A METHODOLOGY FOR THE DEPLOYMENT OF LIVE AUDIO AND VIDEO SERVICES

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Keywords: Methodology, deployment, live, audio, video, streaming.

Abstract: Since the development of the first live audio and video services in the 90s, the deployment of these services has always been a challenging issue. Not only is it necessary to deal with the problems of the delivery of continuous information and the high consumption of resources, but also with those imposed by the nature of these services. Service managers do not get a second chance to broadcast live contents so it is important to ensure that everything works as planned. Most service managers only work based on their own experience, but they rarely follow any standardized method. With the aim of improving the current situation, the authors have designed a methodology for the deployment of live audio and video which is presented in this paper. The methodology tries to cover almost all the issues that may arise while putting one of these services into operation and proposes mechanisms to deal with those issues from a management perspective. It has been successfully used by the authors in the deployment of several live services for different companies.

1 INTRODUCTION

Since the development of early web pages for scientific purposes, Internet has suffered huge changes mainly due to the improvement of access technologies and the massive access of users from the home environment. Many services have been designed, developed and deployed, making the web a vast repository of resources for entertainment, research, study, etc. The ideas behind most of these services have been taken from other activities, e.g., e-mail from snail mail, audio conference from telephone services, etc. Audio and video have also taken advantage of this adoption of ideas and, in the 90s, these services were deployed taking ideas from tape and video recorders and *TV* and radio services.

Mainly, there are two types of audio/video services: live and on-demand. On-demand services are similar to a tape or video recorder, while live services are similar to a conventional radio or *TV* service. They differ in many aspects. The interaction capabilities of their users are different. These users even behave differently as stated in the literature (Cherkasova and Gupta, 2004) (Veloso et al, 2002). Live services generally require more transmission capabilities as all the users connect at the same time and remain connected during long periods. Also, on-demand services use stored contents, so there is always a chance to perform tests to ensure that everything works as planned. On the other hand, most live services use live information, so testing is very limited and there is never a second chance. Taking into account these particular problems, those related with the delivery of continuous data and the high consumption of resources, the design of methodologies may be meaningful for administrators to maintain the quality of their services.

In this paper a methodology for the deployment of live audio and video services is presented. It covers almost all the issues that may arise while putting a live service into operation and proposes mechanisms to deal with those issues from a management perspective. The whole process has been defined, considering the workflow, roles, products and techniques. It allows managers to evaluate the feasibility of a service, develop deployment plans, perform evaluations and deliver evaluation reports. It has been designed following the structure and philosophy of other methodologies and standards such as *ISO/IEC 12207* (ISO, 1995), *RUP* (Kruchten, 2003) or *Six Sigma* (Pyzdek, 2003). Although similar experiences have been done for other types of services (Ginige, 1998), there are no

Melendi D., G. Pañeda X., Vilas M., Garcia R. and Garcia V. (2007).
A METHODOLOGY FOR THE DEPLOYMENT OF LIVE AUDIO AND VIDEO SERVICES.
In *Proceedings of the Second International Conference on Signal Processing and Multimedia Applications*, pages 15-21
DOI: 10.5220/0002133000150021

deployment methodologies for live audio/video to our knowledge, only recommendations or generic methods. The methodology has been specifically designed for the deployment of live audio video services, thus, it includes elements to deal with their particular problems.

The authors have previous experience in the creation of analysis and configuration methodologies. One such methodology was specifically designed to analyze and configure video on demand services (Pañeda et al, 2004). Nevertheless, it did not cover issues considered in the presented methodology. The current methodology has been successfully applied in the deployment of services such as the radios in the *Asturies.Com* newspaper (http://www.asturies.com), the *Aula18* annual movie contest or some of the daily conferences organized by the *La Nueva España* newspaper (http://www.lne.es). Some of the obtained results are available in (Melendi, 2006)

The rest of the paper is organized as follows. Section 2 describes the general structure of the methodology. Section 3 details the involved actors. Section 4 describes the designed processes. Finally, Section 5 presents conclusions and future work.

