A Proposal for Media Component Brokerage

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Abstract

This paper describes how MPEG-4 *object based video* (obv) can be used to allow selected objects to be inserted into the play-out stream to a specific user based on a profile derived for that user. The application scenario described here is for personalized product placement, and considers the value of this application in the current and evolving commercial media distribution market given the huge emphasis media distributors are currently placing on targeted advertising. This level of application of video content requires a sophisticated content description and metadata system (*e.g.*, MPEG-7). The scenario considers the requirement for global libraries to provide the objects to be inserted into the streams. The paper then considers the commercial trading of objects between the libraries, video service providers, advertising agencies and other parties involved in the service. Consequently a brokerage of video objects is proposed based on negotiation and trading using intelligent agents representing the various parties.
The proposed Media Brokerage Platform is a multi-agent system structured in two layers. In the top layer, there is a collection of coarse grain agents representing the real world players – the providers and deliverers of media contents and the market regulator profiler – and, in the bottom layer, there is a set of finer grain agents constituting the marketplace – the delegate agents and the market agent. For knowledge representation (domain, strategic and negotiation protocols) we propose a Semantic Web approach based on ontologies. The media components contents should be represented in MPEG-7 and the metadata describing the objects to be traded should follow a specific ontology. The top layer content providers and deliverers are modelled by intelligent autonomous agents that express their will to transact – buy or sell – media components by registering at a service registry. The market regulator profiler creates, according to the selected profile, a market agent,

which, in turn, checks the service registry for potential trading partners for a given component and invites them for the marketplace. The subsequent negotiation and actual transaction is performed by delegate agents in accordance with their profiles and the predefined rules of the market.

Keywords: *intelligent agent, brokerage, multi-agent systems, interactive TV, MPEG-4, MPEG-7, OWL ontology, metadata, user profile, video on demand.*

1 Interchangeable Video Objects

Apart from more efficient video compression, MPEG-4 is specified to offer object based media components representing 2D and 3D graphics, audio and video (*e.g.*, sprites) [1]. Media objects are compressed and coded into the play-out file for transmission to the user, and for commercial media distribution the MPEG-4 file is served as part of a Video on Demand (VOD) service operator's network (see Diagram 1).

Media objects can be assigned characteristics to potentially allow interaction, for example, allowing end-users to click on objects and link to services (*e.g.*, web sites) external to the presentation. In this paper we propose that this interactivity also allows personalisation of TV services.

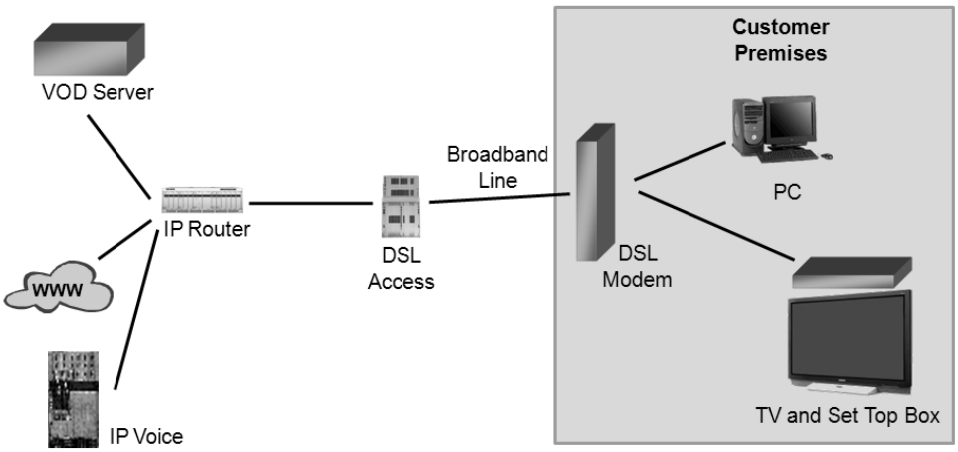

Diagram 1 – A simplified media distribution network: A Telco broadband implementation with Video on Demand is shown here (Cable TV is similar).

For MPEG-4 to be utilised in this manner, content needs to be authored specifically for the processing of media objects. End-user clients (PC clients, Set Top Boxes) need to support object processing, *e.g.*, decoding and rendering needs to be supported in advanced codecs. However these developments will occur as a matter of course and are not limited to the proposals in this paper.

