Modelling Software-Intensive Ingest System: Behavioural Description and Domain Model

Aleksandar J. Spasic, Dragan S. Jankovic

***Abstract* — The new model of television 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 to be available to all users on the system as soon as it arrives at the production facility. 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. Behavioral description and domain model of ingest system in problem space are presented in this paper. During the analyses of new content ingest workflow, behavioural description is modelled by the Use Case diagram. Structural static representation is presented with Class Diagram.**

***Keywords* — Software Intensive System, Content Management, Television Production, Ingest System.**

I. Introduction

A. Background

The technological changes dramatically altered the way in which television programme is produced and distributed. Small and medium-sized broadcasters had opportunity now to produce the multimedia content in the quality which is comparable with content produced by big players in broadcasting market. Importance of the independent networked local and regional television broadcasters is described in [1] and [2].

Media asset management (MAM) is consisted of the processes and systems responsible for the identification, capture, digitization, storage, cataloguing, retrieval, use and re-use of multimedia materials. Essence is the media itself e.g. video, audio, graphic, still image, text. Metadata is any information related to essence or describing essence, but not the essence itself. Metadata holds the key to the usefulness of the essence to the user. It can permit media assets to cross over between multimedia applications and to contribute positively in each and every application environment. Content is the combination of essence and metadata. Asset is the combination of content and rights.

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Traditional tape based production systems have been very successful over the past decades. However they have all suffered from a number of fundamental limitations [3].

An effective modern digital production system should allow incoming media – text, audio, video and associated metadata – to be available to all users on the system as soon as it arrives at the production facility.

Business process definition and analyses of production stages are shown in [4]. Basic production stages defined here are: development, planning, acquisition, processing, control, archiving and publication.

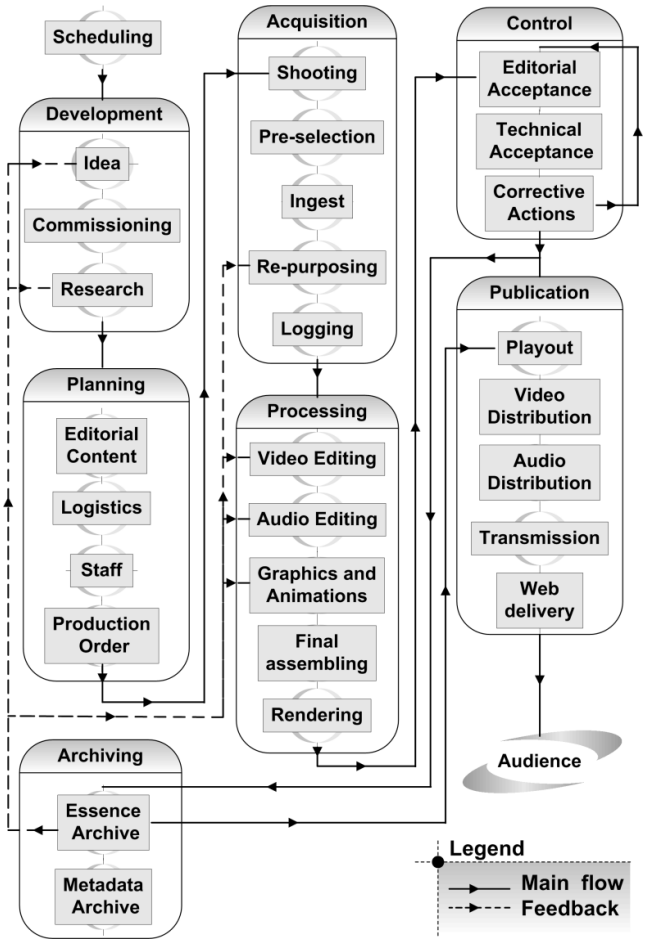

Fig. 1. Program Production Workflow

These stages are shown in Figure 1, as well as what the production processes are consisted of. At each step in the production workflow we can collect, and possibly re-use the metadata.

B. 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. 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 [5]. 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 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 [6].

The UML diagrams that helps express what is expected of the system, rather than how the system will be implemented, are Use Case diagrams. 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.

Class diagram is used in this paper to provide the structure of the domain model. In the problem space, class diagrams represent business domain entities, not the details of their implementation in a programming language.

II. Ingestion Workflow

During the acquisition stage, video shoots, audio clips and other programme items are created, pre-selected, ingested into production system and logged.

The importance of the ingestion process is emphasized by Airola, Boch and Dimino in [7] and noticed that *"crucial problem of Content Management Systems (CMS) is constituted by the ingestion of new content. As we cannot realistically expect that all the aspects of a production/archive environment are under the rules of a CMS, we need to set up gateways through which the content must pass when migrating from a non-managed environment to a CMS. The role of these gateways, that we call Ingestion Systems, is that of collecting and organizing as many relevant information (metadata) on the item as possible ... ".*

Ingest is the first stage to efficiently transfer the content to the television production infrastructure. 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 are 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.