2 GENERAL STRUCTURE

Due to the broad set of tasks to be carried out during the deployment of a live audio/video service the methodology has been designed to have several *processes*, all shown in Figure 1 in the order to be followed. Each process groups a set of *Activities* with a common purpose and is described in Section 4. *Activities* group tasks performed by *Actors* generating *Products*. *Products* can be sections of a document or deliverables.

3 INVOLVED ACTORS

Three types of companies intervene: *Content Provider* or *CP*, *Network Operator* or *NO* and *Content Distribution Network Manager* or *CDNM*.

The *CP* wishes to broadcast the contents. They provide the materials but they do not have the infrastructure or even the knowledge. Its *CEO* (or *Chief Executive Officer*) is the person approving money expenditures based on the information provided by the *Manager*, who is responsible for a particular deployment, has to report to the *CEO* and has to take decisions based on the information provided by other companies and the *Production Designer*. The *Production Designer* designs the contents, the look and feel, etc. The *Operator* deals with the generation of contents and the tasks to be carried out on a day to day basis.

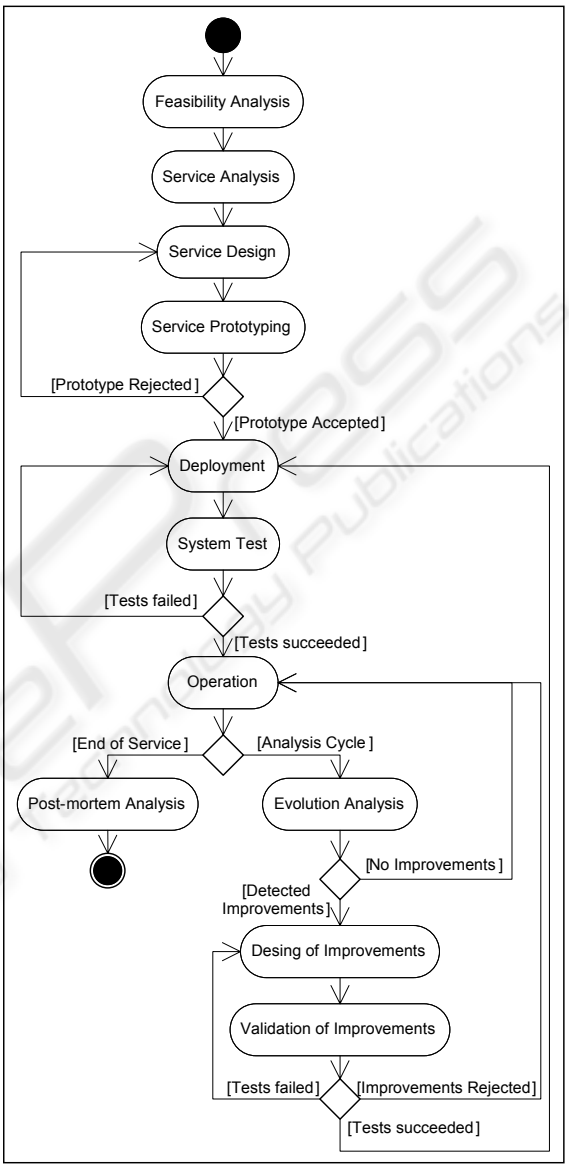

Figure 1: Processes in the methodology.

The *CDNM* manages the hardware and software used in the service. This implies having proxies, servers and other devices with the most adequate peripherals and software. The infrastructure can be installed ad-hoc or reused. The *Technical Director* is the person in charge, plays an assessment role and takes decisions based on the requirements or the evolution of the service. The *Service Analyst* analyzes the needs of each service, designs the architecture, ensures the fulfilment of all the *Service*

Level Agreements or *SLAs* (Lee and Ben-Natan, 2002), etc. The *Systems Administrator* manages the devices of the *CDNM*, applies the changes approved by the *Technical Director*, generates reports, etc.

Finally, the *NO* provides the communication infrastructure. The *Technical Director* is the person in charge, plays an assessment role, and takes decisions based on the requirements.

There might be scenarios where only one or two of these companies appear. For instance, a *NO* may have deployed several devices, so both the *NO* and *CDNM* roles are played by this company. Also, all the roles may be played by the same company, such as the case of a cable operator offering contents and owning devices and networks. Regarding the interactions between these companies, *CP* and *NO* interact with the *CDNM*, but rarely interact with each other. These interactions will be defined later.

