Towards an IP/GSE-Only Signalling Framework for DVB Transmission Systems

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Abstract. An Internet Protocol/Generic Stream Encapsulation (IP/GSE) signalling framework is proposed to replace the current MPEG-2 Transport Stream (TS) Table-based signalling system and to enable smoother convergence of Digital Video Broadcasting (DVB) transmission systems and IP networks. GSE suitability is explained and a review of IP-based signalling techniques is presented in order to select the optimal candidate methods for this architecture.

Keywords: GSE, DVB, IP signalling, MPEG-2 TS Tables.

1 Introduction

IP-based signalling procedures for content metadata currently take place in DVB networks, e.g. acquisition of an Electronic Service Guide (ESG) in a DVB-H system. However, the signalling for network metadata is still being performed through MPEG-2 encoded Tables conveyed by the TS even though the second generation of DVB systems can also support the Generic Stream (GS).

The GS is expected to be used for IP-based services, where IP packets can be encapsulated using the Generic Stream Encapsulation (GSE) protocol [1]&[2] as an adaptation layer that provides efficient IP packet encapsulation and fragmentation.

In current network signalling, two sets of MPEG-2 encoded Tables are necessary for DVB system signalling, the Program Specific Information (PSI) and the System Information (SI) defined by MPEG and DVB, respectively. Tables are segmented in Sections, directly encapsulated in TS packets and sent with high repetition rates (e.g. 25 ms) to allow fast acquisition and updating. Figure 1 shows the protocol stack for current network signalling in a generic second generation DVB system.

In the current TS-based signalling framework, the receiver, initially, filters the Tables with fixed Packet Identifier (PID) field in the TS packet header, such as the Program Access Table (PAT). Next, it extracts the PID of the Network Information Table (NIT) that contains the tuning parameters. It accesses NIT and obtains the PAT PID of the respective TS. Finally, the receiver acquires the PAT and obtains the PIDs of the Program Map Tables (PMTs) where the PIDs of the audio/video Program Elements can be found. Thus, TS signalling strongly depends on PIDs filtering.

If signalling were conveyed by GSE packets instead of TS packets, there would not be a direct equivalent to the PID filters used for TS given that GSE does not contain a

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PID field. Thus, in an IP/GSE-only signalling framework, the receiver will need to identify which BB frames or GSE packets carry the network signalling information that it requires. In addition, for the realisation of this architecture, it will also be necessary to determine the respective Network Discovery and Selection (ND&S) procedures and a new flexible signalling metadata syntax. To clarify, Service Discovery and Selection (SD&S) methods are used for content metadata (e.g. ESG) discovery whilst ND&S are defined to be used for network metadata (e.g. PAT-like records) in this paper.

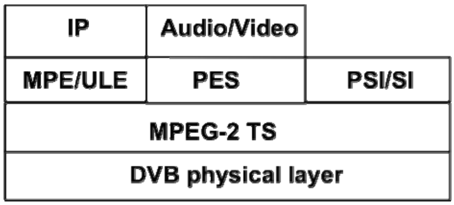

Fig. 1. Protocol stack for a generic DVB system

IP-based ND&S techniques will provide network bootstrapping and network selection in a similar manner to PAT. A new syntax with extensibility features, different from the present MPEG-2, will allow the easy modification of the signalling metadata. This network metadata is expected to experiment continuous change with the convergence of DVB and IP networks given that this union will enable DVB transmission networks to become networks functioning as a part of the Internet infrastructure. Even when the IP/GSE signalling framework intends to be DVB generic, the focus is on DVB-S2 in this paper.

This paper is divided as follows: GSE suitability for signalling is briefly examined in section 2, a review of current IP-based signalling procedures is given in section 3, the IP/GSE-only signalling framework is proposed in section 4 while section 5 concludes the paper.

2 GSE Protocol

The GSE protocol, defined in [1]&[2], provides flexible fragmentation, opposite to the fixed size of 188B TS packets, and extensibility through its extension headers. Figure 2 shows the GSE header format, the shadowed areas indicate optional fields thus the minimum header length is 4B.

The 1-bit S and E flags along with the FragID are used to indicate fragmentation. If both are set, the PDU encapsulated in the payload is not fragmented. Otherwise, the PDU is a fragment and the Total length and the Fragment ID provide the length of the PDU before fragmentation and the identification to allow re-assembly or loss detection at the receiver buffer. A CRC-32 is added to the last fragment to check the payload integrity.

The GSE length field allows encapsulation of a PDU with a length of up to 4096B, which can, potentially, improve bandwidth efficiency given that the Table Sections should not be larger than 1024B. Therefore, one 1024B-Section could be sent as the payload of a GSE packet with an overhead of 4B (plus higher-layer headers) instead of fragmenting it into 188B-TS packets. In addition, if the Table comprises several Sections, these can be sent in the same payload, as long as the size is lower or equal to 4096B, through the use of the PDU-Concat extension header [3].

