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BUSINESS ANALYSIS OF SOFTWARE-INTENSIVE TELEVISION PRODUCTION: MODELLING THE CONTENT PRODUCTION WORKFLOW

A. Spasić*

String, B.Stankovica 26, 18300 Pirot, Serbia

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Abstract

The new technology induced some fundamental changes in the basic workflows and business models of the content creation in the television industry. The changes in how the television broadcasters conduct their businesses lead to the wholesale replacement, or new construction, of practically all the television production and distribution facilities worldwide. The new model of production is based upon: digital formats, the centralized management of media content and associated metadata, non-linear assembly of media elements, high-speed networks, format agnostic distribution and automated processes. An effective software-intensive production system should allow incoming material - text, audio, video and associated metadata - to be available to all users on the system as soon as it arrives at the production facility. The business analyses presented in this paper is done from the point of view of the Information Technology Business Analyst - an integral part of a software development team responsible for documenting and verifying the business and user requirements for a software system. During the analysis of the content production workflow, basic production stages are defined as well as the production processes consisting of. Modelling the behavioural description and the flow of programme production process is made by using the use case diagram and the activity diagram, respectively.

Keywords: Software-intensive system, Content management, Television production, Model of Problem Space (MOPS)

1. INTRODUCTION

The technological changes dramatically altered the way in which television programme is produced and distributed. Broadcasters and media producers are facing an enormous challenge. A wide range of media intensive organizations are struggling

* *Corresponding author: aspasic@string.co.yu*

with a common set of challenges: how to improve their production models and cope with an increasingly futile battle against massive amounts of videotape, constantly evolving digital standards, and increasingly fragmented workflows. In an industry where margins are often razor thin and operational budgets have been squeezed to the breaking point in an effort to provide the highest quality content for the lowest possible cost, tape-based production models are beginning break down. Traditional production workflows are incapable of accommodating the immense proliferation of new formats and the increased pace of digital production.

Video and audio compression methods, server technology and digital networking are all making a big impact on television production, post-production and distribution. Accompanying these technological changes are potential benefits in reduced cost, improved operating efficiencies and creativity, and increased marketability of material. Countering the potential benefits are threats of confusion, complexity, variable technical performance, and increased costs if not properly managed.

The competing interests of a variety of factors, such as audience, equipment manufacturers, content producers or advertisers, play significant roles in the business processes, and the area in which their interests converge is relatively small [1].

The success or failure of new technology is not dependent upon whether it is innovative, useful, or desirable but rather on questions of whether it can find a means of obtaining and maintaining sufficient usage and turnover so that it is not rejected by users, entrepreneurs, or financiers.

Program makers in search of a solution quickly discover that there is no existing model within the broadcast and production industry to which they can turn. Today's "off-the-shelf" digital production solutions rarely do everything needed by the typical media enterprise. Ultimately, what is needed is a complete re-thinking of the way technology can be applied to the art and business of program making.

The main goal of this paper is to analyze this area of interest in a systematic way and to discuss underlying organizational and technical issues.

2. THEORETICAL BACKGROUND AND LITERATURE REVIEW

Business models have been described as the architecture for the product, service, and information flows, including a description of the various business activities and their roles. They include a description of the potential benefits for the various business actors and the sources of revenues [2].

A business model embraces the concept of the value chain, that is, the value that is added to a product or service in each step of its acquisition, transformation, management, marketing and sales, and distribution. The value chain concept for products and services is now well established in business literature in which it was widely embraced after its exploration by Porter [3]. This value chain concept is particularly important in understanding market behaviour because it places the emphasis on the value created for the customer who ultimately makes consumption decisions.

In [4] it is emphasized that in the traditional value chain the core competence in the (public) broadcasting institution is the (continuing) mandate to conduct the "broadcast mission" as a public service with strongly democratic aims. Broadcasting business history between the late of the 80s and the end of the 90s featured a modernized version of an analogue value chain where the substantive work of corporate planning activities expressly coordinated the development of strategic programming goals with targeted resource allocation. The analogue era featured an approach based on controlling production. The management strategy separated programming activities, content production and resource functions. The digital value chain emphasized its technological convergence, customer orientation and increased market competition.

A key element of the new broadcasting system architecture is the adoption of a strategic business process architecture derived from a high-level value chains analysis. This leads to an enterprise view based on functions and activities which add value, rather than on the organizational, historical or geographical factors which have traditionally governed broadcasters' choice of technology solutions. Abunu et al. in [5] identified five distinct regions in the broadcast value chain: consumer, broadcasting, asset management, producing and business support.