As object-based media increasingly inhabits the content market, there will be a requirement for such objects to be catalogued, indexed and managed. Content is

tagged with metadata as a matter of course. Media objects will require additional information as description and interaction becomes more sophisticated. For example, projectiles may be tagged with their position coordinates in time, and users can search and locate these objects in a programme. MPEG-7 [2] is specified for this type of content tagging.

2 Technical Scenario – Traded Media Components

If media objects are to be utilised in this manner, we can consider the evolution of a more sophisticated and complex media market. In MPEG-4 object-based video, objects are defined, and their position in the video stream is defined within a *scene graph* [3]. This raises the possibility that objects authored for one presentation may be utilised in another. Alternatively objects may be defined externally to video capture and coding, and then imported into predefined positions given by the scene graph. These positions are specifically reserved for imported objects as part of the authoring process. The selection of imported objects for specific positions allows for personalisation of the programme content allowing a range of applications discussed in this paper.

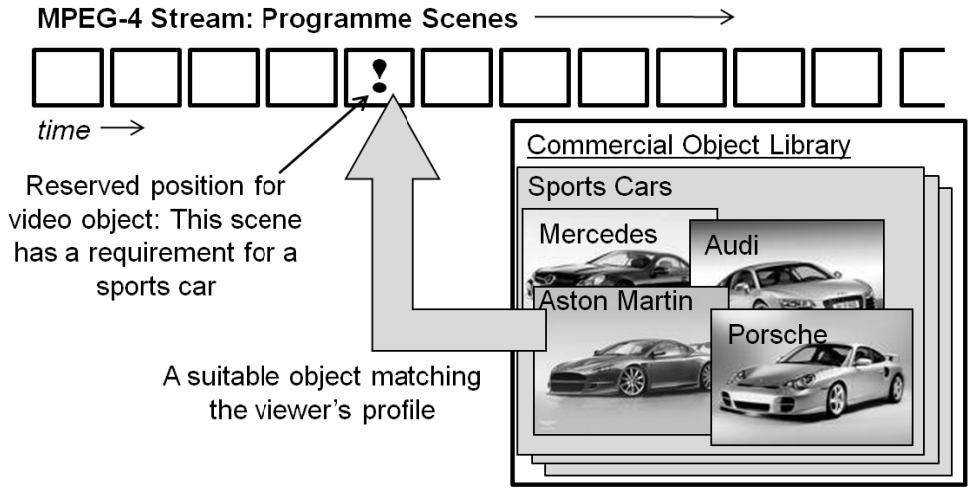

Diagram 2 – Objects can be acquired from a library and inserted into the programme

Diagram 2 offers a simplified explanation of the process and shows a series of scenes for a video programme. Reserved slots are defined for external objects to be imported into the stream. Objects may be sourced from libraries of objects available trading. In this example the objects are supplied from an external library.
In this scenario there is a requirement for a sports car to be placed in to the scene. In a search for a suitable "sports car" video object, the library has a suitable match, so the object is selected and imported into the programme stream. The suitability

of the match depends largely on the profile and personal preferences known of the viewer.
The scenario is now extended: The viewer of the programme has a profile known to the service operator which is likely to be based on previous viewing history, *etc*. This profile determines exactly which object is to be selected from a range of possible libraries. This activity would likely take place in a commercial environment in which the objects are traded (possibly in near-real time) from a library which provides the suitable object for an agreed contract and associated service level agreements.

2.1 Networked Libraries and Brokerage

In this scenario it is possible that the object could be selected from a trawl of a number of libraries. Content metadata is required to describe (*i*) the objects available in the libraries and (*ii*) the requirements of the video stream requesting the object. It is also likely that there is a commercial value attached to the objects, depending on the type of interactive service being offered. For example, if the video stream requires an object for an interactive service requested by the user, the object may attract a contractual usage fee; i.e. an entertainment agency is paid for the usage. However, if the service is to place an object into the video stream for the purpose of advertising to the viewer, then there is a value to an agency (*e.g.*, an advertising agency) in placing the object into the stream. Consequently, there is a two-way negotiation involved in the acquisition and usage of an object from a library.
The scenario considered in this paper is for personalized product placement, since this is likely to be a high-growth market in the next few years. There are many other scenarios including:

- Personalized video for training and information
- Replacement of objects depending on the cultural traditions of the viewer audience, for example the removal of alcoholic content from a video scene.

