IPTV for Educational Multimedia Content distribution. Uvigo-TV, ARCA and PuMuKIT projects in Spain.

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IP television, multimedia services, streaming, digital repository.

1. EXECUTIVE SUMMARY

This paper describes the University of Vigo (UVIGO) IP television (Uvigo-TV) deployment experience as an example of one of the cutting edge services to provide not only in present but in next generation networks as well. Hence, it will explain how the project started and the technical/organizational decisions made, including those that were successful and those that were not.

IP television at the University of Vigo started more than 3 years ago as a "technological experiment" and became one of the most successful services at present. By the end of 2007 a repository of more than 2000 hours of recorded classes and lectures are available online to teachers and students and more than 200.000 videos were served showing an increasing interest of users in the service. We will explain the 3 major challenges (in our opinion) to setup an educational IPTV**: Production, Publication** and **Distribution**. Those sections are summarized next:

In the Production section it is described the solution given by the UVIGO to record a large number of conferences and lectures with a small technical staff. In the Distribution section the method to send/distribute the multimedia content over IP networks to users is explained. And finally, the Publication section will be explained. The Publication of contents means the orderly presentation of the available videos. This is one of the most complicated areas.

In the publication area the application "**PuMuKIT**" (Multimedia Publisher KIT) was developed by the University of Vigo, giving the administrator an easy way to catalog produced videos and generating an IPTV website, a podcast site and an "ARCA project" compliant feed, in a very easy way.

By means of the **ARCA project** each institution can provide their audiovisual production in order to create a huge, common, ordered repository of scientific and educational videos. The idea is to set up a central node capable of gathering information in metadata format from audiovisual content available at the PuMuKITs of different university repositories and from affiliated institutions and then provide a solitary search point and access to the content.

At present the central ARCA system (arca.rediris.es) is managed by RedIRIS, the Spanish NREN and there are 12 affiliated organisations making a total of over 3,000 videos available and the number is growing daily. It is the largest free access repository of educational content in Spanish on Internet.

2. INTRODUCTION

NRENs (National Research an Education Networks) and Internet grew providing limited access to content due to technical limitations on networks. Nowadays these limits have been overcome, giving the chance to deploy new Internet Information Services.

IP television at the University of Vigo started more than 4 years ago as a "technological experiment" and became one of the most successful services presently available. By the end of 2007 a repository with over 2,000 hours of recorded classes and lectures was available online for teachers and students and more than 200,000 videos were served that year, showing an increasing user interest in the service. The Uvigo-TV web site can be visited at http:// **www.uvigo.tv**

In this paper we will briefly describe the beginnings and the present situation of Uvigo-TV, the initial approaches, the solutions adopted and the services provided for users. We will place special emphasis on the three great challenges which we believe to be fundamental for the successful operation of IPTV: **Production, Distribution** and **Publication**. As part of the Publication infrastructure we will describe the **ARCA** and **PuMuKIT** projects.

3. UVIGO-TV, THE BEGINNINGS AND THE PRESENT SITUATION.

The University of Vigo has around 20,000 students and is in the south of Galicia, near the border with Portugal. It has three campus in the cities of Vigo, Ourense and Pontevedra. At present the three campus are connected via 1 Gbps links. Within each campus the buildings are connected in a star shape with a minimum speed of 1 Gbps per building. Our Internet connection is a 2 Gbps link to CESGA [1] PoP (point of presence) of RedIRIS [2], our NREN.