S	E	LT	GSE length	Protocol Type	Frag ID	Total length	Label	Extension Headers
1b	1b	2b	12b	2B	1B	2B	3/6B	>=2B

Fig. 2. GSE header format [2]

The Protocol Type field denotes the protocol of the PDU in the payload, e.g. IPv4 or IPv6. Potentially, a new Type field can be defined to identify the GSE packets carrying network metadata signalling.

GSE extension headers [3] are envisaged to provide a range of features to GSE. Besides the PDU-Concat extension header, the TS-Concat extension could be used during the transition from the TS to the GS. So concatenated TS packets would comprise the GSE payload. A new extension header could be defined to identify network signalling. Potentially, a security model can be implemented through the use of GSE security extensions (if these are standardised).

3 IP-Based Signalling Systems

The current literature was surveyed to determine the status and deployment of GSE-only signalling systems. The only standards-related documentation found in the area of GSE-only signalling was that of the DVB TM-GBS Common Metadata Toolkit (CMT) sub-group. There was also preliminary work on a GS/address resolution in the IETF IPDVB working group [4]. This lack of work on GSE-only signalling is the result of the currently limited availability of chipsets that support a GS interface to the S2 waveform. There are not known operational systems that have use the GS, all current systems use the TS, and may, in the first stage, decide to employ signalling using the TS SI/PSI Tables.

This section provides a survey of current systems employing IP signalling in DVB and non-DVB transmission networks. It seeks to understand the different signalling mechanisms and to identify suitable candidate methods that could be used to derive an IP/GSE signalling framework.

3.1 Metadata Signalling over DVB Systems

Different approaches of IP-based signalling procedures for content, applications and services over DVB systems are described below. Particular emphasis is given to the bootstrapping mechanisms.

3.1.1 IP Datacast over DVB-Handheld (DVB-H)

DVB-H [5] is a broadcast system for the delivery of digital content and services using IP-based mechanisms for terminals with constrained computational resources and battery. It uses PSI/SI Tables to perform signalling combined with content metadata, as shown in Figure 3. A PSI/SI generator, in the broadcast network, creates DVB-H specific descriptors and MPEG-2 encoded Tables such as NIT, PAT, PMT and the IP/MAC Notification Table (INT). Some of these tables are adapted whilst others are created specifically for the system, e.g. the INT exists only in DVB-H systems to signal the availability and location of IP streams in DVB networks. A DVB-H receiver includes a PSI/SI handler that extracts and interprets the PSI/SI signalling to configure the terminal for the IP service received over DVB-H.

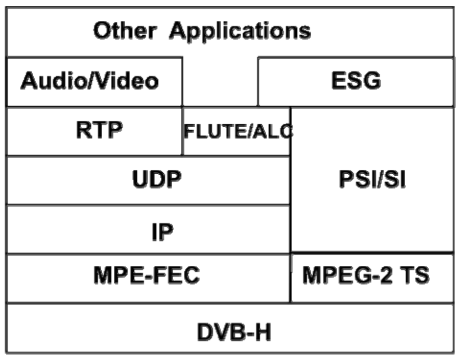

Fig. 3. DVB-H system protocol stack

A bootstrap entry point discovery can be performed using any of the following options: a preconfigured address at the receiver, a manually entered ESG bootstrap entry point information (provided out of band) and an entry point determined by terminal provisioning.

Once the network bootstrap stream is identified, the network bootstrap metadata can be received, to identify the IP platform (network service). The INT bootstrap information may be included in a SI/PSI table, e.g. the PAT or NIT tables.

The content is described using the ESG, content discovery follows the network bootstrap. The ESG bootstrap uses descriptors transported by the Asynchronous Layer Coding (ALC) using a File Delivery over Unidirectional Transport (FLUTE) session via UDP for broadcast channels or transported by HTTP over TCP for interactive channels. This specifies all the available ESGs in an IP platform. The appropriate ESG is selected using the ESG bootstrap information. The ESG content metadata describes the different IP-based services available in the handheld terminal's region.

The ESG data model is described by eXtensible Markup Language (XML) Schemas [6] that define ESG bootstrap descriptors and ESG fragments (e.g. Service, Service Bundle, Content fragment). Two compression algorithms, GNU- ZIP (GZIP) [7] and the Binary MPEG format for XML (BiM) [8] are recommended. GZIP is intended to be used for handheld terminals because of its simplicity.

XML fragments form the majority of the ESG information. However, part of the acquisition information contains Session Description Protocol (SDP) [] files that allow the end-device to locate service streams and configure service consumption applications appropriately. Once the ESG is acquired, service discovery is available through the information contained in it.

