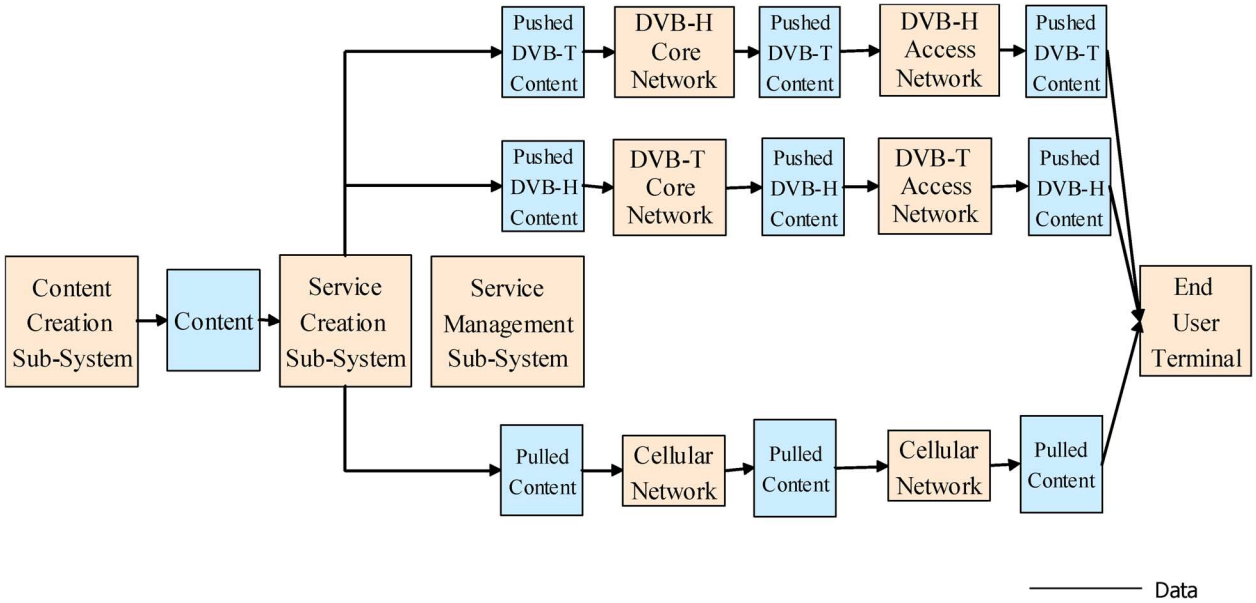

Fig. 7. Media flows through system.

TABLE I
AUDIO FORMATS

Sampling Rate	Codec	Bit Rate	Transmission
32kHz, 44.1kHz, 48kHz (for music)	MPEG-1 layer II	64kb/s – 384kb/s,	DVB-T
	MPEG-4 AAC		Additional audio content with video via IP
	Windows Media Audio and Dolby AC3		Audio on its own via IP

TABLE II
VIDEO FORMATS

Sampling Rate	Codec	Bit Rate	Transmission
Full D1 or Half D1	MPEG-2	2 – 4 Mb/s (constrained by quality at low end and processor power at high end)	DVB-T
CIF	MPEG-1	1 Mb/s	IP
CIF, QCIF, HalfD1	MPEG-4	1.2 – 0.2 Mb/s	IP
CIF, QCIF, HalfD1	Windows Media Video	1.2 – 0.2 Mb/s	IP

of video, audio, images, graphics and text media provide value added value for service providers to distinguish their services.

Since the future mobile multimedia market is likely to be supported by a wide range of terminal types (e.g. tablet PC, Personal Digital Assistant (PDA), mobile phone) with different capabilities, scaled versions of the multimedia for the service are provided. The choice of audio-visual media formats and bit rates to support the different terminal types used in this work is given in Table I and Table II.

For all class of terminals the Flute protocol is used for file and XML signaling delivery. Flute (version 1) is an open source protocol for unidirectional delivery of files over the Internet and is applicable to the delivery of large and small files to many hosts, using delivery sessions of several seconds or more. MPEG-4 streaming uses RTP protocol. MPEG-2 TS over IP is used for the delivery of MPEG-2 TV programs. The benefits of streaming a MPEG-2 TS are that it incorporates audio and video synchronization data and error protection.

VI. SUB-SYSTEM TOOLS

The converged broadcast wireless service platform consists of Content Creation, Service Creation and Service Management sub-systems as shown in Fig. 2. This section presents the features of the tools that were designed for each of the sub-systems to facilitate the creation, delivery, management and consumption of interactive, multimedia content and services to three different terminal types.

A. Content Creation Sub-System

The Content Creation sub-system consists of the Content Processing, Content Annotation and Content Integration components.

The Content Processing component was required for creating different versions of the same media for delivery to different types and capabilities of end-user terminals. It provides, via configuration control through the MediaGateway Services tool, access to and processing of MPEG encoders, transraters and transcoders (MPEG-2 to MPEG-4). The transraters were required to modify on-line MPEG-2 satellite streams into MPEG-4 streams and the encoders were required to encode live audio-video from camera.