According to Shannon and Weaver's model of the communication process [6], also known as a general communication model, a message begins at an information source, which is relayed through a transmitter, and then sent via a signal towards the receiver. But before it reaches the receiver, the message must go through noise (sources of interference). Finally, the receiver must convey the message to its destination.

Not surprisingly, many people (in almost every field) have developed much more complex, socially situated models of the communication process that take into account the reader's role in the construction of meaning, the contingency of meaning, the context in which communication takes place, politics, and other factors. The model of the content production and distribution that is in the base of the broadcasting business process can be represented as a simplified version of the above mentioned general communication model [7].

European Broadcasting Union (EBU) and the Society of Motion Picture and Television Engineers (SMPTE) formed a joint Task Force for the Harmonization of Standards for the Exchange of Programme Material as Bitstreams. Its purpose was to facilitate exchange of programme material in the face of the move from tape to disc storage. The Task Force was charged with two assignments: (i) to produce a blueprint for the implementation of the new technologies, looking forward a decade or more, and (ii) to make a series of fundamental decisions that will lead to standards which will support the vision of future systems embodied in the blueprint. In 1998 an EBU/SMPTE Task force published their Final Report [8]. In present time-moment, many of the technical concepts described in the report are already implemented or are at advanced stages of development. The improved capabilities in hardware platforms permitted systems to be based on radically new concepts, aimed at achieving the required improvements in efficiency and utilization. The new concepts included: programme data transport in the form of compressed bit streams, non-real-time data transfer, simultaneous, multi-user access to random programme segments stored on servers, inter-networking on open platforms of all production tools within the post-processing chain, hierarchical storage concepts based on tape, disk and solid-state media and the treatment of data on an opportunistic basis. The work of the Task Force is presented in [9]. As well as proposing a layered model for broadcast system architectures similar to the ISO/OSI communication model, the EBU/SMPTE task force proposes the use of an object oriented reference model as a way of abstracting the detail of devices and their properties away from their management and control.

The SMPTE Advanced System Control Architecture Working Group continues the work that resulted from the EBU/SMPTE Task Force [10]. The entirety of the broadcast operations is visualized in [11] and the fifth component plane is suggested - the management services plane. The component planes (X axis: device, path, service, content and management services) refer to the primary means of programme generation and transmission. The communication layers (Y axis) relate to the standard ISO/OSI 7-layer stack with the physical layer at the bottom and high-level network applications at the top.

The value and cost of digital broadcast equipment are now primarily in the software rather than in the hardware. However, the marketing model for broadcast equipment is still based on loading all the development and support cost into the hardware, while the software, including upgrades and maintenance, is provided at low or no cost. This model is outdated and serves neither the manufacturer nor the purchaser well.

Software engineering must respond to the growing complexity of systems and the requirement for high quality, bug-free and fast implementation upon a wide variety of platforms. Albert and Brownsword in [12] defined software intensive system as "one that relies on software to provide core/priority mission function(s)". More detailed, software intensive systems are those complex systems where software contributes essential influences to the design, construction, deployment and evolution of the system as a whole [13]. There is a growing body of knowledge in the application of architectural concepts to these systems to attain the benefits of reduced costs and increased quality, such as usability, flexibility, reliability, interoperability and other system qualities.

Above mentioned Shannon and Weaver's model of the communication process is related to modelling end users' requirements for software intensive systems [14]. This relationship emphasizes the importance of end users' requirements and justifies the need for a requirements-driven software development process. Shannon and Weaver define information as a reduction in uncertainty. For a system to be of value to its users, it has to reduce the user's (user is equated with receiver) level of uncertainty. Modern software development processes are driven by user requirements.

3. TRADITIONAL MODEL OF TELEVISION PRODUCTION PROCESS

Traditional production is based on analogue processes and expensive analogue components without computers in the technological system, minimal using of the computers in the other parts of workflow and tape-based technological chain.

Segment production, in which primarily archival material is used to assemble the final program, has traditionally been characterized by organic workflows and extremely high quality output. It is built around analogue processes that depend on expensive equipment located in expensive facilities. Media is edited and stored on magnetic tape, production tasks are strictly defined, and workflows are largely linear in nature.

Much of the same has been true for real time production environments. Except that in a nightly news or sports production studio, the production cycles are often razor thin. Material must be scripted, edited, and sent directly to air. Production systems in this environment are mission critical and, therefore, must be extremely stable and fault tolerant. Nonetheless, the workflows are still primarily linear and tape-based.

The simplified chain of production is shown in figure 1 [15].

