

System for Automatic Audio Video Service Creation for Mobile TV and Mobile Web Applications

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ABSTRACT

This paper describes an innovative prototype system created to build up multimedia services addressed to mobile users, starting from automatically retrieved and processed archive contents or from User Generated Contents. The system targets both broadcasting Mobile TV on DVB-H and interactive mobile web over WiFi or 3G networks, both usable from handheld devices. Two pilot services based on the prototype system, available for experimental purposes over the area of Torino, are also described. The first pilot service is based on the automatic creation of a thematic news channel fed with contents from the Regional News, the second one allows to seamlessly distribute User Generated Contents.

Categories and Subject Descriptors

H.3.4 [Information Storage and Retrieval]: Systems and Software - *Information networks, distributed system.*

General Terms

Algorithms, Management, Documentation, Experimentation.

Keywords

Mobile TV, DVB-H, Ambient, Archive Contents, Video Blog, Regional News.

1. INTRODUCTION

The need for new appealing thematic television channels is becoming more and more clear in the Mobile TV arena, where users will likely expect to get more than only generalist TV programmes, seeking for very dynamic, short and targeted contents (see [1 - 2]). This is evident analysing the results of the Mobile TV over DVB-H trials (DVB to Handhelds, see [3 - 5]) and commercial services going on all over the world (see [6] for an updated list of them), confirming Marshall McLuhan's arguments: mobiles with TV are really new media, not just small televisions. Furthermore, connected devices used for Mobile TV

also allow bidirectional point-to-point connections, enabled by GPRS, UMTS and Wi-Fi, satisfying customers' requests for on-demand contents and interactivity. DVB-H and 3G (or Wi-Fi) networks, due to their complementariness, allow to build a geographically and functionally pervasive network infrastructure, well suited for ambient media delivery. It should be noted that other technologies for Mobile TV delivery were discarded because DVB-H was officially endorsed by the European Commission, although other comparable competing technologies, like T-DMB or Qualcomm's MediaFLO™ System, were available.

However, building networks and creating new contents, either for Mobile TV or 3G, is also expensive, and requires certain revenues, a constraint difficult to be satisfied in a new market with a few customers, very distant from maturity. Therefore the exploitation of archive contents from one side, and User Generated Contents from the other, could be a substantial help for the enhancement of a Mobile TV offering. That was the key idea behind the creation of the prototype system described in the present paper.

Two pilot Mobile TV services were created using the prototype system: a Regional News carousel and a User Generated Contents Videoblog.

Regional News programmes are being broadcast every day on the third RAI TV channel (RaiTre), with three daily editions in each of the 20 Italian regions, reporting local news and weather forecast relevant to that region. Each Regional News programme is typically constituted by an initial summary of the main news, followed by the detailed news. The basic idea for creating the *Regional News Carousel* was to extract from the whole Regional News programme only the "summary" news (about 90 seconds each) to be offered to mobile users. Then all the 20 Regional "summaries" are used to build a sequence of news including all the regions (about 30 minutes), cyclically broadcast and updated. Thus, for example, customers residing in Piemonte (a region in northern Italy) interested in the news from other regions may easily have access to them. On the other side, customers coming from a region different from the one they actually reside in, can still follow the main events happening in their region. Associated with each Regional News overview there's a web page downloadable in the terminal, allowing interested customers to get further details from the web. The Regional News Carousel has been tested and demonstrated with live transmissions over the Torino area since early 2006.

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User Generated Contents (UGC) are becoming very popular, and a number of well known web sites provide tools to publish them (we can refer to the YouTube site as a reference case). The idea behind the *UGC Videoblog* over Mobile TV was that the most popular UGC video clips have a number of accesses justifying to put them on a broadcast channel like DVB-H. The prototype system allows users to put their contents (and related metadata) on a web repository, from which they are selected (the only human intervention), adapted to both Mobile TV and mobile web, transmitted (on DVB-H) and published (on the web). The UGC Videoblog pilot service has been available in Torino since the beginning of 2007.

2. OVERVIEW OF THE SYSTEM

The prototype system allows an almost automatic creation of multimedia services addressed to mobile users, starting from automatically retrieved and processed archive contents or User Generated Contents. The system targets both broadcasting Mobile TV on DVB-H and interactive mobile web over Wi-Fi or 3G networks, both usable from handheld devices. Human intervention is only required in higher level and editorial operations like contents validation and final contents quality checking.