The Content Integration component was required for creating different user interface designs for different types of end-user terminals. It aggregates all the User Interface (UI) elements

(graphics and buttons) and content elements (video/audio clips, Internet links) that comprise the service's content and user interface look-and-feel. A desktop publishing tool was used to prototype services quickly and iteratively construct and test them on organizations and their customers who were commissioning the service.

The Content Annotation component was required for creating the multimedia services by integrating a number of different content elements into a single service. It consists of a Service description tool that generates, imports and maintains content descriptions and basic service descriptions. It imports an xml file generated by the Application Generation tool that describes the basic services, contents and associated content and enables the addition of more content service descriptions, which are stored into the common database that was shared with the Service Description tool.

B. Service Creation Sub-System

The Service Creation sub-system consists of the User Interface Generation, Application Generation, Service Description, Content Packaging and Interactive Services components.

The UI Generation component was required to adapt the user interface into any type of markup language that was needed by the end-user terminals to support downloadable services. It was used to parse the desktop publishing tool file and generate a XML description of the user interface with its graphical components. The XML description could be further translated to HyperText Markup Language (HTML), TeleVision program Making Language (TVML) Wireless Markup Language (WML) etc. depending on the navigation engine resident on the targeted end-user terminals.

The semi-automatic Application Generation component was required to add application software functionality to the user interface graphical widgets depending on the type of operating system and API used on the supported end-user terminals. It was used to map terminal functions onto UI graphical widgets. Different terminal profiles take into account aspects such as operating system (Linux, Windows Mobile), middleware API (MHP, MIDP, JSR272[1]) and form factor (Tablet PC, PDA, Mobile Phone).

The Service Description component was required to generate descriptions of scaled versions of the services that are suited to different types of end-user terminals. It generates scalable service descriptions, which include the session, the schedule, the coding format attributes, and the network area descriptions and delivers these descriptions as a package to the Push Broadcast Portal (SS9) in the Service Management sub-system. Before delivering the service description to the Service Management sub-system it configures the Flute IP carousel server, video streaming server, encoders, transcoders and transraters that reside on the Content Packaging component.

The Interactive Service component is required to authenticate the use of downloaded interactive services. The Interactive Services tool consists of a Mobile One Time Password (MOTP) authentication system [40], which provide server side authentication and the administration console for user provisioning of interactive services.

[1]JSR 272—Java Specification Request: "Mobile Broadcast Service API for Handheld Terminals"

C. Service Management Sub-System

The Service Management sub-system consists of the Service Scheduler, Service Manager and User Manager.

The Service Scheduler was required to deliver ESG to multiple different types of end-user terminals in an efficient way. It consists of a PushBroadcastPortal tool, which ingests packaged service descriptions from a number of Service Description components. It unpacks and integrates them. It then edits the schedule time for each service checking the availability of bandwidth over the selected multicast channel and checks if the proposed schedule is in line with the current Service Contract. It also consists of an ESG announcement tool, which builds the ESG every n seconds, activates and then sends the ESG to the FLUTE Server for delivery to the terminals.

A Service Manager was required to orchestrate the negotiation of contracts between the Service Creator, Networks and the end-user in order to establish interactive multimedia services for a range of different terminals delivered over a range of different networks. A set of contract negotiation tool pairs were developed to agree a Service Contract between the Service Creation and Service Management sub-systems, a User Contract between the end-user and the Service Management sub-system and a Network Contract between the core and radio access network operators and the Service Management sub-systems. The contract drafting process can be either negotiable or non-negotiable. The negotiable process was interactive in nature where one party proposed a set of contract parameters and the other party counter-proposed modifications. This process continues until agreement is obtained or until one party withdraws from the process.

The User Manager component was required was required to prepare personalized EPGs for those end-users that were pulling the ESG from the Internet server. It consists of a tool for drafting User Contracts and establishing user profiles. Filtering of ESGs based on user profiles is performed on ESGs that are pulled over the unicast cellular radio network.

The Service Manager component was required to ensure that the quality of the interactive multimedia services. It consists of a tool for drafting Service and Network Contracts and a tool for monitoring end-to-end service quality. The end-to-end service monitor delivers an agent to certain targeted end-user terminals that simulates user behavior at regular intervals and reports on the existence of acceptable service parameters as perceived by the end-user e.g. how much time is needed to receive services via the cellular radio network pull of Web page content. A tool to record terminal profiles from terminal manufacturers was designed to facilitate the drafting of Service Contracts by establishing which terminal types to support.

VII. Potential Technical Enhancements

This section presents a discussion on how the converged service platform can be technically enhanced by increasing the functionality of the components within the sub-systems.