4 DETAILS OF THE PROCESSES

4.1 Feasibility Analysis

The goal of this process is to establish if it is feasible or not to deploy a service. A deliverable document called *Feasibility Report* will be generated, containing a set of requirements, a first approach to the solution and a preliminary evaluation of costs.

First, the *Manager* of the *CP* must define the service, preparing a document providing a description, its type and important dates and times. Also, some goals need to be included with potential groups of users, number of expected accesses, business and productivity profits, strategic goals, brand improvements, etc. If he has organized other events, the goals can be adjusted with their results.

After that, the *Manager* and *Production Designer* of the *CP* must set their initial requirements. The requirements should be provided to the *Technical Director* of the *CDNM*, and discussed to check their feasibility. Also, the *Technical Director* provides his requirements and, once they have all been discussed, a list of preliminary requirements is obtained. Then they need to establish the risks which may affect the deployment, such as failure to reach the goals.

Now, the *Technical Director* of the *CDNM* must meet the *Manager* of the *CP* to check if the latter has infrastructure which can be reused. Through meetings, a document must be generated stating everything suitable to be used including available communications, servers, software products, licenses and any audiovisual equipment. *UML* deployment diagrams and anchored notes (OMG, 2006) can be used to describe how and where each element is.

After this activity, the *Technical Directors* of the *CDNM* and the *NO* need to establish the deployment plan for each of the available alternatives. At this point it is very important to estimate the required infrastructure as this may have a strong impact on the final cost. To this end, they can use the access expectations stated by the *CP* to estimate the consumption of resources and the needs of this deployment. The more accurate the expectations are, the better the design of the service will be. To achieve this activity, the *Technical Directors* need to discuss hardware, software and communication needs and the final architecture. A document describing the alternatives needs to be produced, with a schedule and an estimation of costs. *UML* deployment diagrams and *Gantt* Charts can be used. The *Technical Directors* also need to agree on the best alternative. The alternatives and the proposal are delivered to the *Manager* of the *CP* who needs to decide if it is suitable or not. If he disagrees, he must meet the *Technical Directors* to reach an agreement.

At this point, and apart from the costs reported by *NO* and *CDNM*, the *Manager* of the *CP* needs to estimate the costs derived from the use of his own resources. These costs are mainly capital expenses (Pisello, 2001) including the costs of reutilized infrastructure and staff. With the estimations, the alternative and the goals, the *Manager* analyzes the expected *ROI* (*return on investment*) of the deployment. This requires the calculation of the *ROI*, *net present value* savings, *internal rate of return* and *breakeven point* (Pisello, 2001).

Finally, the *Manager* puts all the products in a single document called *Feasibility Report* and delivers it to its *CEO* for its review and approval.

4.2 Service Analysis

Once the deployment has been approved, it is necessary to analyze its needs. A deliverable called *Analysis Report* will be generated, with a description of the service, necessary prior to its final design.

First, the *Manager* of the *CP* and the *Service Analyst* of the *CDNM* must meet to further define the service. This includes stating technologies, actors, laws, standards and recommendations. A high-level description of the technologies involved forms the technological environment: encoding formats, software and hardware products, protocols and distribution technologies. Also, a section with

the involved actors should be included stating who is responsible for what. Finally, it is necessary to reflect standards, laws and recommendations, including business, modelling and notation standards and procedures as well as related legislation such as intellectual property rights (EPCEU, 2004) or personal information protection (EPCEU, 2002).

Once the service has been described in detail the *Manager* and the *Production Designer* of the *CP* must meet the *Service Analyst* of the *CDNM* to obtain a final catalogue of requirements. All the requirements associated with the selected alternative must be added to the previous catalogue, such as product requirements (efficiency, reliability, etc.), high-level broadcast requirements (expected quality) and requirements obtained from the description of the service (business standards, legislation, etc.). *SLAs* also need to be defined around measurable events so they can be easily monitored.