Simplified ingestion workflow is shown in Figure 2.

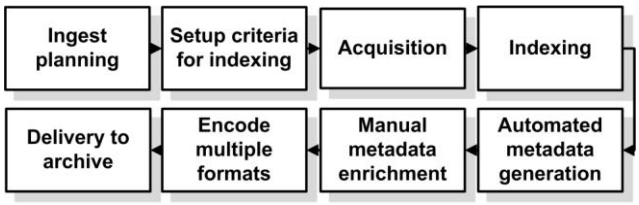

Fig. 1. Ingest Workflow

Ingestion can be considered in terms of two processes, or fundamental tasks:

- Content acquisition and optimization, and
- Content description and referencing.

Content acquisition and optimization assume capturing the audio-video essence and content compression. The obvious capture device is the camera, but equally, sound effects, graphics, stills, captions and music may all be added. Typically, users of Content Management System will want to utilize high resolution master file (MPEG2 encoded) which contains the content in professional broadcasting quality, as well as low resolution proxies of same content for searching and previewing archived material or for web delivery. Ingest system should provide automatic generation of high and low resolution content representations.

During the content optimization the key frames should be extracted and recorded. Key frames are valuable for providing asset management solutions with representative images for browsing video, as well as for making edit decisions. Key frames should be extracted and converted to JPEG images based on scene changes or predefined time intervals.

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. Also, technical metadata, like time code information or light information can be captured from camera. Manual adding of metadata for description and indexing of content, however, should significantly enrich the content and support the asset management applications.

III. Modelling Behavioural Description of Ingest Process

The main objective of a behavioural description is to visualize how the user (represented by the UML 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.

Main actors in problem space of ingest process are producer, ingest operator, essence gathering crew (cameraman, sound recorder) and ingest automated system.

Use cases important for modelling in problem space of ingest process are as follows: Ingest planning, Setup criteria for indexing, Start acquisition, Automated metadata generation, Manual metadata enrichment, Indexing, Encoding multiple formats and Delivery to Archive. Use Case diagram is shown in Figure 3.

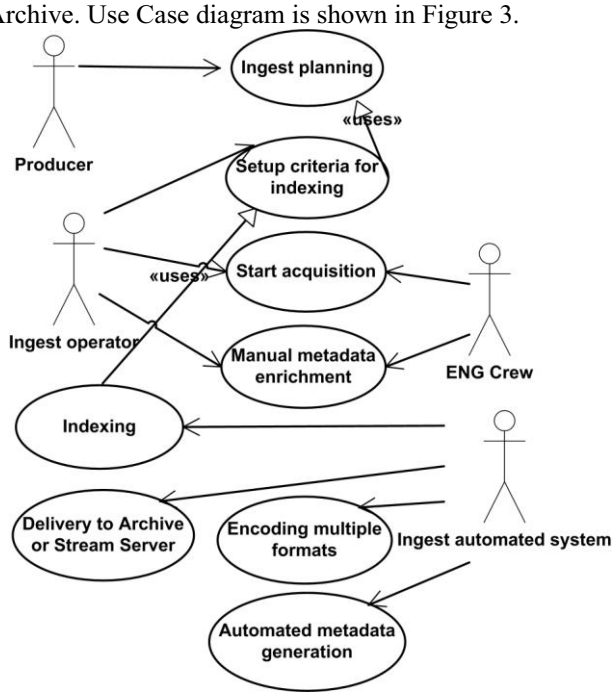

Fig. 2. Use Case diagram of Ingest Process

A. Use Case - Start Acquisition

Short Description: Video shoots, audio clips and other essence items, as well as attached metadata are extracted from the continuous acquisition bin, such as cameras, sound recorders, digital tape players, different editing workstations, servers etc.

Actors: Ingest operator and essence gathering crew members.

Pre-Conditions: Video essence (footage) is shoot, audio essence is recorded, other program items are created and pre-selected.

Post-Conditions: All essence materials, as well as related metadata, are ingested into production system.

Main Flow: (1) Ingest operator starts acquiring the raw material or previously produced essence from cameras or other sources. (2) During ingest all the content collected during a shoot, recording and repurposing, as well as new metadata is taken and transferred into the production environment. (3) Ingest operator reviews what he/she has, and marks down its possible use. Use Case terminates.

B. Use Case - Indexing

Short Description: Ingest system extracts a number of key attributes from the source essence and converts them to metadata.

Actors: Ingest automated system.

Pre-Conditions: Criteria for indexing are defined and parameters are setup.

Post-Conditions: Key attributes are extracted and related metadata are produced.

Main Flow: (1) System analyzes the acquired essence in accordance with parameters which are previously set-up. (2) Metadata generator module produces related metadata. Use Case terminates.

C. Use Case - Automated metadata generations

Short Description: System generates metadata from the acquired essence files.

Actors: Ingest automated system.

Pre-Conditions: Essence material, as well as files with related metadata, are ingested into production system.