Libraries would therefore be populated with video objects uploaded by content producers, advertising agencies, *etc*. The objects carry play-out rights to be negotiated as they are required.

3 Service Scenario – Personalised Product Placement

Targeted advertising is now one of the main investment areas for commercial TV distributors. For example, *Packet Vision* provides technology for targeted advertising in IPTV based on end-user profiles. They claim “The average increase in the value of a targeted ad spot is at least 50 %” [4]. They also claim a better end-user experience (because it is more relevant).
However it is likely that advertisements will become increasingly personalised, sophisticated, and will find their way into the main programme content. Personalised product placement is a consequence of this. For example, at an appropriate position in the programme a media object (specifically selected based

on the end-user profile) is acquired following negotiation for contractual usage fees and integrated into the content.
It is significant to note that product placement has been under great debate. Recently the UK regulatory body Ofcom has withdrawn restrictions on product placement, and the practice is set to continue. One of the driving forces is the requirement to fund the large growth in TV channels.
Whilst the majority of TV delivery is via satellite, cable and terrestrial TV, Telecommunications operators (Telcos) are moving into the TV delivery market to maintain the revenue growth of their broadband installations. This has resulted in the growth of Internet Protocol TV (IPTV) in the Telco market. This is now driving cable TV providers towards an all IP platform including their own IPTV service [5], [6]. The advantage of all-IP platforms is the integration of all user services (including web browsing and voice services). This allows user data to be collected and processed, and also allows user profiling. The next growth area for TV delivery is increasingly personalised services. Targeted advertising is currently an area of massive investment.

4 Integration of Objects into the Programme Stream

Diagram 3 shows the potential method for integrating acquired objects into a play-out content stream.

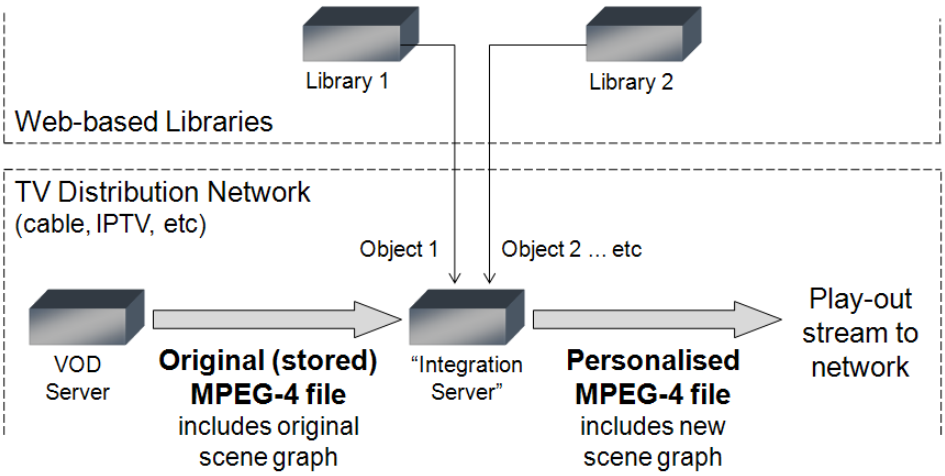

Diagram 3 - Possible method of integrating objects into personalised play-out stream

The VOD server hosts the source video which contains the original scene graph stating the position and details of reserved spaces into which objects may be imported. The file is passed to an *integration server* where the final play-out stream is constructed. At this point the imported objects are integrated into the file and the scene graph is updated with details of the inserted objects ready for

transmission to the viewer. The MPEG-4 file consisting of object planes, objects, scene graph, *etc*. is multiplexed and streamed to the viewer.
At the viewer's equipment (*i.e.*, PC, set top box, *etc*.) the streamed file is demultiplexed. At this stage there is a requirement for the codec to process the object-based video.
The objects are acquired via a brokerage process in which the various parties negotiate for fees and contractual details for usage of the objects. For example, the objects are the property of an advertising agency that is using the services of the libraries to store and publish the availability of the objects. When a file is requested by a viewer the integration server searches the libraries for suitable matches for the reserved object spaces in the file. This search is qualified with details known about the end user from the user's profile. Advertising agencies bid for the right to supply their product objects into the stream. In this proposal a brokerage process implemented via intelligent software agents is advocated, and the brokerage model is described in the next section.