3.1.2 IP Datacast over DVB-Satellite Services to Handheld (DVB-SH)

The announcement of services and ESG delivery in DVB-SH networks for "regionalised ESGs" is described in [10]. The delivery of ESGs for DVB-SH Single Frequency Networks (SFN) is identical to that for DVB-H networks. In Multi Frequency Networks (MFNs), content regionalisation is possible therefore the ESG delivery uses additional descriptors and procedures. However, the mechanism is not changed even if, for example, there are new ESG bootstrap descriptors to indicate the local provider: information is transmitted using FLUTE sessions for broadcast channels and via HTTP for interactive channels.

As in the previous case, the bootstrap, transmission and syntax for DVB-SH refers to the content metadata while network signalling is carried in MPEG-2 PSI/SI Tables providing the information to bind PIDs with well-known IP addresses.

3.1.3 Interactive Applications and Services in Hybrid Broadcast/Broadband Environments

The DVB TM-MIS (Middleware for Interactive Services) group developed a specification, Blue Book A.137 [11], on signalling for interactive services or applications in hybrid broadcast / broadband networks. This specification builds on the work of [12]. It defines the application metadata signalling for two syntaxes, MPEG-2 and XML Document Type Definitions (DTDs) encoding, for broadcast and broadband networks (it is assumed that a return channel is in use), respectively. It is intended to define how interactive applications and services are to be announced and deployed. This should apply to any interactive application or service independent of the technology.

In a broadcast network, the receiver identifies the applications associated with a service through the MPEG-2-encoded Application Information Table (AIT) [13] whose location is retrieved from the PMT. The AIT contains application metadata such as its type, identifier, control code, priority and storage information.

In a broadband network, the SD&S procedures for DVB-IPTV described in [12] and in section 3.2.1 are followed to acquire the interactive applications through the XML-encoded AIT transported through HTTP1.1, multicast is not defined. In broadcast networks, Digital Storage Media-Command and Control (DSM-CC) [14] object carousel is used. It is also possible to signal applications using both syntaxes for hybrid broadcast/broadband networks.

3.2 Content Metadata Signalling over Non-DVB Systems

Current IP-based SD&S procedures in non-DVB transmission systems are described below.

3.2.1 Transport of MPEG-2 TS DVB Services over IP Networks

ETSI TS 102 034 [12], also known as the DVB-IPTV book, defines a framework for delivery of MPEG-2 services over bidirectional IP networks. The syntax and transmission of SI/PSI signalling is the usual MPEG-2 encoded Sections in TS packets, as shown in Figure 4, and transported by UDP/IP, which reduces the efficiency of the system.

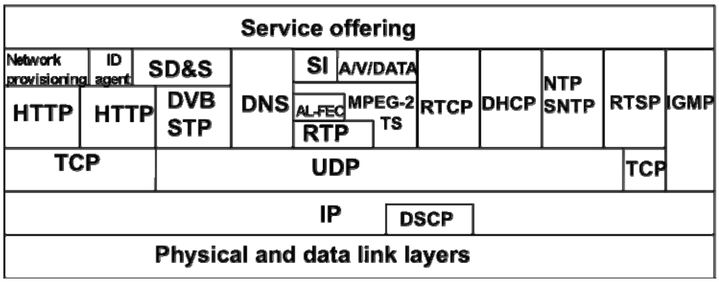

Fig. 4. Protocol stack for DVB-IP services [12]

The service discovery is defined in three steps. First, the service discovery entry points are found (bootstraping). Then, for each service discovery entry point, the service provider discovery information is acquired. Finally, for each service provider, the DVB-IP service discovery information is obtained.

Service discovery entry points can be well-known multicast addresses. Also, they can be acquired using multicast Domain Name Server Service (mDNS SRV) records [15]. In addition, SD&S entry point addresses can be obtained using an mDNS SRV record received via the Dynamic Host Configuration Protocol (DHCP) option 15. Alternatively, entry points can be given in the configuration data received on a provisioned network.

The service provider and DVB-IP service discovery information are carried in multicast and unicast modes. DVBSTP [12] is defined for the delivery of the mentioned content metadata records in multicast mode while HTTP is used for unicast.

Several types of record can be provided by the DVB-IP service discovery information (e.g. Broadcast, Content on Demand, Package). One of them, the Broadcast service discovery information presents two types of record, TS Full SI and TS Optional SI. TS Full SI provides information to create a list of available services and to find available live media broadcast services which have embedded SI, then, information on individual services is acquired from the transport stream by the usual PIDs scan. For the TS Optional SI record only PSI information, PAT and PMT, is embedded, i.e. it does not contain SI information.

XML Schemas are defined for all DVP-IP discovery information records and BiM is recommended for compression.

3.2.2 The Internet Media Guide (IMG)

The IETF MMUSIC working group defined the Internet Media Guide (IMG) framework and requirements [16]. An IMG provides “an envelope for metadata formats and session descriptions defined elsewhere with the aim of facilitating structuring, versioning, referencing, distributing and maintaining such information" [16]. Thus, the IMG methods and protocols refer to content metadata.