A. Content Creation Sub-System

The Content Creation sub-system can be enhanced by increasing the type of graphics systems that could be used to render the UI (bit map or vector graphics or both). Bit map graphics is quick and computationally cheap to render but takes much more memory space and can not be scaled so easily. Therefore it is not so suitable for downloading applications with their UI. Conversely vector graphics is slower and computationally expensive to render but requires much less memory space and is easier to scale and so is most suitable for downloading applications with their UI to a range of different terminal types. Ideally a combination of both graphics systems would allow fast rendering of fixed terminal resident UIs using bit-map graphics and low bit representations of scalable, downloadable UIs using vector graphics. However the graphics that is prepared is entirely dependent on the types of terminal supported by the service provider.

The sub-system design can be improved by improving the tools that are used to simulate the services. There are many well known commercial bit-map and vector graphics graphical design and animation packages but there are no known packages that combine the design of both vector and bit-map graphics.

Incorporating the efficient ingesting of externally generated metadata can enhance the sub-system design. Since TV program listings are already drafted for standard TV terrestrial broadcast using TV Anytime, this data can be ingested and transformed to the ESG format (off-line or in real-time) using an eXtensible Stylesheet Language Transformations (XSLT) tool. This approach can be applied more generally for example to transpose data from news agencies such as Reuters into an ESG compliant textual news service.

B. Service Creation Sub-System

In this work a linear list of terminal descriptions was generated for the terminal database within the Service Description tool. However a more intelligent classification of terminals could have been incorporated in the database depending on their degree of similarity. For example some terminals could have the same UI graphics markup language but might have completely different software and applications driving it. This intelligent database can be used to more efficiently map applications onto user interface graphical components.

The semi-automatic creation of applications considered in this study involved the manual mapping of pre-written applications onto the graphical components. A more intelligent system could be conceived where the mapping of software applications to UI graphical components is manually conducted once for a particular service on one terminal and this information is then used to conduct the corresponding mappings onto other terminal types automatically depending on their degree of similarity.

A transcoding system can be used to repurpose live MPEG-2 TV programs into low bit rate H.264 [41] TV programs. In our work we used MPEG-4 but H.264 is preferable because of its ability to compress video more efficiently thereby enabling more services to be provided. The H.264 encoder can be used with standard compliant scalability extension (SVC encoder) to avoid wasting valuable bandwidth by simulcasting. It is important that the SVC codec is used because this maintains compatibility with the H.264 coding format used in 3G mobile terminals while at the same time achieving high compression efficiency in the scalable mode thereby saving valuable transmission bandwidth.

The range of third party service providers that feed into the Service Creation sub-system can be extended to include advertisers as well as program producers. This can be achieved by developing technology to allow advertising and programs to be spliced into existing AV transmissions.

The degree of visibility that the Service Description component has of the rest of the ESG data could include some sort of visualization of the metadata that is exclusively generated by the Service Management sub-system (e.g. commercial and schedule Metadata). Furthermore this visibility could be made configurable thereby making the tool more flexible to the needs of the individual organizations using the tool.

The Service Description tool functionality can be constrained by the output of the Commerce Manager and Network Manager so that no service descriptions are generated that violate commercial and network constraints imposed on it.

The Service Description tool was designed with DVB CBMS ESG as the target schema. It is perfectly possible for the system to be designed to include OMA BCAST ESG schema because of their similarity.

C. Service Management Sub-System

Enhancements to the Service Management sub-system could include a strategy for delivering the ESG more efficiently to mobile devices. In our work the entire ESG was repeatedly delivered on FLUTE carousel. However more elegant strategies of delivering the ESG could consider: encoding the ESG would require less bits and time to transmit it; fragmenting the ESG would allow select parts of the ESG that are used more frequently to be delivered quicker over one or more FLUTE carousels; supplementing the ESG would allow ESGs that have already been delivered to be supplemented by updates quicker than if the whole ESG was re-accessed.

VIII. Conclusions

This paper has presented a system to create, deliver, manage and consume converged interactive multimedia content and services to three classes of terminals for services. This is important to the future of mobile TV because all the current trials and deployments have focused on the re-provisioning of existing terrestrial TV programs and have not included fully interactive services to a range of different terminal types. Interactive converged services are important to network operators, because they can be used to derive additional revenue from the end-user through services such as betting, voting, buying, booking etc. Both broadcast and cellular network service providers can use this system to create services that have been designed to suit how their business requirements. This work has explored what are the typical service design issues for broadcast oriented and cellular telecom converged service providers in order to meet their business objectives.

Furthermore this paper investigates the range of tools required for creating and supporting the range of interactive multimedia services and end-user mobile terminals supported by the system. From this investigation we can see that tools are required to scale the video, design different versions of the user interface, adapting the user interface for different navigation engines, designing different versions of applications, integrating metadata for creating multimedia services, creating service descriptions for scaled services, providing different ways of accessing the ESG over the network, providing personalized version of the ESG, defining the main parameters of the ESG through a negotiated contract and ensuring quality of the delivered services.

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