5 Media Brokerage Modelling

The real world scenario is made of companies which are prospective buyers or sellers of media components. However, the simple existence of buyers and sellers does not generate *per se* a market – it is necessary to commit to a set of rules, define a meeting place, a timetable and invite the participants. Since this is an intrinsically distributed, dynamic and open scenario, we propose a multi-agent architecture with two classes of agents: agents that represent the real world actors – the buyers, sellers and the market regulator – and the actual trading agents which will go into the market on behalf of their owners – the delegate/proxy agents. Since the market itself may be governed by distinct approaches such as direct trading (cooperative or competitive), auctions or bargaining, it will be also represent by a delegate agent.
Our approach is to create a virtual marketplace where these entities or their delegates meet and fulfil their goals according to the selected rules of the market. The companies are modelled as autonomous intelligent agents – enterprise agents – driven by their own profile, which includes identification, goals to achieve – buy or sell specific multimedia components – and strategies. The characteristics of the market are configurable via a market profiler agent.
The virtual place where the transactions take place is herein called the Market and includes the market agent – a delegate created by the market profiler agent – and a service registry. The market agent acts not only as a regulator – defining the type of market and ensuring that the selected rules are followed – but also as an organizer, inviting to the marketplace all relevant agents registered in the service registry that wish to sell or buy a specific media component.
The enterprise agents, once deployed, register their goals in the market registry service and wait to be summoned by the market agent to the marketplace. The market agent periodically inspects the service registry looking for potential buyer

and seller candidates for listed media components and, if it discovers suitable candidates, invites them to the marketplace.
Each invoked enterprise agent creates and dispatches a delegate agent with a specific role – buy or sell a media component – to the marketplace, resulting in the spawning of a collection of transaction (buyer or seller) agents in the marketplace for each identified item.
Once the final buyer-seller pair for each media component is found, the delegate agents involved in the round report back to the enterprise agents, the market service registry is updated and the delegate transaction agents are destroyed.

5.1 Knowledge Representation

We decided to adopt an ontology-based knowledge representation for domain, social and strategic knowledge. In the context of computer and information sciences, an ontology defines a set of representational primitives with which to model a domain of knowledge or discourse. The representational primitives are typically classes (or sets), attributes (or properties), and relationships (or relations among class members). The definitions of the representational primitives include information about their meaning and constraints on their logically consistent application [15]. Ontologies allow agents both from within and outside a system to have a common understanding of information used in the system and promote interoperability between systems [13].
In this project we decided to adopt Ontology Web Language[i] (OWL) as the knowledge representation language of all ontologies used within the platform.

5.1.1 Representation of the Media Components

MPEG-7 is an ISO/IEC standard developed by MPEG (Moving Picture Experts Group) for describing the multimedia content data that supports some degree of interpretation of the information meaning, which can be passed onto, or accessed by, a device or a computer code [16]. The MPEG-7 standard, formally named "Multimedia Content Description Interface", provides a rich set of audiovisual Description Tools (Descriptors and Description Schemes) and a Description Definition Language (DDL) that can be used to create the metadata for multimedia documents and can be the basis for applications enabling search, filtering, browsing and retrieval of multimedia content [17]. The standard allows the description of the content of a video/audio stream both in general terms (creation, terms of usage, storage, *etc*.) and in detail (colour, texture, sound timbre, *etc*.). A key feature is content interpretation through annotation: it is possible to represent the structural, spatial, temporal and spatiotemporal relationships between scenes or regions, motion tracking and the identification of the objects within a scene and their interaction. Finally, the user preferences, summaries, usage history, *etc*. are additional features that may be stored when using MPEG-7.
One of the advantages of MPEG-7 is that it allows the association of descriptors with any media segment, diverse levels of granularity and using different

abstraction levels. However, this feature may also lead to a higher complexity and ambiguity of the media components descriptions. In order to overcome this drawback and still describe the media components using MPEG-7, we decided to use a MPEG-7 ontology which provides the necessary semantics to the components descriptions.
We found four OWL MPEG-7 based multimedia ontologies that cover the different features of the MPEG-7 format: Hunter Ontology, DS-MIRF Ontology, Rhizomik Ontology and COMM [18].