Post-Conditions: Metadata are stored in database.

Main Flow: (1) System search for metadata files accompanying acquired essence. (2) System checks the metadata format and if metadata format is in accordance with systems metadata formats, metadata are stored in database. (3) If metadata format does not confirm, corrective actions must be undertaken [alternate flow A1]. (4) Steps (1) and (2) are repeated until all metadata is generated and Use Case terminates.

Alternate Flow (A1): No need for corrections. Metadata are approved and stored in database.

D. Use Case - Manual metadata enrichment

Short Description: Automatic extracted metadata can be validated. New metadata (descriptions, business information etc.) can be added.

Actors: Ingest operator, Essence gathering crew member.

Pre-Conditions: Essence material, as well as files with related metadata, including indexed and generated metadata are ingested into production system.

Post-Conditions: Stored essence, as well as related metadata.

Main Flow: (1) Ingest operator validates previously generated indexes and metadata. (2) Ingest operator add new descriptions of essence. Use Case terminates.

E. Use Case - Encoding multiple formats

Short Description: Create high-resolution master essence file and low-resolution proxy file.

Actors: Ingest automated system.

Pre-Conditions: Essence acquired, metadata generated and stored in database.

Post-Conditions: Essence encoded in hi-resolution version and stored in archive. Essence encoded in low-resolution version and delivered to stream server.

Main Flow: (1) In accordance with production format essence is encoded in high quality broadcast format

(usually MPEG2). (2) Essence is encoded in several different versions of low-res. files. Use Case terminates.

F. Use Case Delivery to Archive and Stream Server

Short Description: System stores essence in deep archive and send low-resolution proxies to stream server.

Actors: Ingest automated system.

Pre-Conditions: Essence is encoded in hi-res version. Essence is encoded in low-resolution version.

Post-Conditions: Essence is stored in archive. Essence is delivered to stream server.

Main Flow: (1) System stores essence in deep archive. (2) System delivers low-resolution proxies to stream server which serves low-resolution proxies for searching, previewing, non-linear editing etc. Use Case terminates.

IV. Domain Model of Ingest Process

The objective of modelling structural static representation is to represent, in one or more views, various business entities and their relationships in MOPS.

Class diagrams, by their very nature, are very strong, structural, static representations. Class diagrams show business-level classes as well as technical classes derived from the implementation language. In addition to showing the classes, class diagrams show the relationships between them. The entire description of the classes (or "entities," as they may be called in the problem space) and their relationships with each other is static. No dependency is shown in this diagram and no concept of time. Class diagram of the ingest process is shown in Figure 4.

V. Conclusions

The primary aim of this paper was to describe ingest system as one of the main areas in a production environment and to summarize the essence, metadata and control flow, as well as the main processes involved in a typical ingesting of television content.

The first step in modelling of software intensive ingest system, modelling of problem space, is presented here. Use Case diagram is used as an ultimate tool for behavioural description of the ingest system. Class diagram is used for description of Domain model.

The challenge for the future is to make complete business analysis of problem space using the use case, class, activity, state machine and sequence diagrams. Also, the model of solution space, as well as the model of background space should follow the current work presented in this paper.

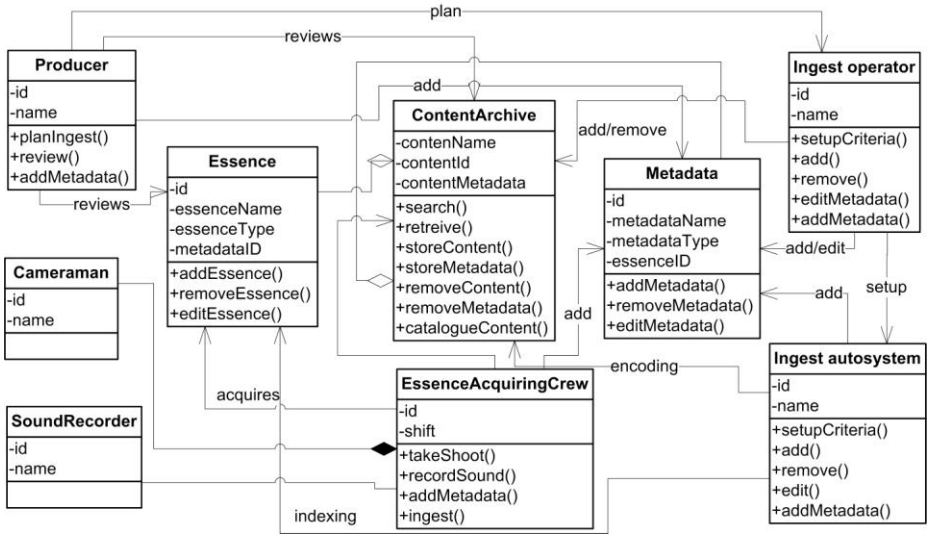

Fig. 4. Class diagram: Domain Model of Ingest Process

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