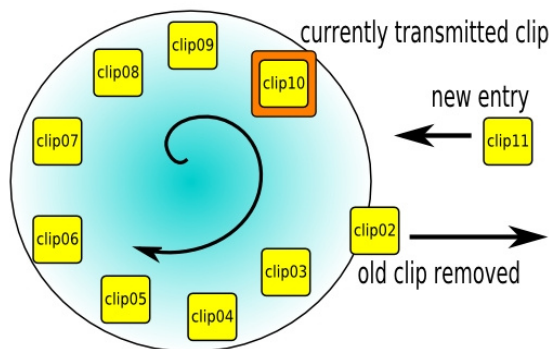


Figure 1 Carousel transmission of the clips.

The prototype system is flexible in its core part, and it has been built to satisfy different service types, involving automatic transmission on the broadcast DVB-H channel and publication on

the web. The service transmission on Mobile TV of the service can be easily structured in the form of carousels, i.e. sequences of video clips (e.g. 20 video clips) transmitted repeatedly, and partially updated during each.

Figure 1 illustrates the concept of carousel transmission.

During the repetition interval, each clip is transmitted together with the associated metadata and at each new repetition interval substitutions of some old video clips with new ones are possible.

Two kinds of service have been created and demonstrated; the first one is the creation of the a carousel transmission of news video clips starting from archived contents, the second one is the creation of carousels using semantically similar video clips contributed by users (User Generated Contents - UGC).

The system has been built using components performing automatically the following functionalities:

- **Automatic capture and cut** of the news from pre-recorded archive contents (generating the *source video clips*)
- **Gathering of source video clips metadata**; metadata can be provided by the broadcaster (Regional News case) or contained in XML metadata files provided by the customers (UGC case)
- **Format adaptation** of the source video clips for the transmission on the Mobile TV channel. This includes the transcoding of the video clips from high bit-rate and high quality to a format compliant with the receivers in use
- **Format adaptation** of the source video clips for the web publication
- **Generation of the appropriate metadata** for the transmission and publication on the web, including the creation of a titling clip ahead of each video clip
- **Scheduling** of the video clips transmission
- **Actual transmission and publication** of the service

In addition to the above functions a manual supervision function is implicitly involved: in an operational service, each clip will be supervised to validate it against the editorial requirements of the Broadcaster or the Service Provider. Furthermore, if transmission of UGC is expected, the Automatic capture and cut will be skipped, being the clip ready for adaptation.

The general architecture of the system is illustrated in **Figure 2**.