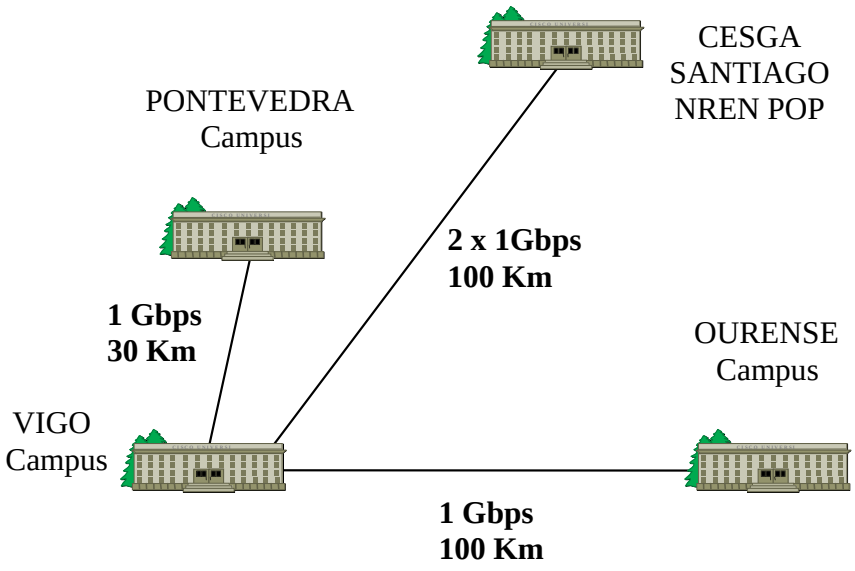

Figure 1: University of Vigo Inter campus distances and WAN network

A significant investment of over 4 million € was made in 2004 in the WAN research network infrastructure in the south of Galicia and the north of Portugal. Approximately 1 million € was assigned to the internal network of the three University of Vigo campus, which enabled us to reach the present state of connectivity. Complementary to this investment a decision was taken to work on the implementation of new high value services for users. Those services with heavy Bandwidth (BW) demand, do not have been possible with the old network infrastructure. In the end two projects related to NEM (Networked and Electronic Media) [3] technology were carried out: a first project related to advanced videoconference technology based on the deployment of AccessGrid rooms [4] and an IPTV project, Uvigo-TV .

So began the University of Vigo IPTV project. At first it was seen as a "technological experiment" whose aim was to evaluate the possibility of using the new network as a support for scientific and educational video recording, postproduction and distribution tasks in different qualities. In the end video formats requiring speeds of up to 25 Mbps in production and 6 Mbps in distribution to end users were employed (High Definition content, 720p).

The experience was entirely positive, the network was enhanced making transmission and production processes of audiovisual content possible in a distributed environment which would otherwise have been impossible. Using mobile audiovisual production equipment we can broadcast live from any point on campus. Recorded content is saved in a NAS (Network Attached Storage) central storage system and then, later on, edited by our collaborators from different geographical points on campus with total transparency.

At present it is one of the most successful IT (Information Technologies) services at the University of Vigo. A repository with over 2,000 hours of recorded classes and lectures is available for teachers and students. Most are accessible for any Internet user.

Over 200,000 videos were served in 2007 and the estimate for 2008 is to reach over 300,000 if the trend from the first quarter of the year continues.

Year	Videos Served
2005	*15,000*
2006	*90,000*
2007	*210,000*
2008	*340,000 (estimated)*

Uvigo-Tv records and emits a large number of lectures and classes live from our three campus. This means, for example, that students and lecturers do not have to be physically present at a lecture. Once the material is recorded it is accessible as Video on Demand (VoD) and is thus available 24 hours a day on Internet for the general public. Other recorded material, fundamentally classes, is made accessible only for students registered in the subject via an e-learning platform.

Recorded material is available in different formats and bitrates which go from 40 kbps for access with dial-up modems and on mobile devices to HD content at 720p coded at 6Mbps for home users with advanced connections or users on NRENs. Most content is distributed using **Windows Media** technology, which among other things enables end users to automatically adapt the content bitrate to the available BW.

The material available on Uvigo-TV is mainly educational and scientific, but we also have certain content of other kinds - institutional events at the university, sports competitions and award giving, which we call "campus live" in general. All content is classified into topical channels. Academic content is classified according to UNESCO knowledge area codes.

4. PDP ARCHITECTURE

With all the experience gained over the years we realised that we can divide up the tasks we have to carry out in order to provide an IPTV service into three main functional areas: **Production, Distribution** and **Publication**.