Existing Internet protocols and standards are proposed to be used with the IMG framework. For example, SDP is a candidate method to convey session-level parameters. Because of limitations in SDP flexibility for extensions, SDP would only be used just to carry a small subset of IMG metadata. SDP with negotiation capabilities (SDPng) could also be used, as SDP, to carry session-level parameters. However, extensions and integration with other description formats are allowed because of SDPng XML-based format.

However, there are sets of mechanisms needed to meet the requirements of IMGs. Four specific mechanisms are identified [16], 1) a multicast-unidirectional, capable announcement protocol, 2) the design of a new multicast-unidirectional protocol based on ALC/FLUTE is recommended, 3) use of existing unicast protocols for subscribe and announcement/notification, e.g. the Session Initiation Protocol (SIP), SIP events (IETF RFCs 3261 and 3265, respectively) and HTTP and 4) definition of a metadata envelope.

The metadata model should allow reusing and extending the set of metadata and enable the use of different syntaxes (e.g. SDP, MPEG-7, XML). However, these design decisions were based on the need for Internet content discovery and selection.

3.2.3 The Open IPTV Forum (OIPF)

The OIPF [17] defines a set of specifications for an end-to end platform for the deployment of IPTV services in managed and unmanaged (open Internet) networks. In managed networks, a WAN gateway may act as DHCP server and Network Address Translator (NAT) to allow communication among the Application Gateway (AG), the IP Multimedia Subsystem Gateway (IG) and the Open IPTV Terminal Function (OITF) within the residential network. In unmanaged networks, the OITF is allowed to send/receive messages from the Internet.

For managed networks, the WAN gateway assigns IP addresses to the AG, IG and OITF so the configuration information (e.g. DNS server) is obtained directly by them. In case of unmanaged networks, the WAN gateway (acting as a NAT) translates the IP address to be recognizable to the provider's addressing plan. When an OITF powers up, it should automatically discover the IG using the Universal Plug and Play (UPnP) discovery mechanism (described in section 3.2.5).

Three steps are defined to enable SD&S of IPTV services, which are based on those of DVB-IPTV described in section 3.2.1 [12]. In managed networks, the WAN gateway provides the IP address to start the IPTV service provider discovery phase. Once the entry points are found, the terminal retrieves the IPTV service provider information, which can be given as a web page or as a XML record. SIP/SDP over HTTP is used to obtain this information. Once a service provider is selected, its IPTV service information can be obtained as a web page or as a XML record (e.g. DVB-IP records). This signalling is performed over HTTP (unicast) and over DVBSTP (multicast).

In unmanaged networks, the terminal requests the IPTV service provider information using HTTP. In this case, the terminal finds the entry points by either manual, pre-configured or DHCP configuration.

SD&S metadata uses and extends the XML Schemas defined by DVB-IPTV [12]. The OIPF framework allows discovering servers via web-based applications, the extensions allow signalling these from within SD&S records.

3.2.4 Universal Plug and Play (UPnP)

The UPnP Forum [18] defines an architecture for pervasive network connectivity of intelligent devices, which supports zeroconf and automatic discovery of devices. Devices are classified as controlled devices or control points. Controlled devices function as servers, responding to requests from a control point. The steps needed for a device to use UPnP networking are: IP addressing, discovery, description, control, eventing and presentation.

Addressing is performed using standard IP methods. If the controlled device or control point does not provide a DHCP server, it must implement a DHCP client and will look for a DHCP server to obtain an IP address. If a DHCP server is not found, they implement Auto-IP, that is, intelligently choose an IP address from a set of link-local IP addresses.

Once a controlled device or control point obtained an IP address, discovery takes place. It is possible to know the appliance's (or services) UPnP type, its universally unique identifier and a URL to its description through discovery messages. Discovery allows a controlled device to advertise its services to control points and, similarly, it allows a control point to find interesting controlled devices. If a controlled device or control point are new in the network, they send multicast discovery messages. In the case of the control point, to a specific IP address on port 1900 or on a manually entered port.

Discovery messages are carried using the Simple Service Discovery Protocol (SSDP), defined by Microsoft and Hewlett-Packard [18]. It uses part of the header field format of HTTP1.1. Since SSDP is only partially based on HTTP1.1, it is carried by UDP instead of TCP.

After a controlled device has been discovered by a control point, description takes place to discover services and capabilities. These are retrieved from a URL (provided during the discovery phase). Each service included in the device contains URLs for service description, control and eventing, respectively. Each device description includes descriptions of all embedded devices and a URL for presentation of the aggregate. The descriptions are in XML syntax, thus specific Schemas have been developed for this purpose. No compression method is recommended for XML. HTTP1.1/TCP provides the transport for the description phase and the control, eventing and presentation stages.

Once the device description and its services are known, a control point may request a certain service to perform an action and, consequently, it may receive responses indicating the result of the action as well as polling for values. This is done by sending/receiving control messages, expressed in XML, to/from the control URL (previously sent in the device description) using the Simple Object Access Protocol (SOAP).