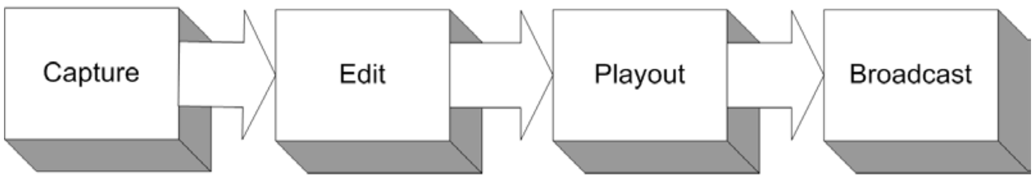

Figure 1: Simplified chain of the traditional production

A production process can be considered in a number of stages. A program's life begins with scheduling, research and planning. Video shots, audio clips and other program items are created during the acquisition stage. In this stage, archived material is also checked for immediate suitability for re-purposing. Next stage is editing, when shots, clips, animations and assembled items are put in the order. After editing, program is sent to delivery point for transmission or play out. Finally, program is archived on tapes.

Traditional tape based production systems have been very successful over the past decades however they have all suffered from a number of fundamental limitations

In general tape based workflows are linear in nature; one task has to be completed before the next can begin. For example the recording of source material from an incoming feed to tape has to be completed before the tape can be taken to the edit suite, on completion of the edit it is again laid back to video tape and taken to a playout tape machine.

The following represents just a few of the problems experienced by traditional tape-based production systems [16]:

- Locating appropriate footage is difficult and time consuming

  Text-based library systems are extremely limited and hard to use. Locating the right shot takes time and, once a promising shot is located, the system may only provide a written description. It is still necessary to physically get the tape in order to view it. If it turns out that the shot is no good, the producer is back at square one.

- Tape is expensive to store and to transport

  A production studio may possess thousands of hours of footage. At a busy studio, many of these tapes will be in constant use. So, despite expensive accommodation costs, on site storage is often the only option. When specialist footage is involved, such as nature or sports video, the need for a dedicated on site archive is even higher. Even when tapes are not stored on site, the costs involved in transporting tape between libraries and studios can be considerable.

- Tapes are easily lost or damaged

Every production will lose tapes. This is particularly true for large productions that require a great deal of archival footage. Producers may replay the same tape over and over again. Each time a tape is played, digitized, or transferred to another format, it degrades. Ultimately, it may become unplayable or even break. When a master tape is lost or damaged, there may be no way to retrieve the data. Sometimes unique footage is lost forever.

- Tape formats are proliferating at an alarming rate

There are more than 14 different tapes formats on the market and many programs end up using up to six of them. European Broadcast Union defined List of codes for Recording supports [17] and 131 types of the recording media are mentioned in this document.

Even programs originated on tape often have to be transferred to other formats for editing purposes. Production units are forced to carry an incredible variety of tape machine and spend thousands of dollars every year to buy new equipment or replace existing equipment that has worn out.

4. THE METHOD

A model, by its very nature, is an abstraction of the reality. The modeller, depending on his/her needs, keeps parts of the reality that are important to him/her in a particular situation and leaves out others which may be considered less important. Therefore, the model is not a complete representation of the reality. Modelling raises abstraction to a level where only the core essentials matter. The resultant advantage is twofold: easier understanding of the reality that exists and efficient creation of a new reality [18]. However, the role of modelling is even more important in software development, where it provides the means of understanding existing software systems, as well as in developing and customizing new software systems. Modelling also facilitates smoother creation of the new reality. For example, creating a model of a software system is much easier, cheaper and faster than creating the actual system.

Software projects use modelling throughout the entire life cycle. Subsequently, modelling is used not only to create the software solution but also to understand the problem. The modelling output in such software projects transcends both data and code and results in a suite of visual models or diagrams. Successful modelling needs to consider the areas in which modelling needs to take place. These modelling spaces have been formally considered and discussed by Unhelkar in [18]. The three distinct yet related modelling spaces are defined: problem, solution and background. These divisions provide a much more robust approach to modelling, as they segregate the models based on their purpose, primarily whether the model is created to understand the problem, to provide a solution to the problem, or to influence both of these purposes from the background, based on organizational constraints, and need to reuse components and services.