- The **Production** area includes the systems, the workforce and the work flow necessary to record, edit and transcode content, ending up with a finished video piece ready to distribute and a series of metadata for classification.
- The **Distribution** area includes all the video storage and distribution systems on IP, including streaming servers, downloading, network equipment etc.
- The **Publication** area includes the systems, workforce and work flows necessary to classify and present Multimedia content so that users can find and access it as easily as possible from different access terminals, PC's, mobile devices etc…

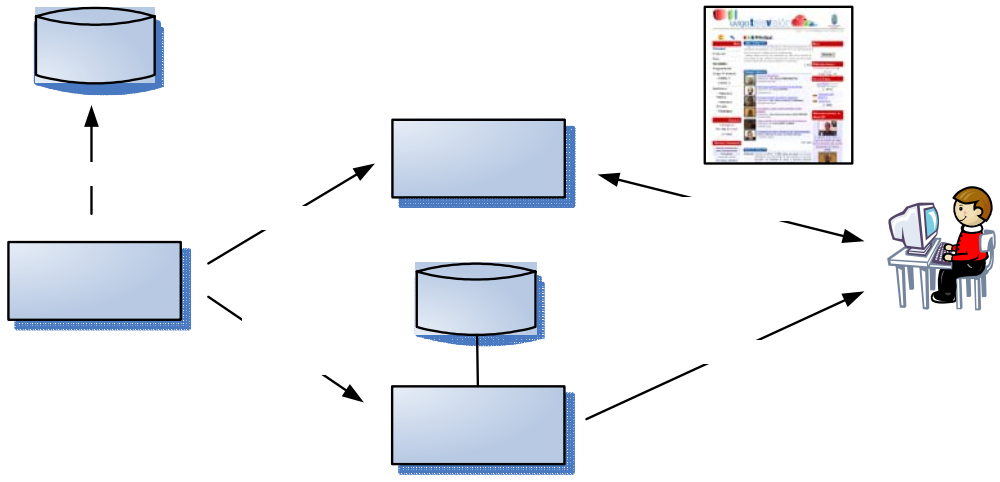

Figure 1: PDP architecture overview

We would like to propose using this approach which we have called "**PDP**" as a reference point for the deployment of this kind of services. In the sections below we will look at each of the three areas in more detail.

A University IPTV programme should have balanced solutions for all three areas; a great production capacity is no good with poor solutions in distribution and vice versa, neither is a fantastic solution in production and distribution any good if classification and publication are not good enough.

We believe the best idea is to maintain each area as independent as possible so that we can, as far as is possible, change and update our distribution solution without having to change publication, as this gives us great flexibility and enables us to avoid certain monolithic commercial solutions which end up creating a technological dependency as they virtually oblige us to start again from scratch if we wish to change our technology or supplier.

4.1 Production

Under the term production we have included the technical and human means which enable us to record and edit multimedia content, producing a high quality video archive which we call the master copy; in our case this archive is transcoded into Windows Media Video with three different bitrates so the system could automatically adapt the content bitrate to the available BW at the user endpoint.

The production phase comes to an end with a master file which is typically in H264, DV or HDV which is stored for later use, a Windows Media Video file which feeds our distribution system and a metadata table which feeds the publication system.

According to the kind of event we wish to record we use different formats and technical means:

- Single camera PAL system: we use this in standard lectures and classes. There is 1 robotic camera with 3 CCDs (Sony BRC300) and a coding and recording system directly to hard drive and with a network connection. These systems are mobile and can be installed and operated by just one person.

- Multi-camera PAL system: we use this in complex lectures and important institutional events. It consists of 3 robotic cameras and a real time editing system simulating a small mobile television unit in a small PC. They record directly to hard drive and enable live transmission via native streaming (NEWTEK Tricaster, Sony AnyCast).