5.1.2 Market-based System

Markets are an organizational paradigm used in multi-agent systems. The marketplace is populated with buyers and sellers striving to maximize their individual utility [22], resulting typically in a competitive multi-agent system. Agents may provide items to be sold as well as request or place bids for items, such as shared resources, tasks, services or goods [21]. Mediators such as auctioneers are used to process the bids and determine the winner.
According to [22], markets excel at the processes of allocation and pricing and, as such, the marketplace paradigm can be viewed as a general programming methodology that efficiently addresses multicommodity flow and resource allocation problems. The concept has been applied to several domains such as electronic commerce, transportation logistics, scheduling, product design, manufacturing control systems, reconfiguration of shipboard power systems, multirobot coordination, formation of virtual organizations, optimization of query processing, travel-shopping, distributed information services, *etc*.
Furthermore, in 1999 [23] proposed a competition called the Trading Agents Competition (TAC) to promote the research in the field and provide a concrete setup to compare and evaluate different approaches and methodologies. Nowadays, TAC constitutes a unique forum to test new ideas and communicate research results and includes three different tournaments (supply-chain management, advertisement auctions and market-based control).

5.1.3 Negotiation

The *rules of encounter* depend on the selected negotiation protocols: auctions, contract net, game theory, bargaining, argumentation, *etc.* A negotiation protocol specifies the allowed types of participants (*e.g*., the negotiators and relevant third parties), the negotiation states (*e.g*., accepting/rejecting bids, negotiation open/closed), the events that cause state transitions (*e.g*., no more bidders, bid accepted), and the valid actions of the participants in particular states (*e.g*., which can be sent by whom, to whom and at when) [10].
The negotiation shall be conducted according to a set of allowed operations and based on the relevant negotiation dimensions: a single characteristic, *e.g*., price, or multiple features, *e.g*., price, quantity, delivery time, *etc.* When the content of an offer is fixed (non-negotiable), the negotiation is reduced to the acceptance or

rejection of offers. Alternatively, when offers are negotiable, counter-proposals will be generated, changing the values of the relevant features. The agents will analyse the offers and decide according to their individual goals. The complexity of a negotiation model depends on the protocol adopted, the relevant negotiation dimensions and the set of allowed operations.

5.1.4 Auctions

An auction is a market in which buyers and sellers gather to do business through announced bids and asked prices[ii]. There are single and double-sided auctions. In single-sided auctions, such as supply or demand auctions, several bids are made regarding a single item (good or service). In a supply (or reverse) auction, several sellers compete to sell a good or service and in a demand (or forward) auction, multiple buyers compete to obtain a good or service. In a double-side auction, several buyers bid goods from multiple sellers simultaneously. This means that, depending on the type of auction, there are rules that specify which bidders are authorized to make which types of bids [11], *e.g.*, in a classic English auction only the designated seller can place a sell offer (which determines the reserve price).

Auctions can also be classified as open or closed, depending on how the bids are placed. Whereas in an open auction participants may repeatedly bid and are aware of each other's previous bids in a closed auction buyers and/or sellers submit sealed bids.

Finally, auctions may differ as to the price at which the item is sold, whether the first (best) price, the second price, the first unique price or some other. Auctions may set a reservation price which is the least/maximum acceptable price for which a good may be sold/bought[iii].

The standard types of forward auctions are: (*i*) the English auction which is an open ascending price auction; (*ii*) the Dutch auction, which is an open descending price auction; (*iii*) the Sealed First-Price auction, which is a first-price sealed-bid auction (FPSB); and (*iv*) the Vickrey auction, which is a sealed-bid second-price auction.

5.1.5 Contract Net Protocol

The Contract Net protocol was first proposed in 1980 by Smith [12] as a high-level protocol for communication among the nodes in a distributed problem solver.

Since 2002, the Foundation for Intelligent Physical Agents (FIPA) defined the FIPA Contract Net Interaction Protocol Specification, a standard that includes only minor changes to the original Contract Net protocol proposal. This standard belongs to the group of FIPA specifications for interoperable intelligent multi-agent systems [9].

This standard protocol specifies that in any negotiation there is an initiator agent that calls for proposals from other agents by stating all relevant conditions regarding a required task, good or service. The agents addressed by the call –the prospective business partners – answer by sending their proposals containing the

preconditions they stipulate or simply refuse to propose. Once the deadline passes, the initiator evaluates the proposals and selects the agent(s) to perform the task or deliver the good or service.
To avoid deadlocks there are fail-safe mechanisms included in the protocol.