It is also necessary to refine the risks identified in the previous process. The *Manager* of the *CP* and the *Technical Director* of the *CDNM* must consider failures in the network, hardware, software, third companies, an unexpected demand, lack of staff, other business risks, delays in the deployment, etc. Now, for each risk a list of possible occurrences must be developed. This will permit to establish a priority for each of the risks. The risks need to be detailed using Ishikawa diagrams (Ishikawa, 1976).

At this point, the *Service Analyst* of the *CDNM* must identify the subsystems to be considered. First, the architecture of the service must be depicted, identifying each subsystem (encoders, servers, etc.). This can be done using *UML* deployment diagrams. Each subsystem must be described providing a name, description, details of the action performed, inputs, outputs, origin and destination subsystems, preconditions and post conditions and actor in charge. It is necessary to distinguish between new and reused subsystems. Subsystems not managed by the *CP* or the *CDNM* need to be put on an *Interfaces with External Subsystems* list.

Meanwhile, the *Production Designer* of the *CP* must define the user interface. First, it is necessary to identify the rules used to decide how the contents should be offered depending on the user device. It is necessary to document screen heights and widths, bandwidths, interaction capabilities and other constraints. For each combination, the *Production Designer* must provide a draft of the layout and a summary of the expected user interactions, if any.

After this activity, the *Manager* and the *Production Designer* of the *CP* must meet the *Technical Director* of the *CDNM* to design a test plan to be used prior to the execution of the service. With the catalogue of requirements, several test cases must be designed, such as checking that all the required subsystems exist, the correctness of their configuration and the compatibility between their outputs and inputs (Myers, 2004). For each test case, it is necessary to provide an id, description, list of affected subsystems, related requirements, expected results and a priority.

Using all the products generated in this process and the previous definition of the service, the *Manager* of the *CP* generates a document called *Analysis Report* which is delivered to its *CEO*.

4.3 Service Design

Several deliverable documents will be produced in this process: a *Deployment Plan* defining how everything needs to be done, a *Quality Plan* to ensure that the initial requirements are met and a *Maintenance Plan* with maintenance routines.

First, the *Service Analyst* of the *CDNM* and the *Technical Director* of the *NO* need to define the architecture of the service. This can be done by reusing products from the previous processes. It is necessary to place every subsystem in a device in a specific location. Again, *UML* deployment diagrams and anchored notes can be used. Physical devices must be defined providing, a description, the list of subsystems running on it, its configuration and the actors in charge. Also, the configuration of each subsystem needs to be added to its definition: it is necessary to define how the inputs and outputs are formatted, reflecting the number of audio and video streams to be generated and their details (codecs, frames per second, bitrate, height and width). The *Catalogue of Risks* needs to be considered here as most of the risks can be minimized and even avoided with an appropriate architecture. Aspects such as fault tolerance and detection need to be considered. It is necessary to develop a *fault recovery and repair* document which includes documenting how the system will recover once a failure has happened and what needs to be done to solve it. For each of the failures in the *Catalogue of Risks* it is necessary to define the involved devices, actors in charge, contact information, workflow to be followed, expected recovery time, loss of capabilities during the failure and equipment and tools utilized. The last product to be generated is a summary of needs including hardware, software and communication needs.

Meanwhile, the *Production Designer* of the *CP*

needs to work on the design of the contents and user interface. Depending on the type of service, it is necessary to establish how the contents will be broadcast. If the service is deployed for a particular event and works with live information, the contents are conditioned by the event. On the other hand, if the service is continuous (24x7) and works with stored information, it is necessary to define the order of the contents. Table 4 shows the minimum set of information to be determined depending on the type of service and contents.

Table 1: Minimum data for the design of contents.

Type	Stored contents	Live
Eventual	Files to be used and their details, order to be followed, length of transmission	Main source of contents and interruptions
Continuous	Files to be used and their details, initial order to be followed and policy of change	

Now the previous user interface guidelines need to be complemented with a detailed description. For each user device set of characteristics, it is necessary to define the type of interface to be used, types of media, encoding qualities and formats for audio, encoding qualities, formats and frames per second for video and a general picture of the layout. If users can perform interactions, these also need to be documented with a description, the place where they can be performed, the expected result, the input device to be used and the set of data associated.