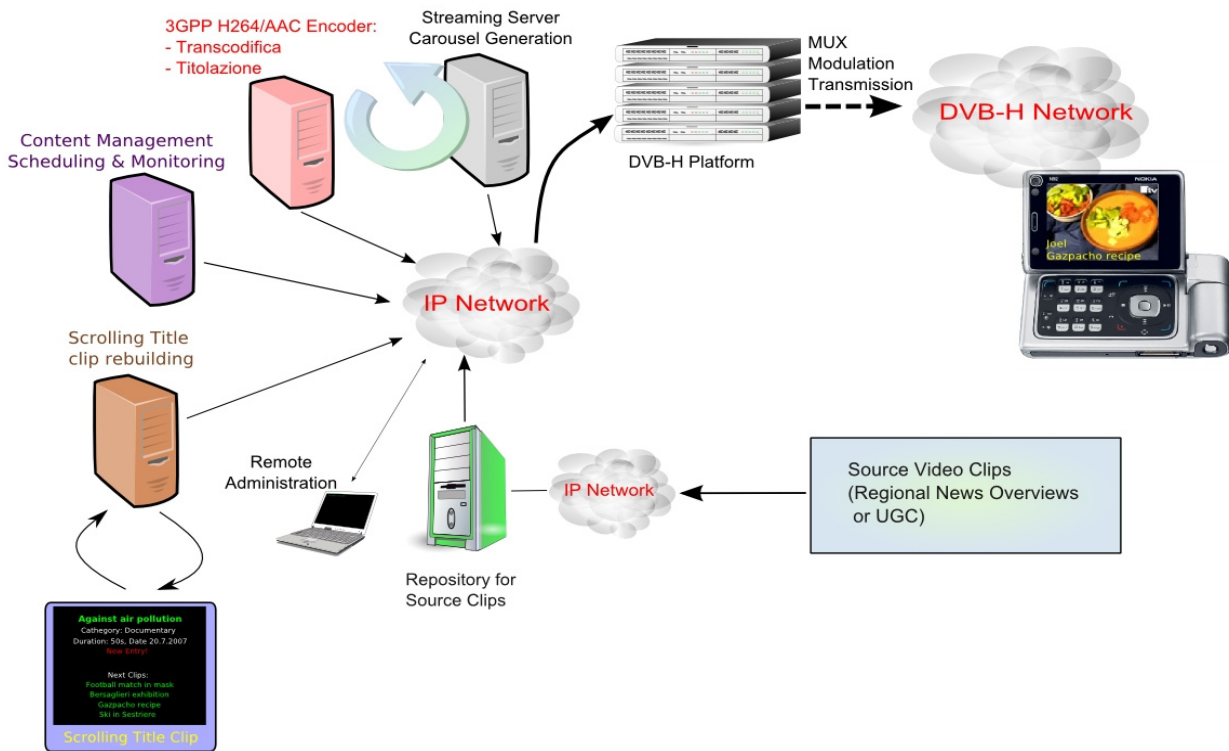


Figure 2 The general architecture of the prototype system

The “Source Video Clips” block on **Figure 2** is different, depending on the implemented scenario (UGC, Regional News, or a different one).

The UGC scenario requires a path to easily import video clips from the Internet to the system (which is generally placed on the company intranet). The following figure clarifies the input part for this scenario (see **Figure 3**):

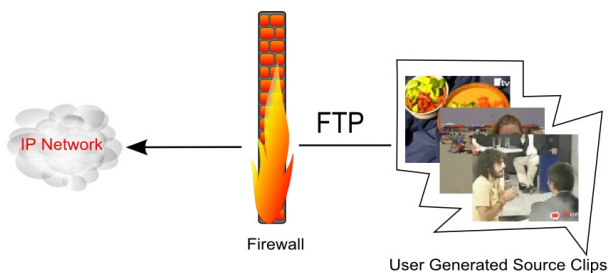


Figure 3 The source video clips acquisition for the UGC scenario.

As the previous picture shows, UGC clips are directly uploaded to the system’s ftp site, without the need of an automatic capture and cut of the video clips .

In the other scenario, a Grabber component allows two key functions. The first one is to retrieve a proper A/V segment from the archive of pre-recorded contents; this segment *contains* the News clip to be processed. Indeed Rai has 20 Regional sites, producing the Regional News; these news, besides being transmitted in a standard television channel, are recorded in the local sites and become available over the company Intranet. The second key function of the Grabber component is the precise cut of the segment (refinement), so that the clip starts exactly when the main news programme starts, and ends at the end of the summary section. This is what we call creation of a *refined* video clip, as explained in the next section. In this second case the ingestion part of the scheme is illustrated in **Figure 4**.

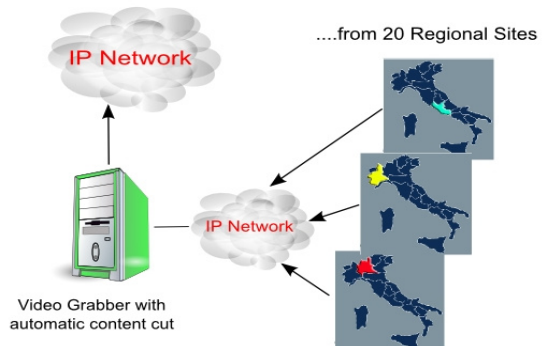


Figure 4 The source video clips acquisition for the Regional News scenario.

In the refinement of the Regional News, a critical point is the source contents quality, which has to be suitable to be adapted (encoding it in the final format) to the publication media.