- 1024x768 systems: enable us to combine a computer desktop image and the video image of the lecturer or presenter in the same video. The end product is a video with resolution at 1024 x 768 including the lecturer, his/her voice and the PC background used for the presentation in all its resolution, with any programme used and the mouse pointer movements. This is very valuable in scientific explanations where the lecturer is pointing out a certain area on a graph with the mouse or a particular physiological formation. We call this format 1024P+P.

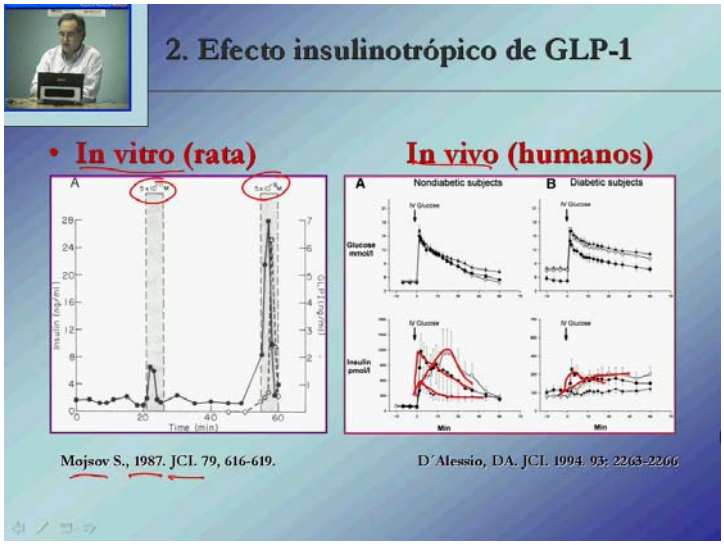

Figure 2: 1024P+P format

- HD 720p system: a single camera system similar to single camera PAL, but the recording capacity is 720p directly to hard drive.

Using these recording systems in an environment such as a campus endowed with a modern network enables us to carry out, at very low cost, tasks which up to now were only feasible for commercial television stations.

We go out live from any room in any of the over 30 buildings in the three cities where the University of Vigo is present. Once recording is finished anywhere, the raw file of various Gbytes is transferred to storage and we start postproduction just a few minutes later. At times the content is available on Internet before the recording team are physically back at our facilities.

4.2 Distribution

Distribution systems were historically where we first focused our attention in the Uvigo-TV project. For us this includes all the storage and distribution systems of video on IP, streaming and downloading servers, network equipment etc.

We think there are two groups of solutions for video distribution on Internet, each with its pros and cons:

- **Downloading files**. This is the simplest solution and in many situations it is very suitable. It is simple and cheap, and can be implemented with any WEB server. Very suitable for short clips or to start an IPTV experience.
    - **Problems :**
        - We cannot broadcast live.

        - No "FFW" (Fast forward) in content without downloading the whole content to that point.
        - There is no control over the BW employed, the server serves the content at the maximum speed available.
        - We lose control over our content as it ends up on users' hard drives.

- **Streaming.** A little more complicated, it requires a specific server but it gives us a series of advantages.

    - **Advantages:**
        - Live broadcasting
        - Permits FFW
        - Control over BW
        - More difficult to download the file

In the end we decided on a distribution system based on streaming and then we had to decide which of the multiple available streaming technologies was the one which best adapted to our needs.

Our priorities in the selection of a solution for streaming were as follows:

- Very user friendly
- Low or no cost for concurrent users
- Open source or development kit available

At this starting point four years ago we reached the following reasoning which we think is still basically valid today:

In order to guarantee easy user access we wanted a solution which did not involve installing anything in most users' equipment, or if they had to install something it should be a simple and fast process.

On applying this restriction we were left with two technologies:

- **Windows Media**: the player is not light but most users already have it on their system as they use Microsoft systems.

- **Flash:** Many users already have this Player and if they do not, it is fast and easy to download and install.

Then we applied the low cost restriction for concurrent users and in the end we decided in favour of **Windows Media.** At that time with Flash Media Server you had to pay a cost for each 100 additional concurrent users while Windows Media Server was free and had no user limit, if you bought the Windows Server 2003 operating system in its different versions.