With the previous summary of needs, the design of the user interface and the design of the contents, the *Manager* of the *CP* and the *Service Analyst* of the *CDNM* need to establish which components need to be acquired or need to be developed. These can be developed by the *CDNM* or by an external company.

Now the *Manager* of the *CP* must meet the *Technical Directors* of the *CDNM* and the *NO* in order to agree on the schedule of the deployment. The following needs to be considered: acquisition, installation and configuration of hardware devices and software tools, installation and configuration of network infrastructure, development, installation and configuration of new components, initial generation of contents and satisfaction of legal requirements (EPCEU, 2002) (EPCEU, 2004). Each task needs to be assigned to one or more actors, finish within a predetermined period and shows dependencies with other tasks. They can be represented using *Gantt* charts. It is very convenient to consider in the project schedule the *Service Prototyping* and *System Test* processes of the methodology.

At this point, the *Service Analyst* of the *CDNM* must design the measures to be applied in case some of the previously identified risks occur. If possible, it is necessary to prepare a plan of action with alternatives to apply for each of the avoidable risks, providing contact information for the actors with technical and management responsibilities, tasks to be achieved and reports to be generated.

During the life of the service, it is recommendable to perform frequent analyses as they permit the fulfilment of business goals to be checked, make the error identification process easier and allow administration staff to generate reports. Thus, the *Manager* of the *CP* must agree with the *Technical Director* of the *CDNM* on a frequency to perform analyses and the set of metrics and analyses to carry out: behaviour of the users, perceived quality, consumption of resources, etc.

Now, the *Manager* of the *CP* can develop the *Deployment Plan* with the definition of the architecture, the design of the user interface, contents and components and the project schedule; the *Maintenance Plan* with the fault recovery and repair mechanisms, the design of analysis and improvement cycles, the design of contingency plans and, depending on the service, the policy of updates; and the *Quality Plan* with the analysis of profitability, the refined requirements and risks and the design of analysis and improvement cycles.

4.4 Service Prototyping

After the *Deployment Plan*, a prototype needs to be developed. It needs to be as realistic as possible to perform tests and discover limitations in the service. Two deliverables are produced: *Prototype Report*, with the results of the prototype, and *Change Proposal*, when changes need to be applied.

First, the *Service Analyst* of the *CDNM*, the *Technical Director* of the *NO* and the *Manager* of the *CP* need to agree on the design of the prototype, setting its scope and limitations.

The tests to be performed need to be designed as well. They can be extracted from the test plan or agreed between the *Manager* of the *CP* and the *Technical Director* of the *CDNM*.

Now, the *Operator* of the *CP* needs to produce a set of contents or set up an environment where they can be generated. At the same time, the *Systems Administrator* of the *CDNM* deploys the architecture on a controlled environment provided by the *NO*. After the installation and configuration of devices, the contents or the set up can also be installed.

To execute the tests, the *Systems Administrator*

of the *CDNM* can configure and run a workload loader (Melendi et al, 2005). Its configuration can be obtained from the literature (Veloso et al, 2002) or from the analyses of other events. These parameters also need to be documented. At least, in the tests it is necessary to verify the evolution of the accesses, the maximum number of connections, the evolution of the consumption of resources and transmission problems or bottlenecks. These results, along with the description of the contents, prototype and load, need to be placed in a document called *Prototype Report* by the *Manager* of the *CP*, who also needs to take a decision on the approval of the prototype.

4.5 Deployment

The *Deployment Plan* is executed and, after its completion, the service is ready to operate.

4.6 System Test

It is now necessary to perform the tests designed in the *Test Plan* developed in the *Service Analysis*. A document called *Test Report* will be generated, providing information about the obtained results.

The *Systems Administrator* of the *CDNM* needs to proceed with the tests generating a *Test Report* containing, a table summarizing the results, a description of the execution of each test case and a list of the incidences detected.

The *Test Report* is provided to the *Manager* of the *CP* who needs to take a decision. If no incidences are detected, the service can be put into operation. On the other hand, he can decide to cancel the service, to request the *CDNM* or the *NO* to solve the incidences or to ignore the problems.

4.7 Operation

After the *System Test* process, the service is put into operation and the users of the service may access the offered contents. If any problem is detected the *Maintenance Plan* needs to be followed.