Independently from the source type (UGC or Regional News) the clips are then encoded in the final format. At this point it was possible to use a high quality format to make the storage and editing, or to choose an intermediate quality format. The architectural choice was to encode the clips in an intermediate format suitable to mobile applications (low bit-rate), instead of using full quality formats. In this way the intermediate clips size becomes shorter, the required storage smaller, the editing and the network transit time faster. Furthermore, the video clip high quality source is generally already available in the Content Provider archives (e.g. the Regional News scenario); on the other hand, the VideoBlog scenario already came with low resolution video sources. After some quality tests, the agreed intermediate format for the source clips was SDTV MJPEG at 4Mbps at 25fps, with stereo PCM 16 bit, 44.1kHz audio at 1.5Mbps; this allows a good scaling to the chosen Mobile TV format, i.e. QVGA H.264 baseline profile at 200kbps and 15fps for video and stereo AAC 64kbps or eAAC+ 32kbps for audio. The video clip adaptation for Mobile TV is currently the most critical step, because mobile terminals support only a subset of the specified A/V formats. For the system in use in Torino, we adopted Realnetworks Helix Mobile Producer ProfessionalTM to transcode the MJPEG sources to streamable H.264. The adaptation for mobile web is at the moment easier, as many more formats are supported; on the other hand the size of the clip to be placed on the mobile web should be limited to speed up download, so a bit-rate lower than the Mobile TV case has been selected.

For the Mobile TV *medium*, information about the transmitted video clips is provided to customers in two different ways. First of all, information is sent using the standard Mobile TV Electronic Service Guide (DVB-CBMS ESG, see [7]), which allows to dynamically update the broadcast content descriptions. However the majority of terminals available during our research didn't support a fully dynamic update of the ESG, being the refresh time very long (2 or 3 hours). Second, a Video Clip with titles is created and transmitted before each UGC video clips. The title video clip presents a scrolling list with metadata relevant to the content like title, duration, creation date, and information about the next scheduled contents, useful as a quick way for users to have an idea of the following scheduled programmes.

Metadata for the mobile web scenario include the visual aid of a small image automatically captured from the contents video clip and other information like title, clip duration and creation date.

For mobile web consumption, publication on the web is the final step: customers will download only the interesting material, using a GPRS, 3G or Wi-Fi connection.

The clips prepared for Mobile TV need an additional scheduling and transmission step. The prototype system uses a Scheduler, an *ad hoc* software component, which allows a flexible scheduling, described in the following paragraphs. The Scheduler controls the streaming servers (one server required for each service) allowing to continuously stream selected contents and to dynamically add new contents as they are ready, without human intervention or pauses during the service. The DVB-H platform then gathers the stream RTP packets and the ESG FLUTE [8] packets and

encapsulates them in the DVB-MPE¹ sections, ready to be distributed to the main transmission sites, modulated and transmitted.

3. AUTOMATIC CLIP GENERATION FROM THE A/V ARCHIVES

In the regional news application, the system uses an automatic content analysis-based algorithm to identify and select the clips to be published. Starting from a scheduled temporal reference, the algorithm exploits a video clip matching technique to identify the exact start of the programme and a feature tracking technique based on luminance (pixel intensity) and colour saturation to automatically identify the outer boundary of the clip.

The video clip matching technique uses a basic image clustering process in which video elements (i.e. shots) are associated to known patterns in a nearest neighbour paradigm. A certain element is classified as a known clip if the clustering process associates its representative feature point to the cluster whose centroid is the reference pattern. The features extracted to perform video clip matching are colour histograms, Tamura's texture signatures (see [9]) and temporal activity parameters like the Displaced Frame Difference.

To fulfil its task, the feature tracking technique exploits some domain knowledge, namely the video editorial layout of the RAI regional news programmes, which is made of a first summary in which trailers of the forthcoming news stories are presented in a fixed letter-box layout. The studio contribution, which is following the summary, is not letter-boxed, therefore tracking the letter box configuration is equivalent to identifying the boundaries of the summary part, which is the target clip for publication.

This is done by analysing the pixel intensity of some target areas in the picture (see **Figure 5**) and triggering a cut edit when this feature drops down of a fixed threshold, which has been empirically evaluated on a reference data set and optimised with respect to the overall detection accuracy.

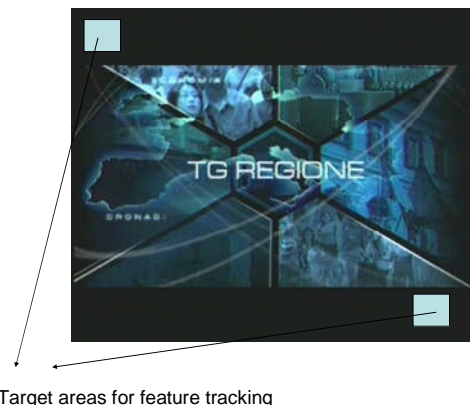


Figure 5. Picture target areas for feature tracking.