Finally, eventing and presentation take place. The control points listens to updates in variables during eventing whilst they can retrieve a presentation page during presentation by subscribing/retrieving the corresponding URLs (acquired during description phase). XML Schemas are also developed for these message sets.

UPnP requires bi-directional connectivity and it is not suitable for unidirectional network signalling. In addition, UPnP, including SSDP, are proprietary standards as compared to mDNS which is an open standard.

3.2.5 ATSC Systems

3.2.5.1 A/92 ATSC Delivery of IP Multicast Sessions over Data Broadcast. The procedures for signalling an IP multicast service over an ATSC A/90 Data Broadcast System are described in [19]. An IP multicast session is announced by SDP. The Session Announcement Protocol (SAP), defined in IETF RFC 2974, is used to encapsulate the SDP protocol in UDP datagrams.

An IP multicast receiver uses signalling metadata, i.e. Tables, to bind the IP multicast media and SDP announcement streams to specific MPEG-2 Program Elements. For this purpose, an optional descriptor listing the MAC multicast addresses where a given MPEG-2 Program Element can be found, is defined for the Data Service Table (DST).

The procedure for the acquisition of an IP Multicast service involves the Program and System Information Protocol (PSIP), MPEG and A/90 Tables. The DST contains Tap structures that are used to find Program Elements in lower layers. This Tap structure includes an *associationTag* to allow the identification of the location of the IP multicast Program Element PID. This location is obtained by matching the *associationTag* in DST with the association tag in PMT.

The location of the SDP streams is also indicated in the PMT since the SDP datagrams are encapsulated as DSM-CC addressable sections. The *deviceId* field of these addressable sections represents the SDP IP multicast address, thus the receiver filters these sections based on the value of this field. Optionally, the MAC address descriptor in the DST can be used to discover multicast addresses.

3.2.5.2 A/153 ATSC-Mobile DTV Standard. Also called the ATSC mobile/handheld (M/H) system [20], it uses a portion of the capacity of a mobile DTV link to provide mobile/pedestrian/handheld broadcasting services, while the remainder can be used for HD television. The protocol stack for the ATSC-M/H system is shown in Figure 5, where FIC stands for Fast Information Channel and provides bootstrap signalling.

The FIC channel provides a network bootstrap method that is specified outside of the normal frame payload, and hence is independent of the data channel carrying Reed-Solomon (RS) frames. It provides the binding information between the M/H services and the M/H ensembles. The M/H ensemble is a set of consecutive RS frames having the same FEC coding. Information such as the M/H ensemble ID, Tables carried by the ensemble, number of services carried by the ensemble and M/H service ID is carried by the FIC. The key result is that the receiver can access the FIC information very rapidly instead of having to decode every RS frame.

The procedure for acquiring an M/H service consists of two steps: access to the M/H ensemble and then, access to the IP level M/H service through the Service Map Table (SMT) which lists the IP address for each service.

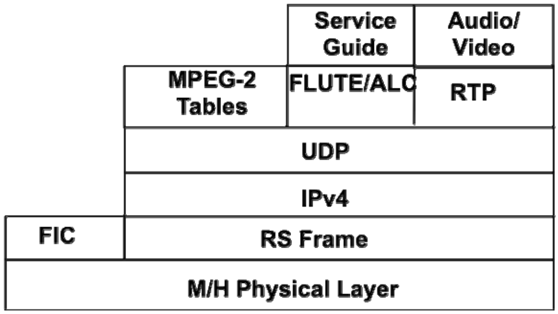

Fig. 5. Simplified protocol stack for ATSC-Mobile DTV [20]

The Service Guide for ATSC-M/H services is based on XML Schemas. SDP records are used to deliver the session descriptions using FLUTE transport. The Service Guide Delivery Descriptor (SGDD) is an XML document used by the broadcast system to describe the structure and declare the content of the Service Guide. If the Service Guide is to be available over an interactive channel, the broadcast system should advertise the whole guide (or some portions) over the interactive channel by setting an alternative access URL in the appropriate SGDD(s).

The use of a dedicated signalling channel (FIC) allows the control information to be acquired faster; however once this bootstrap is complete, the method relies on Tables conveyed by UDP over IP/RS frame. This technology is an optimisation of the physical layer to address the requirements for rapid tuning and separation of content and network signalling.

4 IP/GSE-Only Signalling Framework

The first step towards network discovery and selection is to filter signalling information at the adaptation layer, that is, to identify the GSE packets conveying signalling information. Next, IP-based network bootstrapping procedures will be performed, and finally, network selection will be carried out. It is also considered to modify the current MPEG-2 syntax of the signalling metadata to one that allows extensibility.

4.1 GSE Signalling Identification

The candidate procedures for locating signalling are identified in Table 1. The methods are listed by increasing amounts of information that would need to be parsed by a receiver joining the network. Some of these procedures may be jointly used, e.g. placement of a GSE packet with signalling information at a known position and a dedicated GSE Type field.