6 Multi-agent Brokerage Platform

The transactions platform is a competitive multi-agent system where vendors, clients and market regulator meet in order to fulfil their individual goals: trade multimedia components according to their profiles and the rules of the market. The overall platform is structured in two layers (see Diagram 4).
In the top layer, we have a collection of coarse grain agents representing the real world players – the enterprise agents and market profiler agent – and, in the bottom layer, we have a set of finer grain agents constituting the marketplace – the delegate transaction agents and the market agent.

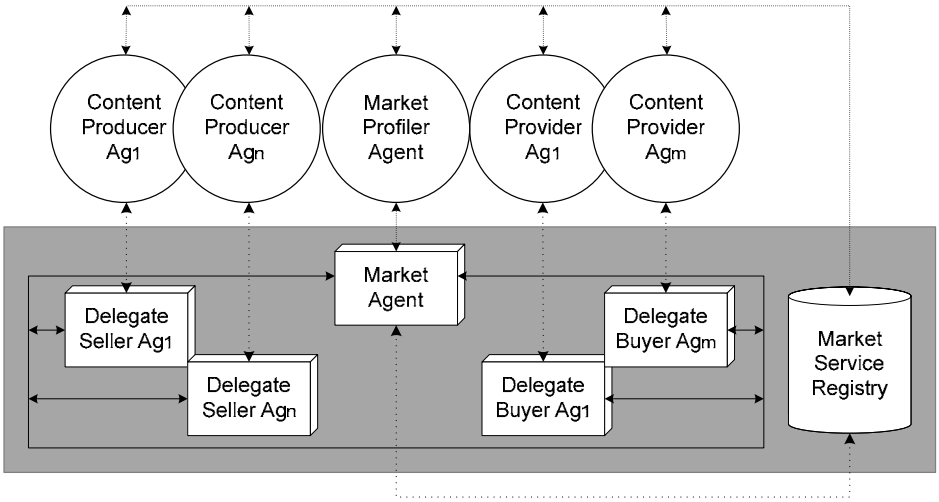

Diagram 4 - Architecture of the Media Brokerage Platform

The top layer agents are autonomous agents with domain knowledge represented by one or more ontologies and strategic knowledge for trading, which is externally loaded as a profile. The designated profile (strategic knowledge) is loaded from a server/file.
The enterprise agents should exhibit a Web Services type of interface to allow the creation of loosely coupled enterprise agents that can enter and leave freely the proposed transaction environment (see Diagram 5). The Web Services approach was designed to promote the interoperability between applications and organizations, namely in the B2B domain. It is supported by a set of eXtensible Markup Language (XML) vocabularies – the Web Service Description Language (WSDL) and the Simple Object Access Protocol (SOAP) – and a specification for Universal Description, Discovery and Integration (UDDI) of services. A WSDL

file is a XML document that contains all the information required for a client to interact successfully with the described service. SOAP is a light information protocol used to exchange messages between distributed and decentralised components over the selected underlying communication protocol (HTTP, SMNP, FTP, *etc*.). The UDDI specification, which defines a data model and registry for Web Services descriptions, ensures that, on one hand, a service provider can publish, update and remove a service description and, on the other hand, a service consumer can discover, download and interact with a service, automatically.