¹ Multi Protocol Encapsulation is the specification allowing the transport of IP packets in DVB protocols (see [5])

To evaluate the performance of the method we performed some tests on a reference data set of N clips (with $N \approx 100$), and we defined a quality indicator as follows:

$$q = \frac{1}{N_+ + N_- + N_{ok}} \left(N_{ok} + \sum_{i=1}^{N_+} \frac{d_i}{d'_i} + \sum_{i=1}^{N_-} \frac{d'_i}{d_i} \right) \quad (1)$$

where N_+ is the number of test clips with extra material (false positives), N_- is the number of test clips with missing material (false negatives), N_{ok} is the number of correctly detected clips. Obviously $N = N_+ + N_- + N_{ok}$. Besides, d_i is the true duration of the clip, d'_i is the detected duration. The q parameter varies between 0 e 1, associating lower values to lower quality refinements.

The total detection error on the test set has been 2.8 seconds (8.5 seconds standard deviation).

Figure 6 shows the distribution of the detection error on the test set. In Gaussian hypothesis for the detection error we have estimated a probability of 0.076 that the detected cut point is more distant than 15 seconds from the actual one, which corresponds to a quality indicator of $q=0.83$. We compared the obtained performance with a blind cutter cutting in correspondence of the observed average length of summary clips on the same test set. The performance of the blind cutter has been equivalent to $q=0.64$. This proves the effectiveness and usefulness of the implemented technique.

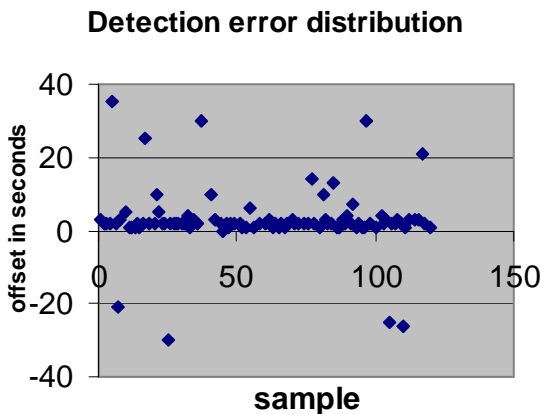


Figure 6. Distribution of the detection error.

The algorithm proved to be effective in the tests during the pilot service. However, it can be customized and enhanced to fit to other service scenarios.

4. AUTOMATIC CREATION OF TITLE CLIPS FOR MOBILE TV

In Mobile TV services similar to the VideoBlog thematic service, video clips are transmitted sequentially, in a carousel manner. It's up to the content provider (or to the service provider) creating a suitable separation between different video clips. The separation clip has several functions: it has to reflect the editorial design of the service, with proper logo, colours and audio track; it has to briefly describe the video clip which will follow; of course, it has to clearly separate one video clip from the next one.

Figure 7 shows the sequence of Title clips and video clips on the broadcast timeline.

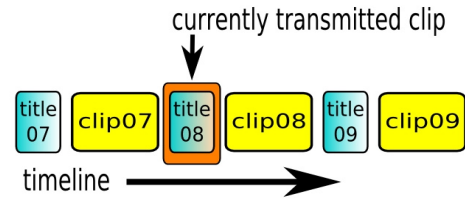


Figure 7 Clips and their Title Clips on the timeline

For the aforementioned reasons, the Title clips of the VideoBlog pilot service are automatically created. In the VideoBlog pilot service, the Title clip briefly shows an introductory picture with service name and RAI Company logo, and then slowly scrolls information relevant to the contents, in a sort of short movie fashion and allowing to well understand when a new clip begins (**Figure 8**).



Figure 8 Mobile TV terminal with a frame of the title clip automatically generated for the VideoBlog.

Information shown in the Title clip can be divided into two parts: the first one presents the Title and description of the next video clip, the second part is a list of the 4 following clips, an easy way to know the next scheduled videos.

In detail, the Title clip is 10 seconds long and it's created by the system frame by frame, starting from an associated XML metadata file and from other metadata available from the Scheduler. Each XML file is parsed and a subset of the information is included in the Title video clip:

- clip title
- clip category (news, documentary, sports...)
- clip duration
- clip creation date

Then Title the label "New Entry" is also inserted if it's the first time the referring UGC video clip is being broadcast. The metadata field to indicate if a video clip is a new entry is provided by the scheduler, as the list of the following video clips.