In UML (Unified Modelling Language) projects, model of problem space (MOPS) deals with creating an understanding of the problem, primarily the problem that the potential user of the system is facing. While usually it is the business problem that is being described, even a technical problem can be described at the user level in MOPS. In any case, the problem space deals with all the work that takes place in understanding the problem in the context of the software system before any solution or development is attempted. Typical activities that take place in MOPS include documenting and understanding the requirements, analyzing requirements, investigating the problem in detail, and perhaps optional prototyping and understanding the flow of the process within the business. Thus the problem space would focus entirely on what is happening with the business or the user [19]. As a description of what is happening with the user or the business, the problem space will need the UML diagrams that help the modeller understand the problem without going into technological detail. The UML diagrams that help express what is expected of the system, and how the content production workflow is organized, are of interest here. The UML diagrams used in this paper are:

Use case diagrams-provide the overall view and scope of functionality. The use cases within these diagrams contain the behavioural (or functional) description of the system.

State machine diagrams-used to help us understand the dynamicity and behaviour of the problem better.

5. REQUESTS FOR REENGINEERING OF PRODUCTION WORKFLOW

As already stated, traditional tape based production systems suffered from a number of fundamental limitations. Tape based workflows are linear in nature - one task has to be completed before the next can begin. As the essence passes from the idea to the finished program, it passes through the different stages along a chain in which the quantity and complexity of the essence increase and decrease from step to step. Traditional programme production process can be considered on a number of stages as shown on figure 1, and the handover from one stage to the next comprises a mix of videotape, proprietary multi-media files, Word documents, Excel spreadsheets, faxes, sticky labels, notes and 'word-of-mouth metadata' transfer.

Producers need to know what they are working on, they need to know when the work needs to be finished, they need to know that they have approval from their managers, and they need to be able to communicate with others that are working on the same project. Presently workflow tools are a separate entity from the tools actually used to complete the work. Workflow is directly connected to, and affected by, the integrated toolset tasks, and vice versa. An effective digital production system should allow incoming material - text, audio, video and associated metadata - to be available to all users on the system as soon as it arrives at the production facility. Producers should be able to edit text, audio, and video as well as create graphics at the desktop and assign the item to particular users as required or store it on a 'virtual shelf' for later use. Producers must also have research capability at the desktop, with online access to archive material.

Rights and billing information must be available at source. However, the system should not require the producer to know precisely where a video or audio asset is physically located. Instead, it should provide producers with enough information to identify the content, to know how long it will take to obtain the media, and whether he/she has the rights to use it and at what cost. Ultimately, such systems should include full-scale transmission by both conventional broadcasting and the Internet.

What is needed is a fully integrated, standards-based environment that provides the following features and functionality:

- Targeted re-use of high value assets through long term storage and management of digital video and related metadata
- The ability to encode and manage video in a variety of resolutions from web quality proxies to full broadcast quality
- Greater use of software intensive systems rather than expensive digital video hardware
- Low-cost desktop editing that integrates directly with high-end production systems and workflows
- Aggregation of multiple underlying data sources, devices and applications into a single high quality user experience
- Integration of business data such as rights clearances and production financials into core production lifecycle and workflow
- Rigorous standards compliance for interoperability with other systems in the studio
- Modular framework for fast and cost effective customization
- Support for both real-time and non-real-time production workflows
- A library of archive stock shots stored near-line for direct access
- Support for a distributed and fully collaborative workflow
- A single common interface for accessing all systems
- All components built to withstand the rigors of broadcast quality production and playout

6. ANALYSIS OF CONTENT PRODUCTION WORKFLOW

Basic production stages are defined here as follows: development, planning, acquisition, processing, control, archiving and publication. These stages are shown on figure 2 as well as the production processes consisting of.

Development

A programme's life traditionally begins with a need to fill a slot in a schedule. New skeleton schedule is produced from the analyses of the audience numbers and reactions. This schedule has to encompass details of the programme categories, possibilities for re-using (repeat) of the programmes as well as outline budgets of the programmes required to fit into slots.

During the development stage, programme ideas are investigated and a commission results when the producer persuades the TV company to finance the conversion of an idea into a real programme. The commission is very important for production as it gathers some key information like the 'working' title, producer's identity, possibly contributor's names, genre and possibly initial scripts. It could well have financial decisions which subsequently apply to the rest of the programme making process. When a commission has been accepted research was doing and archives and other databases are