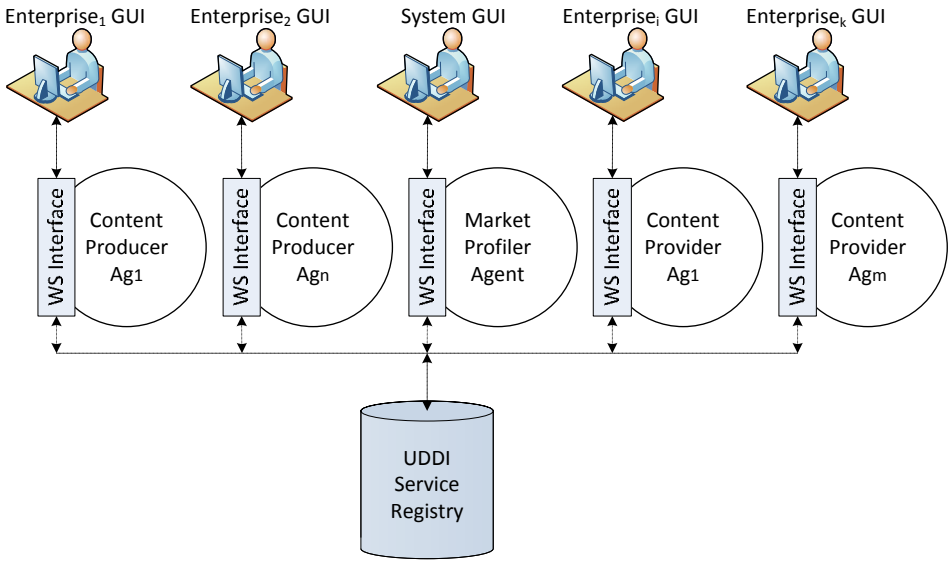

Diagram 5 – First layer architecture

The seller agents, also known as library agents, express their will to participate/enter the market by registering in the platform's service registry the main characteristics of the media components they intend to sell. The buyer agents, also referred as end-user agents, express their will to participate/enter the market by registering the main characteristics of the media components/objects they wish to buy.

The launching of a marketplace occurs whenever the market profiler creates a delegate market agent. This market agent will continuously monitor the list of offered and required media components and, whenever it identifies new trading opportunities, it invites the involved entity agents to send delegate agents into the market. The entity agents, after being informed by the market agent of a trading opportunity, can launch a market delegate agent with a specific trading profile and the relevant subset of the domain knowledge. Once on the marketplace, the delegate agents will conduct the trading according their individual strategic profiles and to the active market approach. Upon the successful/unsuccessful trading of each media component, the delegates report back their results to the corresponding

entity agents that update the list of components they are offering/requiring on the service registry. Finally, the entity agents instruct their delegates to terminate and abandon the marketplace.
This registration, invitation, trading, updating and termination loop will run for as long as the market identifies trading opportunities, resulting in an open, dynamic multi-agent trading platform, where several experiments can be conducted, such as the evaluation of the impact of distinct entity agent profiles and different market approaches.

6.1 Current Work

Our current work is focussed in the development of the bottom layer and in the media component metadata representation.
The market multi-agent system is being developed in Java Agent DEvelopment Framework (JADE) [7] which is a software framework to develop agent-based applications in compliance with the FIPA specifications for interoperable intelligent multi-agent systems [9].
The multi-agent system itself, *i.e.*, the different type of agents, their profiles, actions and relationships are represented by an ontology. This ontology is an OWL ontology created in Protégé [8] using Protégé Bean Generator plug-in which can be used to generate FIPA/JADE compliant OWL ontologies [20]. The media components are, as we previously referred, represented using an MPEG-7 based OWL ontology and the agents rely on an automated negotiation approach based on the declarative and explicit representation of the negotiation mechanism – an ontology – as proposed by [19] to choose the negation protocol that suits the current type of market.
As a result, we intend to implement several negotiation protocols (types of markets) such as Contract Net and auctions to negotiate media components under several dimensions such price, resolution, delivery time, *etc*. The specification of diverse agent profiles will allow us to study and compare their behaviours in the marketplace.
We defined that the enterprise agents will adopt a RPC style Web Services interface. This interface will be used by the enterprises to define new trading intentions and profiles for their respective enterprise agents, the market agent to summon new delegate agents to the marketplace and the delegate agents to report back the trading results.

7 Conclusions

The proposed scenario is complex e-commerce domain that is emerging from the increasing personalization in media content delivery. There are a number of issues which need to be approached in the realisation of the interactive personalised services proposed in this paper, including codecs to support object-based video and video headend equipment to support the object insertion. Content producers will also require intuitive authoring and editing tools to manipulate programme material

and stipulate the conditions for which external objects may be imported into their creative output. The proposal given in this paper allows a scalable market model to cover the global media industry across the full range of TV distribution methods including cable, satellite and telco IPTV. Whilst Digital Video Broadcast (DVB) distributions are also capable of supporting the proposed services, the proposal is mainly aimed at IPTV platforms where the user profiles can be more easily modelled.

We rely on existing standards such as Web Services interfaces, MPEG-4 for media encoding, MPEG-7 based OWL ontology for content description and standard negotiation protocols. The design concept is modular and open and the languages and technologies selected are all open source and Java based. Furthermore, the adoption of a Semantic Web (ontology-based) approach for the knowledge representation intends to contribute to promote the interoperability with other systems and to allow future expansions.

The goals of Media Brokerage Platform under development are: (*i*) to prove the concept; (*ii*) to become a test bed where experiments can be conducted (with different types of markets and diverse agent behaviours) and their results analyzed; and (*iii*) to motivate and attract academic and industrial partners to participate in the project.

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