During the pilot service tests with the Regional News, title video clips proved to be very useful: they present quick information available in a glance to the customer.

We should note that the information given by the Title clip can be also delivered by the Electronic Service Guide (defined in DVB-H specifications [7]); the ESG can be dynamically updated with titles and a short description regarding the next scheduled video clips, and it's indeed a standard way to describe services and programs.

5. FLEXIBLE SCHEDULER

5.1 Scheduler Description

The Scheduling component has been implemented to flexibly plan in advance the streaming of the available video clips. The system is provided with a user interface (see **Figure 9**) allowing remote access to the key functions of the streaming server.



Figure 9 User interface home page.

The Scheduler includes template configurations supporting the two described pilot services and many others. Three usage scenarios have been foreseen: static playlist, dynamic playlist and VideoBlog.

The **Static Playlist mode** allows to manually create schedule items with available video clips. The clips belonging to the playlist are then streamed continuously. This mode is specially

useful with fixed program list structures, repeated every day.

The **Dynamic Playlist mode** allows to schedule a carousel by defining a daily or weekly run list, from which the references of the video clips to be scheduled are taken. The schedule time can be specified for each item in the schedule list. In this way, a run list with precise timing constraints can be planned. In detail the following modes are supported:

- *Synchronized mode* – For each scheduled program, a broadcast time is specified. There could be a problem due to programme durations: if for example a programme stops at 10:29AM and the next is scheduled for 10:30, there is one minute gap that should be filled to avoid problems on the receiver. For this reason, a padding clip is associated to the programme, so that if it stops before a new programme is scheduled, the padding clip can fill the interval. Simple padding clips with the logo of the channel can be used, e.g. in the Regional News scenario a descriptive clip with information about the next available news has been chosen. An application of the synchronous mode is the Regional News Scenario, where the News are transmitted at fixed times, so that customers easily remember when the clip of the Region of interest is broadcast.
- *Sequential mode* – The clips forming the run list are specified without timing information, being transmitted in loop, one by one. This mode allows a continuous transmission for the whole day.
- *Mixed mode* – Of course it's possible to combine the two previous modes, specifying both synchronized and sequential clips. So, not synchronized clips are broadcast in sequential mode, not waiting for a start time, and the run list is synchronized only in some points. This mode is useful for example if we want to create a carousel of thematic clips that depends on the time slot (e.g. News from 19:00 to 20:00, sports highlights until 22:00 and User Generated Contents from 22:00 to 24:00)

The Scheduling system can be remotely controlled using a web browser, through an http interface. A monitoring page allows to

Clip name	Start time	Padding clip	Running clip
La_prova_del_cuoco.3gp	00:00:00	stacco01.3gp	-
Tg_salute.3gp	00:30:00	stacco02.3gp	-
Che_tempo_fa.3gp	00:45:00	stacco03.3gp	-
Occhio_alla_spesa.3gp	00:50:00	stacco04.3gp	Streaming
La_vita_in_diretta.3gp	01:00:00	stacco01.3gp	-
Tg1.3gp	01:30:00	stacco02.3gp	-
Unomattina.3gp	01:45:00	stacco03.3gp	-

Figure 10 Daily schedules in the monitoring page

follow the evolution of the run list, displaying all the scheduled video clips, with the current scheduled program highlighted in red (see **Figure 10**). The monitoring interface is common to both Regional News and UGC Videoblog pilot services.

Finally, the **Videoblog mode** allows to sequentially stream a set of source clips with automatic update. The carousel will include a set of n of the most recently uploaded clips, being the number n will be decided according to the editorial requirements. The set of clips is streamed continuously, in loop mode. When a new clip is uploaded, a priority is associated with it, and so it can be automatically scheduled according to this priority. For example new clips marked as high priority will be streamed as the next clip. In this way, after the source clips have been provided (and validated by the editors), the service can automatically be created and updated, without stopping.

The Scheduling component also exports an up to date complete list of the scheduling items, included the currently streamed clip. The Videoblog mode allows to associate an introductory clip to a source clip. Such introductory clip is scheduled immediately before the source clip (e.g. the Title clip). The introductory clip can present the broadcaster logo and an introduction to the referring clip and a list of the following ones. In the prototype system we're presenting, the creation of the introductory clip is automatic, performed by the scrolling Title Clip component, starting from metadata about the source clip (title, description, category, duration, production date) and the scheduling list (allowing to specify the following clips) as described before. This scheduling mode is deployed in the Videoblog scenario, allowing the selected User Generated Content clips to be continuously broadcast. The Videoblog scenario implements on a DVB-H broadcast channel a very popular concept of the web, where a number of services allowing users to upload their videos can be found.