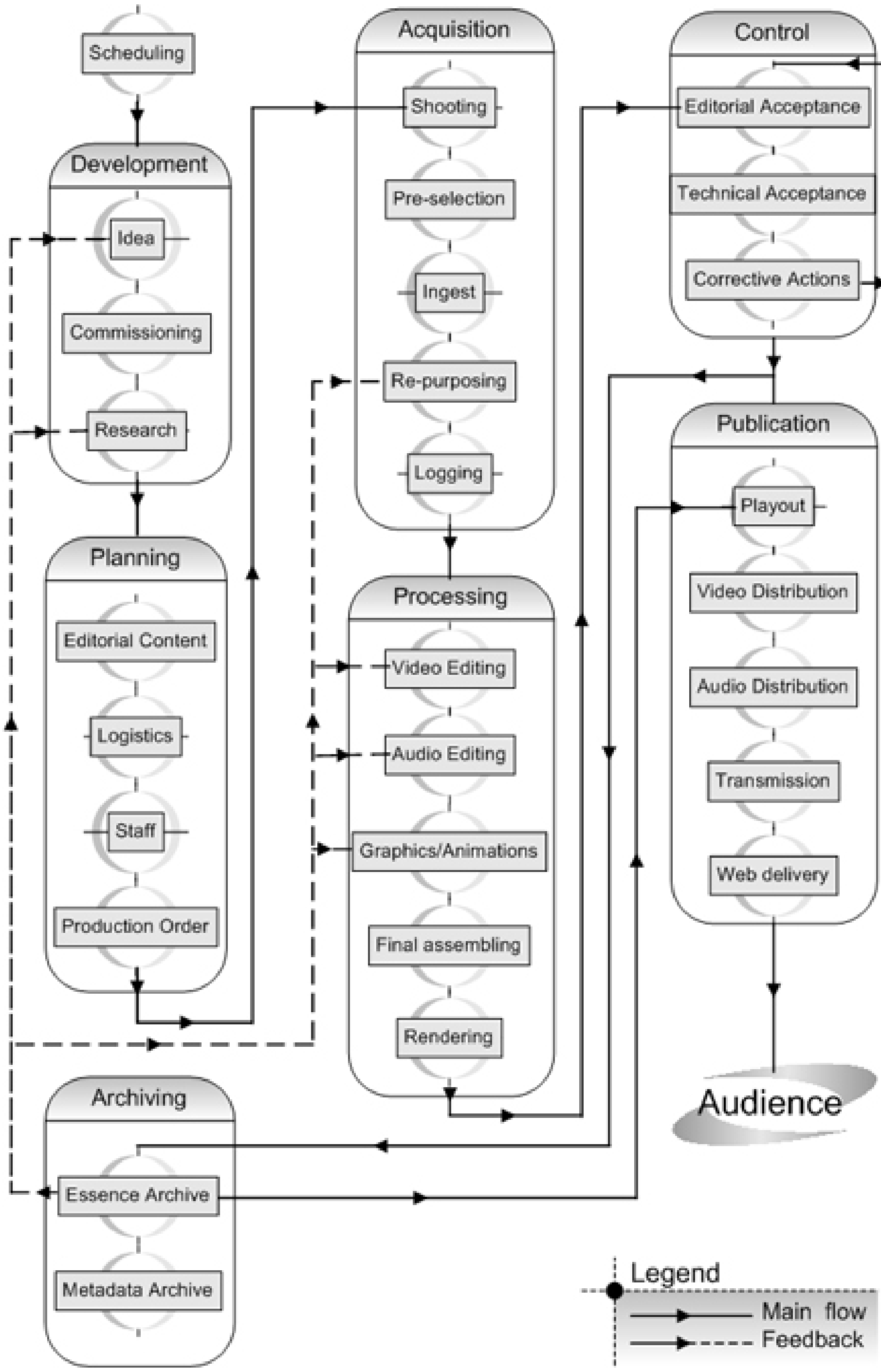

Figure 2. Television Programme Production Workflow

examined for potential contributors, locations, facilities and material that can be re-used.

Planning

On the end of the planning stage a production order may be produced. The planning encompasses the staffing, resources and also the creation of the artistic description in the form of a storyboard and script.

Acquisition

During the acquisition stage, video shoots, audio clips and other programme items are created, pre-selected, ingested into production system and logged. The obvious capture device is the camera, but equally, sound effects, graphics, stills, captions and music may all be added. At all points in capture there is an opportunity for metadata collection. Some of the metadata, like producer's comments and annotation, can only be captured by direct entry at the time of shooting. The metadata at this point in the chain should be viewed as 'portable', carried along with the essence as a link directly to a central. The importance of the ingestion process is emphasized in [20]. During the ingest we take all the content collected during a shoot, as well as new metadata, and transfer it into the production environment. We assume that the planning and commissioning metadata is already in the system. More metadata can be generated at ingest and this can either be directly entered, for example by an operator marking technically poor sections, or regions for special processing, or it can be extracted automatically. Logging is where the producers review what they have, and mark down its possible use. It is expected that all the metadata capture that has taken place up until this stage will greatly reduce this overhead.