The Microsoft solution gave us another advantage – the easy implementation of a system capable of serving content in various qualities and bitrates and capable of adapting automatically to the band width of each user and the availability of a free plug-in development kit.

At present there are very interesting projects like **Red5** (An Open Source Flash Server)[5] which should be taken into serious consideration.

In any case in PDP architecture the distribution solution does not have to be unique – we can install various streaming or download servers with different technologies. As we will see later, the publication system should be capable of indexing the same content, the video of a lecture for example, and providing access to the content in all available distribution technologies.

Solutions which are capable of transcoding content in real time are appearing on the market, so that starting with a MPEG2 or H264 master they provide users with streams in flash, QuickTime, real video and Windows Media.

Another important point is to carefully choose where we connect our distribution systems within a campus network, as in live broadcasting for example, with a high number of concurrent users, the traffic on streaming servers can be very high. In our case we have two streaming servers, each directly connected with a 1 Gbps link to one of the two Cisco 6500 switches, which make up the core of our university network – in this way we avoid overloading individual links.

In our moments of the heaviest loads we have reached almost 800 Mbps in live broadcasting with almost 600 concurrent users, allowing for individual connection speeds of up to 2 Mbps per stream. If our distribution servers had been connected to any other point on our network we would doubtless have endangered or degraded other network services.

4.3 Publication

By **Publication** subsystem we mean an IPTV structure based on PDP for all the physical systems, human resources and work flows necessary to classify and present Multimedia content so that users can easily search for and select them from the different access terminals, whether it is a PC, a mobile device or a conventional TV with a Set Top Box (STB) IP.

Maintaining the publication system clearly separate from the distribution solution and based on standards enables us to update and adapt it without having to make any additional changes such as with the recent development of access interfaces for mobile devices and STB's.

The simplest case involves a publication system made up of just a static web site, which is manually updated as new content is incorporated. This web site provides access to the distribution system publication points so that when a user finds content of interest on the web site and selects the associated link the content is transferred by downloading or streaming from the distribution system.

There are two Publication systems at present at the University of Vigo – one is public and is the Uvigo-TV itself, while the other is our e-learning platform. This platform provides access to very varied educational content in different formats, including audiovisuals. Access to this content is limited to students registered in the subject.

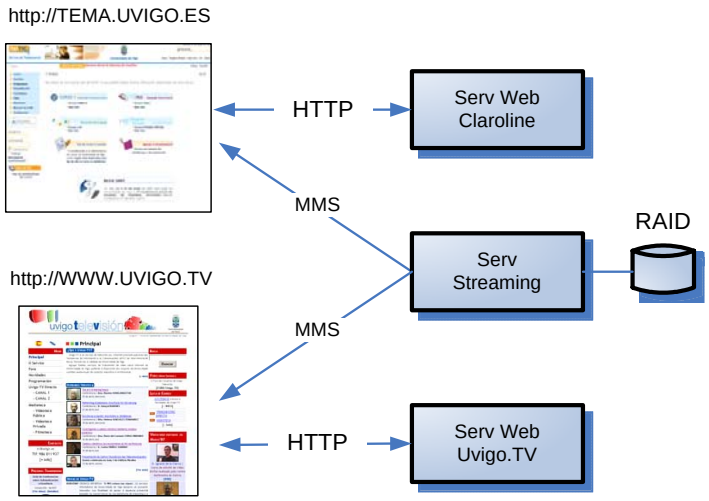

Figure 3: Present Publication and Distribution systems

In our own case we started with a static web site as a Publication system for Uvigo-TV until two factors led us to decide on the development of a more complex multimedia content management system:

- The great amount of recorded material (over 600 hours/year) made for very tedious maintenance work on a static web site
- The need to generate an RSS feed every day with our content in order to take part in the ARCA multimedia content federate repository on-line project, which we will look at below

At this point we decided on the development of an application capable of handling the metadata of our audiovisual content and generating two types of presentation for this metadata: the Uvigo-TV web site (www.uvigo.tv) and an RSS feed which was compatible with the ARCA project.