For candidate method 1, a specific DVB-S2 ModCod could be chosen. Method 3 is similar to the technique used in the DVB-H systems. Candidate methods 1-4 can eliminate the need for a receiver to process non-signalling BBframes. Candidate methods 1-3 require changes to DVB second generation standards but they also represent a faster acquisition of the signalling.

Table 1. Candidate methods for identification of GSE packets conveying network signaling

No.	Candidate method	Filtering level
1	Assignment of a particular physical frame format	BB frame
2	Use of fields in the BB header	BB frame
3	Alignment of signalling transmission to a time-slicing frame	BB frame
4	Placement of a GSE packet containing signalling at a known position	BB frame
5	Allocation of a dedicated GSE Type field value	GSE packet
6	Allocation of a dedicated Label/NPA	GSE packet
7	Allocation of a dedicated new Tag in the GSE header	GSE packet
8	Allocation of a dedicated IP address	IP packet
9	Allocation of a dedicated UDP port	UDP packet

Candidate methods 4-9 operate on the contents of the BBframe, method 4 exploits the flexible placement of fragments provided in GSE. Methods 5-7 operate at an equivalent level. Given GSE support for multiple label formats and the need to support multiple network services, it seems the most consistent and flexible method at this level would be to use a 2B optional Type extension header to identify network signalling. Well-known Type values will need to be specified for other protocol headers to allow correct processing by the receiver stack.

The location of signalling through the GSE Type field (method 5) can resemble the current location of signalling in the TS, e.g. a well-known Type value will carry the PAT, which will indicate the Type fields of the PMT. A well-known IP address (method 8) may be also used for the network bootstrap, as in mDNS.

It is suggested therefore to further evaluate the following techniques: assignment of a particular physical frame format for signalling (if efficient and available at the physical layer), use of fields in the BB header or PL header to indicate signalling content (if available at the physical layer), alignment of signalling transmission to a time-slicing frame (subject to analysis of cost and complexity), placement of a GSE packet containing signalling information at the start of a frame, allocation of a dedicated GSE optional 2B Type field value for all signalling PDU and allocation of a dedicated Label/NPA or IP address for signalling (possibly using multicast SRV records for bootstrap).

4.2 ND&S Procedures

In common with IP-based systems providing content discovery and selection, a two-stage approach is recommended for network discovery and selection.

Once the GSE packets carrying signalling metadata are filtered through some of the methods described in section 4.1, a bootstrap will be performed to select the appropriate network signalling information. The appropriate network signalling information can then be used to select the required network service.

A bootstrap method eliminates the need to manually enter a bootstrap entry point (e.g. configuring IP/NPA addresses out of band, or using device configuration). Instead the device only has to be configured with the logical name for the network to which it is attach.

Most procedures that were described in section 3 have been defined for bootstrapping of content metadata. However, some of these mechanisms may also be candidate methods for bootstrapping of the network information.

4.2.1 Network Bootstrapping

The format of network bootstrap information can be a Table structure (as current MPEG-2 Tables) that maps logical names to appropriate discovery entry points (as in INT) or a multicast service discovery using DNS SRV records to specify the network service discovery entry points, similar to the procedure recommended for DVB-IPTV [12]. This approach is now common in IP networks, e.g. the service discovery information is provided, by default, on the Internet Assigned Numbers Authority (IANA) registered well-known *dvbservdsc* port 3937 via TCP and UDP and on the IANA registered well-known *dvbservdisc* multicast addresses 224.0.23.14 for IPv4 and FF0X:0:0:0:0:0:0:12D for IPv6.

The bootstrap information may also need to support network topology information as that supplied by NIT. In broadcast links, this information may be sent by as a SRV record over mDNS using a well-known multicast address or as a Table directly over UDP using a well-known multicast address. For bidirectional links, a Table could be sent over SSDP/UDP or a SRV record can be transmitted over mDNS or over DHCP option 15. However, the use of SSDP is not recommended since it is a proprietary standard.

4.2.2 Transmission of Network Signalling Metadata

The candidate methods in Table 2, reviewed in section 3, can be considered for transport of content metadata for multicast and unicast delivery.

From all the candidates listed in Table 2, DVBSTP [12] was specifically defined for content metadata delivery in architectures compliant with DVB-IPTV and OIPF [12]&[17]. DVBSTP is used for delivery of SD&S XML records over IP multicast systems. It defines the type of payload carried through its Payload ID field (e.g. Content on Demand, Broadcast discovery information) as well as the type of compression encoding, if any, indicated by the Compression field. Its header would add an overhead of at least 12B per Section. Even though DVBSTP may be able to provide signalling identification though its Payload ID field, a receiver would need to process all GSE packets in order to retrieve the signalling packets since the signalling identifier would be in the header of DVBSTP at the transport layer level.