Processing

Processing stage represents a craftsman work where the shoots, clips, sounds and already assembled items are put into an order. Whole editing process, which is consisting of video and audio editing, has to be concentrated on capturing the composition metadata, so called Edit Decision List, in order to accurately represent the artistic composition of the programme from its constituents. Different graphics, subtitling as well as animations are produced and added to the essence.

Control

Editorial and technical acceptances, which are the constituent parts of the recurrent control stage, approve the use of the produced programme material. If the corrections are needed, corrective action must be undertaken until editorial and/or technical approval is received.

Archiving

Approved final product is catalogued and stored in archive. Archiving is one of the most important and most demanding organizational and technical processes in whole television production. Over time, media-rich organizations realized the value of their media assets. For instance, BBC Archive system has more than 750000 hours of television programmes in the archive, receives over 2000 enquires each weak and loans 45000 items per month [21]. Archival system is usually consisted of different servers such as workgroup media servers for short term storage and deep archive media servers for long term storage. Among the other things, archival systems can contain and manage metadata archives, low resolution archives as well as archives of still images, effects, sounds and other media related data. Archival in any form requires metadata to be captured and archiving is a prime candidate for metadata re-use, as the metadata is the basis for a comprehensive search. The capture of metadata not only enhances the search, but also removes some of the overhead and uncertainty that archivists can have in cataloguing the material.

Publication

Publication is the last but not least stage in the new production workflow. Playout process allows scheduled showing of the programme produced at earlier stages. Programmes, whether live or played from archive, are sent to the delivery point (transmitter chain, web etc.).

7. MODELLING THE LIFE CYCLE OF THE CONTENT: STATE MACHINE DIAGRAM

The traditional emphasis of the media business has been the creation, bundling and distribution of content consisted of information and entertainment. In publishing and media, content is information and experiences created by individuals, institutions and technology to benefit audiences in venues that they value (http://en.wikipedia.org/wiki/Content).

The creation of the content that is of interest to users is the basic issue in the broadcasting business model. Advances in the development of interactive and multimedia technologies are increasing the number of producers and the availability of content and are forcing traditional media industries to develop new understanding of their roles in creating, processing and storing content.

The nature of the state machine diagram is considered dynamic-behavioural. The state machine diagram of UML has the ability to represent time precisely and in a real-time fashion. "What happens at a certain point in time?" is a question that is answered by this diagram. Because of the dynamic nature of state machine diagrams, they are ideal for modelling real-time systems. These diagrams also show the entire behaviour of one object-depicting the life cycle of an object as it changes its state in response to the messages it receives. The state machine diagram representing the life cycle of the television multimedia content is shown in figure 3.

8. MODELLING BEHAVIOURAL DESCRIPTION OF CONTENT PRODUCTION: USE CASE DIAGRAM

The main objective of a use case diagram is to visualize how the user (represented by the actor) will interact with and use the system. This is done by showing the actor associating with one or more use cases and, additionally, by drawing many use case diagrams.

The main objective of the use case (compared to a use case diagram) is to document a process within the system. This is the documentation (content) of the functional requirement of the system.

Use case diagrams can be used by the project manager to scope the requirements. The system designer (or architect) can use them to start creating model in the solution space. An important purpose of use case diagrams is to help schedule development. A comprehensive list of use cases in a use case