Every time the Scheduler detects a new source clip, it publishes it on the web, so broadcast and interactive web contents are available at the same time. A subset of the metadata associated with the source clip is used to build up the link of the clip. Also a small video frame, previously captured, is automatically used to create the web link. **Figure 11** shows the web layout used in the web page of the Videoblog scenario. This web page provides easy access to old video clips and also allows to access more detailed information using the interactive channel.

5.2 Scheduling Strategy and Title Clips

It has to be pointed out that the scheduling strategy of the UGC video clips should be dependent on the number of contributed video clips.

The implemented scheduling strategy for UGC video clips, due to the low number of contributed clips, was the following:

- **First In First Out** as a general rule: the clips in the carousel are broadcast in the order they have been uploaded.
- **Last In First Out** as an exception, for new entries: the system tries to broadcast a new clip as soon as it will be uploaded (as a new clip can be considered more attractive by customers).

So, the list of next video clips shown in the Title clip is not valid if a new UGC video clip has been uploaded, because this clip will be immediately broadcast, and the event is not predictable.

The described broadcast strategy effective if the total duration of UGC daily uploaded video clips is much lower of the available broadcasting time each day, so if a new entry can be considered a sporadic event.

If the number of uploaded UGC video clips uploaded each day increases and becomes comparable to the available time, a pure LIFO strategy is more convenient. Anyhow, human intervention is still necessary to choose the appropriate clips.



Figure 11 Web page with published clips.

Of course, the web publication for the Regional News scenario is very similar, with the addition of web pages with the News of a whole month.

6. SYSTEM SCALABILITY

The described prototype, as described, can face several tens of video clips every day: it has been tested with real UGC uploads. Although that could be a typical business scenario other scenarios are possible, for example with thousands users actively contributing to the UGC creation. The prototype has been designed to be readily scaled. To cope with similar scenarios and to scale the system, the following components can be analysed: the H.264 encoders, the scheduler and the storage and access to the web part.

6.1 The Encoders

The prototype system actually uses only one H.264 encoder, and all the requests are serialized to it. This is possible only if the business scenario is similar to the tested one. If the number of contributed video clips increases, it's necessary to increase the number of encoders. The number of encoders is proportional to the number of provided video clips. Likewise, also the Titling components have to be increased, as they should seamlessly create title clips for each contributed clip. The component used to serialize the encoding requests has to be adapted to balance them among the available encoders.

6.2 The Scheduler

The prototype system has been implemented to manage one A/V service for each scheduler. Depending on a service provider's choice (based on contributed clips quality, customers requests, available bandwidth, advertisements or subscriptions revenues), it's possible to increase the A/V services transmitting the video clips. However, generally the number of A/V services can hardly be increased. The possible schedules overload has to be avoided and, due to the constraints (one or a few A/V service, 24 hours a day), the editorial team should choose the most appropriate clips to include in the schedule pool. Human intervention is at least advisable if the broadcast network is large (e.g. nationwide or covering a big city), to assure a good quality of the service.

6.3 Web Scalability

The mobile web part of the services can grow more than the Mobile TV one, due to the large storage and web access scalability. The prototype system's web component is completely and transparently scalable. Generally the video clips size is a few MB (for a few minutes of video) and the available storage devices allow to record millions of them. Furthermore, a distributed web solution with load balancing can be used to improve connection speed.

7. CONCLUSIONS

In this paper an innovative prototype system used to automatically create and publish multimedia thematic channels addressed to

mobile users has been described. The system allows to automatically retrieve and process archive contents or User Generated Contents, streaming them using different scheduling strategies. Two concrete application scenarios have been implemented and described: a Regional News service, and a Videoblog service with User Generated Contents. Both services are broadcast, together with other contents, using Mobile TV over DVB-H in the area of Turin. The system allows to simultaneously stream the contents for a DVB-H broadcast service, and to publish them to a mobile web site. Thus, the described prototype system, allowing the creation of new thematic mobile TV services and mobile web sites in a seamless way, represents a step forward in the direction of new contents provisioning and media integration.

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