Table 2. Candidate methods for transport of network signalling metadata

Candidate method	Mode
DVBSTP/UDP	Multicast
ALC/FLUTE/UDP	Multicast
SDP/ALC/FLUTE/UDP	Multicast
SSDP/HTTP/UDP	Multicast
SDP/SAP/UDP	Multicast
HTTP/TCP	Unicast
SIP/SDP/HTTP/TCP	Unicast
SOAP/HTTP/TCP	Unicast

Since the requirements of the network signalling metadata are different from those of the content metadata, the transport protocols listed above may not be suitable. For example, DVBSTP and TCP add an overhead of at least 12B and 20B, respectively, and provide reliability, which is not needed for network signalling given its high repetition rates. DVBSTP indicates the type of XML-record carried and the type of compression used. These two features are desirable for the transport protocol that will be carrying the signalling metadata. In addition, a field to indicate if payload encryption is used should be also considered. Thus, the development of a new lightweight transport protocol providing the features above mentioned and a small overhead (1 or 2 B) will be analysed.

4.3 Syntax of Network Signalling Metadata

It is desirable that the network signalling metadata present a more extensible syntax than that of MPEG-2. SDP, SDPng and XML have been identified as candidate methods for network signalling metadata.

SDP is only a format for session description without flexibility while SDPng could be an optimal syntax given that it allows XML DTDs and Schemas as extensions. However, SDPng work was abandoned so specifications were not defined.

XML DTDs and Schemas are commonly used for content metadata in current DVB systems (section 3). XML is a verbose syntax however compression algorithms have been developed with satisfactory results. In [21], XML Schemas were specifically developed for PSI/SI Sections, BiM and GZIP algorithms were implemented and their compression rates compared. Then, they are sent over DVBSTP via UDP/IP. Two sets of DVB-S and DVB-T signalling streams were captured to validate this analysis. The comparison considered three cases: **1)** Sections are compressed with GZIP, **2)** Sections are converted to XML and compressed with GZIP and **3)** Sections are converted to XML and compressed with BiM. The dictionary-based compression approach of BiM was able to offer significant benefit by exploiting knowledge of the syntax of the XML information.

The key advantages of XML are that it represents information in a human readable format, is easy to extend, and can use comments to document a configuration. BiM provides a good compression rate, although future transports may need to also consider newer methods that are also emerging, which could offer further improvements in performance. An XML approach seems attractive for an IP-only solution.

4.4 IP/GSE-Only Signalling Framework

Figure 6 shows the potential protocol stack for the IP/GSE-only signalling architecture. Once a receiver is turned on, it should be able to identify the GS conveying signalling metadata (the bootstrap) and configure an appropriate filter to receive this traffic (preferably without incurring the cost of reading all GS packets in the BBframe), through one of the mechanisms given in section 4.1. This may also require a method to efficiently identify this signalling flow within the multiplex.

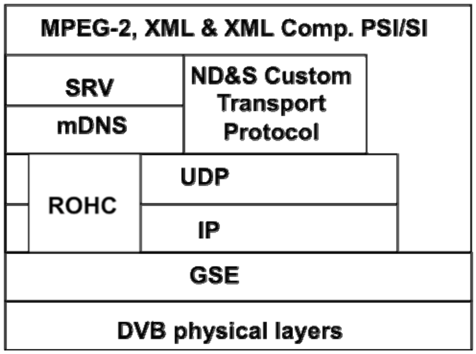

Fig. 6. Prospective protocol stack for the IP/GSE-only signalling framework

Once the bootstrap filter is configured, the receiver will extract the bootstrap information, containing the basic signalling information, to allow network discovery and selection (e.g. using mDNS). The SRV records may replace PAT function. That is, PIDs could be substituted by IP addresses and UDP ports from which the (possibly XML-based) NIT-like information and, consequently, the tuning parameters can be obtained. Similarly, IP addresses and UDP ports could replace the PIDs of the MPEG-2 Program Elements and PAT. This data could be directly encapsulated into GSE or IP encapsulated. The end result will be the signalling metadata of the required network. A preferred method will be identified.

Network discovery requires the receiver to filter a specific signalling stream that identifies a network service and defines how to provide address resolution to the specific services being offered (e.g. to bootstrap an ESG). The signalling metadata will use a transport protocol, linked to the chosen procedure to implement network discovery. The prospect of a new lightweight transport protocol for signalling metadata will be analysed further. This protocol should provide means to identify the payload, to indicate the type of compression and if encryption is present.

A signalling format based on XML Schemas seems attractive. This will allow easily extension of this metadata according to the specific system physical layer, e.g. new descriptors for emerging systems. Since, XML is a verbose syntax, compression should be applied through BiM and GZIP. New compression algorithms need to be evaluated, e.g. Efficient XML Interchange (EXI). Also, hybrid systems using both syntaxes, MPEG-2 and XML, should be considered, as in [11] (section 3.1.3).

A separate set of content SRV records, which indicate the IP addresses and ports providing certain services using existing IP-based mechanisms can also be developed (e.g. acquisition of ESG-like information).