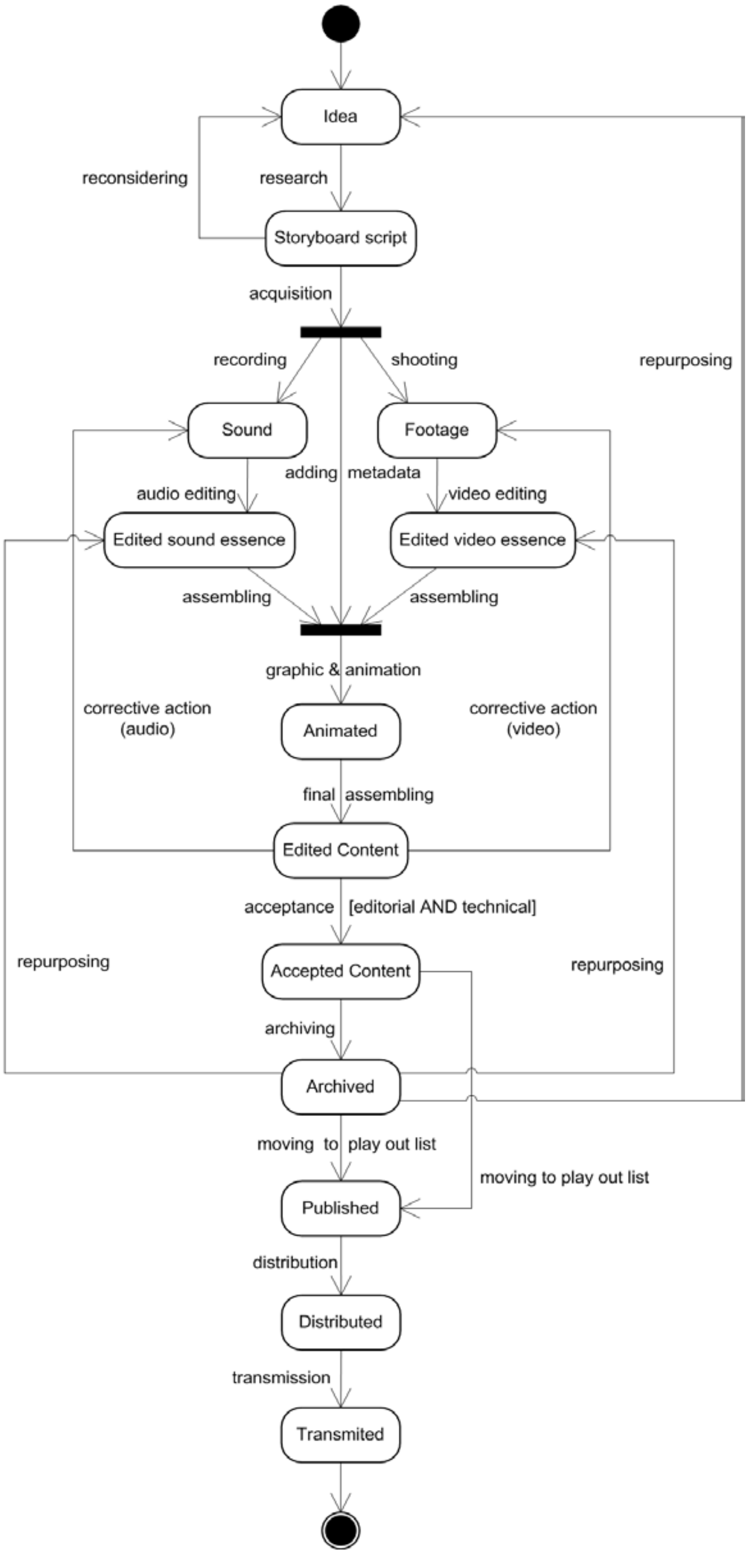

Figure 3. State Machine Diagram of Television Content Life Cycle

diagram helps the users, together with the business analyst and the project manager, to decide which use case(s) to include in the initial iteration of the development cycle.

One of the important strengths of a use case diagram is its ability to model the actor (role). The actor demonstrates clearly to the user who is involved in specifying requirements and where he exists in the context of the software system. The actor also plays a crucial role in enabling the business analyst to understand and document the user's requirements. In addition, the actor helps users to express their requirements in greater detail.

Use cases and use case diagrams help to organize the requirements i.e. use cases document complete functional requirements.

Use case diagrams also provide an excellent mechanism to document the context of the system. By creating a system boundary, it is possible to clearly visualize what is inside the system as compared with external entities in the system, including the users.

Use cases important for modelling in problem space of the programme production are as follows: Research and Develop Idea, Plan Logistic and Staff, Acquire Raw A/V Essence and Metadata, Process A/V Essence and Metadata, Control, Manage and Use Archives, and Publish. The main actors in problem space of the programme production are the producer, the technical manager, the archiving system, the essence gathering crew (the cameraman, the sound recorder), the processing crew (video and audio editors, the animator), the publication system (playout and web delivery subsystems), as well as the audience. The audience is second-level actor, i.e. it is out of boundaries of the system. Actors and use cases are presented in Use case diagram shown in figure 4.

9. CONCLUSION

Video and audio compression methods, server technology and digital networking are all making a big impact on television production, post-production and distribution.

Management concepts can be applied to a wide variety of applications related to the generation and use of audiovisual materials, also outside the broadcast world. Therefore, systems must be conceived with the necessary degree of flexibility required to tailor software and hardware infrastructure and functionalities to the performance demanded by specific applications without incurring into bottlenecks of unjustified investments.