4.8 Evolution Analysis

This process is part of the analysis and improvement cycles designed during the *Service Design* process. The analyses were designed and recorded in the *Maintenance Plan*. Thus, it is only necessary to follow what was stated there. In the end, two deliverable documents, called *Evolution Report* and *Improvement Proposal*, are generated.

The analyses in the *Maintenance Plan* need to be executed by the *Service Analyst* of the *CDNM* and the results written in a preliminary report with some conclusions. With this report, the *Manager* of the *CP* checks the fulfilment of the *ROI* and *SLAs* in the *Quality Plan* by calculating the proper metrics.

The *Manager* of the *CP* and the *Technical Director* of the *CDNM* need to check if improvements can be performed, producing a list of items which may be improved and their priority.

With all the products generated in this process, the *Manager* of the *CP* produces a document called *Evolution Report* which is delivered to the *CEO* of the *CP* for its review and approval.

4.9 Design of Improvements

If some improvements were identified, these need to be defined in detail. This requires the *Technical Directors* of the *CDNM* and *NO* to meet and select the proper solutions. Improvements may require changes in the architecture, in the configuration of the devices, in the network or in the contents. The implantation of these changes requires a new *Deployment Plan*. The structure of this document is similar to that defined in the *Service Design* process so the activities to be performed are the same and depend on the type of improvement.

Once all the activities have been completed another *Project Schedule* is planned and the *Manager* of the *CP* puts all the products in a new *Deployment Plan* which is delivered to his *CEO*.

4.10 Validation of Improvements

Now it is necessary to ensure that the improvements will have the desired effects. Again, following the new *Deployment Plan*, a prototype needs to be developed. Note that it is very useful to reuse the prototype developed in the *Service Prototyping* process. The activities, actors and products of this process are the same as those in the *Service Prototyping* process, so they will not be commented on here. Only the goals change: now the *Manager* of the *CP* needs to know if the service will benefit from the improvements, and if the improvements may cause a deterioration of other aspects of the service.

All the results, along with the description of the contents, the prototype and the load, need to be placed in a *Prototype Report* document by the *Manager* of the *CP* who must decide if the tests are not satisfactory and improvements need to be redesigned, if the tests are not satisfactory and improvements will not be applied or if the tests are

satisfactory and improvements will be deployed.

If the results of the prototype are accepted, the *Manager* delivers the *Prototype Report* to the *CEO* of the *CP* and the designed improvements can be deployed in another *Deployment* process. Otherwise, it is necessary to return to the *Design of Improvements* with the proposals of the *Manager* of the *CP* in a *Change Proposal* document.

4.11 Post-mortem Analysis

Depending on the type of service, this will finish after a certain time. Eventual services are associated to a particular event and once the event finishes, the service finishes. Even a continuous service may end after some time. Thus, it is necessary to analyze what has happened during the service to improve future deployments and generate reports. The *CP* will want to know how the service has evolved. The *CDNM* and *NO* may be interested in the results in order to improve their services. The analyses to carry out are those from the *Maintenance Plan*, also used in the analysis and improvement cycles.

As happened in the *Evolution Analysis* process, the analyses in the *Maintenance Plan* are executed by the *Service Analyst* of the *CDNM*. Their results and a set of conclusions are provided to the *Manager* of the *CP*, who checks the fulfilment of the *ROI* study and *SLAs* established in the *Quality Plan*.

With all the obtained information, the *Manager* of the *CP* produces a document called *End-Of-Service Report* adding a description of the service, the initial goals and requirements and a summary of the changes performed during the analysis and improvement cycles.

5 CONCLUSIONS AND FUTURE WORK

In this paper, a methodology for the deployment of live services is presented. It defines the processes, the roles, the staff, the tasks, the techniques and the products to be generated. It is flexible enough to be used in the deployment of almost any type of live audio and video service, ranging from Internet radios to conventional TV channels. It can be an essential tool for companies interested in the delivery of live contents, offering broadcasting infrastructure or looking for new lines of business. The authors have used the methodology in several live services.

The methodology can be further improved by adding new products to each of its processes and different techniques to make its usage easier. Also, specific metrics can be included to accurately define the analysis activities included in the methodology.

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