RTP with an extension header containing a Network Time Protocol (NTP) timestamp or RTCP carrying NTP and RTP timestamps may be used for synchronisation of the system, as suggested in [21].

Methods to further reduce the signalling capacity requirements will be studied. GSE may use PDU-Concat to improve encapsulation overhead. Signalling information with the same repetition rates may be bundled into one larger signalling block. This may improve compression rates. The use of header compression, e.g. Robust

Header Compression (ROHC), defined in IETF RFC 4815, on UDP and IP headers will be also analysed to identify compression gains.

5 Conclusions and Future Work

Since current DVB transmission systems still perform network signalling through MPEG-2 TS packets, this paper presents a proposal for an IP/GSE-only signalling framework to replace it. This architecture would allow DVB systems to converge with IP networks in a smoother manner. Thus, DVB systems will become part of the Internet and will be able to provide traditional IP network services.

GSE suitability for DVB network signalling was explained. Current IP-based procedures for SD&S in DVB and non-DVB networks were examined in order to identify candidate methods for the IP/GSE signalling framework. Importantly, a range of techniques for identification of GSE packets, conveying network signalling, was also proposed.

As future work, each of the methods proposed to identify signalling at the physical and GSE layer will be analysed in depth. GSE security header extensions will be also further studied. MPEG-2 PSI/SI Tables will be captured and translated into XML Schemas. The performance of compression algorithms, such as BiM or EXI, on this XML data will be evaluated. The DVB system efficiency with these XML-based Tables will be analytically calculated considering the use of GSE PDU-Concat extensions and IP/UDP header compression.

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References

1. Cantillo, J., Collini-Nocker, B., De Bie, U., Del Rio, O., Fairhurst, G., Jahn, A., Rinaldo, R.: GSE: A Flexible, yet Efficient, Encapsulation for IP over DVB-S2 Continuous Generic Streams. Int. J. Satellite Comms. Net. 26, 231–250 (2008)
2. ETSI TS 102 606: Digital Video Broadcasting (DVB); Generic Stream Encapsulation (GSE) Protocol (2007)
3. Fairhurst, G., Collini-Nocker, B.: Extension Formats for Unidirectional Lightweight Encapsulation (ULE) and the Generic Stream Encapsulation (GSE). IETF RFC 5163 (2008)
4. Fairhurst, G., Montpetit, M.-J.: Address Resolution Mechanisms for IP Datagrams over MPEG-2 Networks. IETF RFC 4947 (2007)
5. ETSI TS 102 469: Digital Video Broadcasting (DVB); IP Datacast over DVB-H: Architecture (2006)
6. World Wide Web Consortium (W3C), Extensible Markup Language (XML) 1.0, 5th edn., http://www.w3.org/TR/REC-xml/REC-xml-20081126.xml
7. Deutsh, P.: GZIP file format specification version 4.3, IETF RFC 1952 (1996)
8. ISO/IEC 23001-1 (MPEG-B): Information Technology – MPEG Systems Technologies – Binary MPEG format for XML

9. Handley, M., Jacobson, V., Perkins, C.: SDP, Session Description Protocol, IETF RFC 4566 (2006)
10. ETSI TS 102 592-2: Digital Video Broadcasting (DVB); IP Datacast: Electronic Service Guide (ESG) Implementation Guidelines; Part 2: IP Datacast over DVB-SH (2009)
11. DVB Document A137: Signalling and carriage of interactive applications and services in hybrid broadcast/broadband environments (2009)
12. ETSI TS 102 034: Digital Video Broadcasting (DVB); Transport of MPEG-2 TS Based DVB Services over IP Based Networks (2007)
13. ETSI TS 101 812: Digital Video Broadcasting (DVB); Multimedia Home Platform (MHP) Specification 1.0.3 (2006)
14. ISO/IEC 13818-6: Information technology – Generic coding of moving pictures and associated audio information – Part 6: Extensions for DSM-CC (1998)
15. Gulbrandsen, A., Vixie, P., Esibov, L.: A DNS RR for specifying the location of services (DNS SRV), RFC 2782 (2000)
16. Nomura, Y., Walsh, R., Luoma, J.-P., Asaeda, H., Schulzrinne, H.: A Framework for the Usage of Internet Media Guides (IMGs), IETF RFC 4435 (2006)
17. Open IPTV Forum, `http://www.openiptvforum.org`
18. UPnP Forum, `http://www.upnp.org`
19. ATSC Standard: Delivery of IP Multicast Sessions over ATSC Data Broadcast, A/92 (2002)
20. ATSC Standard: ATSC-Mobile DTV Standard, Part 1-ATSC Mobile Digital Television System (A/153 Part 1: 2009) (2009)
21. Foellscher, H.: Transmission of Media Content on IP-based Digital Broadcast Platforms, Institute for Communications Technology, Technical University of Braunschweig, Dissertation (2007)