As content is one of the most valuable assets for broadcasting companies, ingesting, archiving, accessing, managing, delivering and security of content assets become basic requirements in the everyday life of multimedia producers and providers; at the same time, it becomes ever important the way the company structures its facilities, the processes involved and how it chooses the technologies that best adhere to the purpose related to content handling.

The new model of production and post-production is based upon: digital formats, the centralized management of media and metadata, non-linear assembly of media elements, high-speed networks, format agnostic distribution and automated processes.

The primary aim of this paper was to describe the main areas in a common production and broadcasting environment and to summarize the essence, metadata and control flow, as well as the main processes involved in a typical modern television facility.

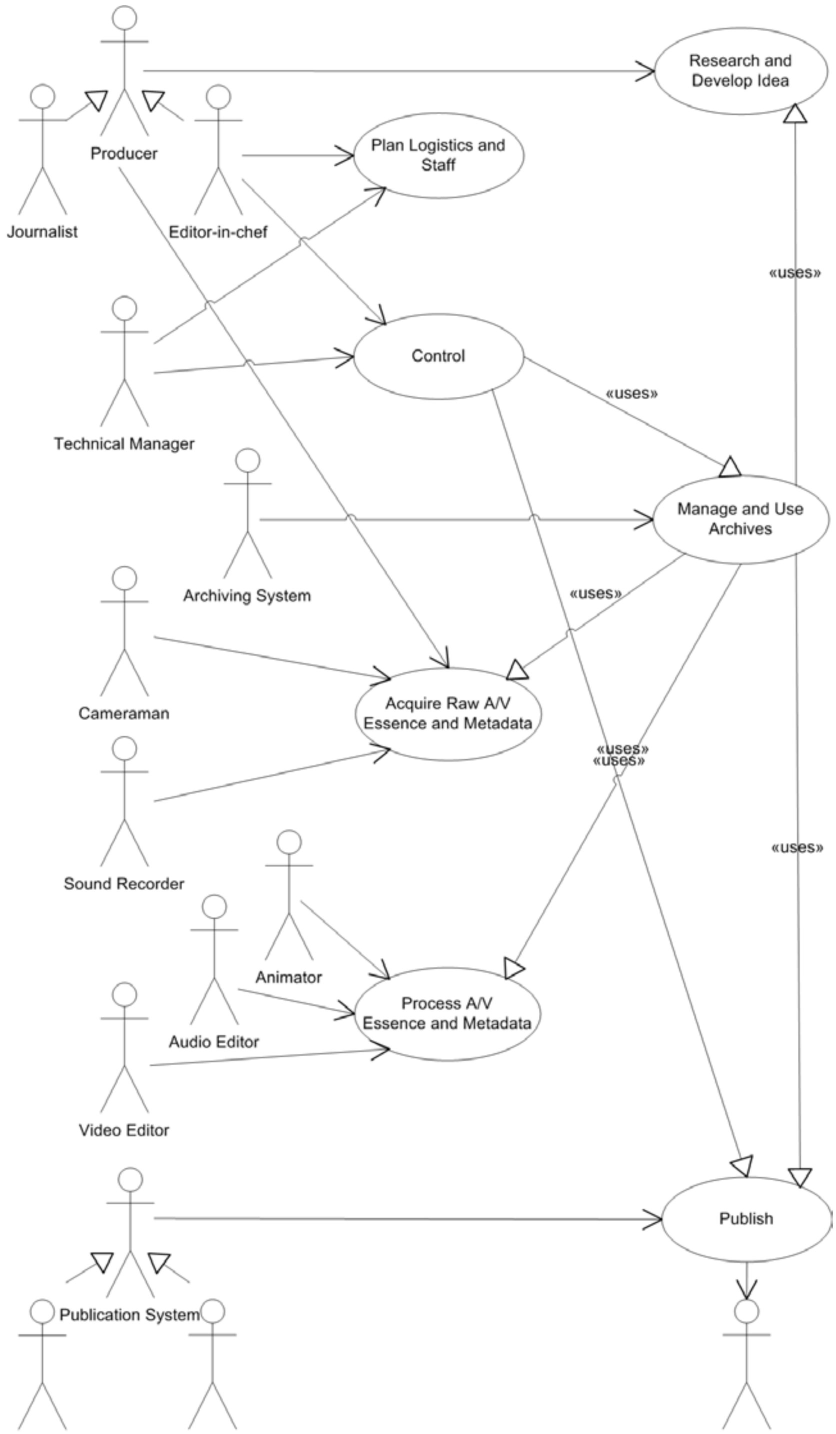

Figure 4. Use Case Diagram of Programme Production

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