5. PuMuKIT

We called the Multimedia Publication in KIT PuMuKIT (from its abbreviation in Spanish), our audiovisual content manager. PuMuKIT is a CMS (Content Management System) type system, specialised in this type of content but with certain peculiarities.

The main classifying element within PuMuKIT is the **OM** (Multimedia Object); an OM might be a class or a lecture. An OM not only contains the video of the lecture but it can also incorporate all kinds of material – audio archives, pdf or Powerpoint documents, URL's etc. Among the metadata which complete OM's are those defined in the Dublin Core Standard as complete with a set of additional fields.

OM's are grouped into **Series**. A series can be a whole congress, a season of lectures or a subject. Sometimes a series consists of just one OM.

Each series is then grouped into **Them Channels**. At present, to simplify data interchange with the ARCA project (described in the next section), the following topic channel system has been used:

- Health Science
- Experimental Science
- Social and Legal Science
- Technical Education
- Humanities
- Live Campus

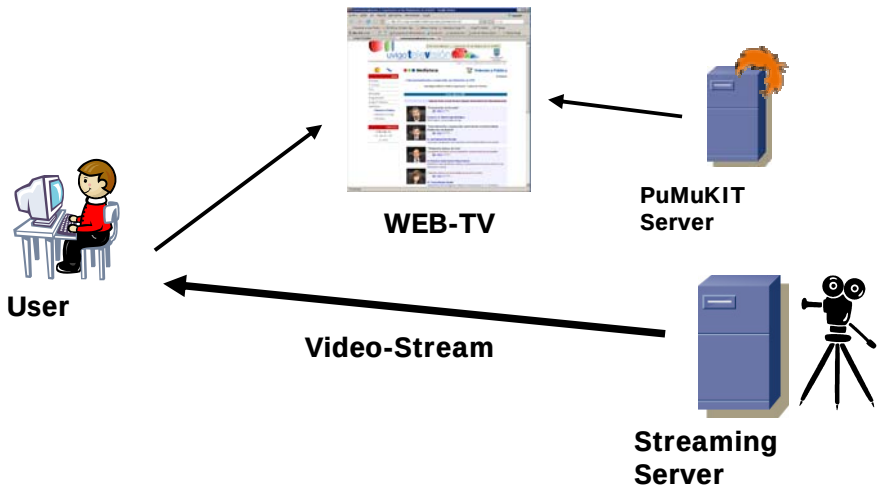

Figure 4: The PuMuKIT as a Publication system

Examples of IPTV created with PuMuKIT can be seen at the following links:

- University of Vigo IPTV: http://www.uvigo.tv
- Supercomputing Centre of Galicia IPTV: http://tv.cesga.es
- University of Murcia IPTV: http//tv.um.es

Not only does PuMuKIT generate a web site to access content – it also generates an RSS feed with a specific format based on the same data. This RSS 2.0 feed is needed to form part of the ARCA project.

Latest improvements (April 2008) includes: OAI (Open Archive Initiative) support to provide compatibility with DSPACE word, and Podcast format generation (podcast format is nothing more than other XML file)

6. THE "ARCA" PROJECT

The ARCA project [6] is directed by the Carlos III University in Madrid. The idea is to set up a central node capable of aggregating information in metadata format from audiovisual content available at

different university repositories and from affiliated institutions and then provide a solitary search point and access to the contents.

Organisations which wish to have their contents indexed by the ARCA system have to be capable of generating an RSS file in a specific format so that the related metadata can be incorporated into the ARCA central data base.

The ARCA RSS feed is compatible with the main names for multimedia content on Internet: Yahoo Media, Google Base RSS and iTunes RSS.

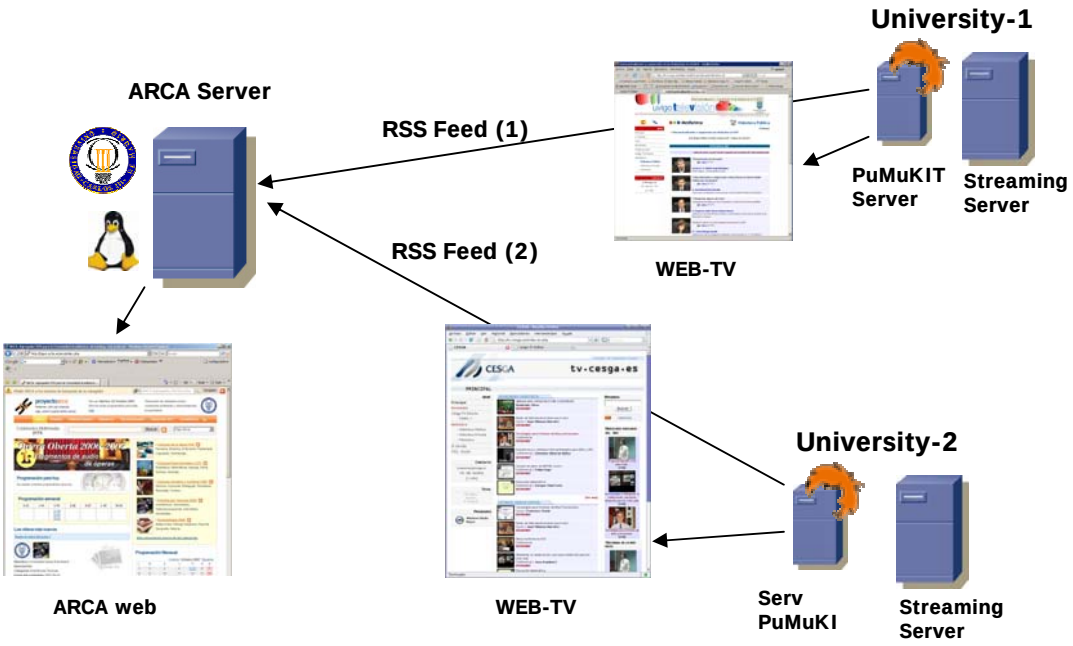

Figure 5: The complete ARCA + PuMuKIT ecosystem

At present the central ARCA system (arca.rediris.es) is managed by RedIRIS, the Spanish NREN and there are 12 affiliated organisations making a total of over 3,000 videos available and the number is growing daily. It is the largest free access repository of educational content in Spanish on Internet.

7. CONCLUSIONS

At present, University and European NREN networks can operate with this kind of on-line multimedia service. Both content distribution services for the end user and services oriented towards production are feasible: the interchange of high quality raw material, the editing and postproduction of such material in a distributed way.

Domestic access networks in most countries in Europe have enough bandwidth to grant access to this kind of contents with no difficulty. The audiovisual content supply via IP is growing fast in our environment; a heavy growth is expected in the NEM sector (Networked and Electronic Media) as a

business area. We find it important that within this content supply universities should be present, providing quality scientific and educational content, free if possible.

What we have tried to do in this paper is to present our experience with the implementation of an on-line multimedia content distribution service for educational purposes but for the general public as well. This type of service has helped us to enhance the investment made in the improvement of our data network.

In this environment, UVIGO-TV, the University of Vigo IP television has not been a "technological experiment" for some time now, as it became a real service requested by our users every day and if the rate of growth noted in the first three months of 2008 remains constant, at the end of the year it will have over 340,000 educational and scientific videos serverd.

8. AKNOWLEGEMENT

This project would not have been possible without the collaboration and help of our workmates at the Carlos III University in Madrid and the Supercomputing Centre of Galicia (CESGA).
This work was possible thanks to the network infrastructure deployed on the European Union INTEREG TORGANET project.
We are now starting up a similar experience in South America thanks to the "Integrated multimedia virtual teaching service" collaboration project, presented by the University of Vigo and the Gastón Dachy University Institute in Argentina, financed by the AECI (Spanish International Cooperation Agency).

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