

# INTEGRATIVE WORKFLOW-EMBEDDED SUPPORT FOR PROCESS AUTOMATION AND MANAGEMENT

**Atta Badii, David Fuschi, Meng Zhu**

[{atta.badii, d.l.a.fuschi, m.zhu} @reading.ac.uk](mailto:{atta.badii, d.l.a.fuschi, m.zhu}@reading.ac.uk)

Intelligent Media Systems and Services Research Centre (IMSS) School of Systems Engineering,  
University of Reading, UK

## Abstract

*This paper presents the on-going research performed in order to integrate process automation and process management support in the context of media production. This has been addressed on the basis of a holistic approach to software engineering applied to media production modelling to ensure design correctness, completeness and effectiveness. The focus of the research and development has been to enhance the metadata management throughout the process in a similar fashion to that achieved in Decision Support Systems (DSS) to facilitate well-grounded business decisions. The paper sets out the aims and objectives and the methodology deployed. The paper describes the solution in some detail and sets out some preliminary conclusions and the planned future work.*

*Keywords: Workflow, Process Management, Software Engineering, Media Production.*

## 1 INTRODUCTION AND CONTEXT

In the media industry the production process has always been rather complex and has often required the adoption of reference models and standards to ensure the desired level of quality; for example in the publishing domain ‘*The Chicago Manual of Style*’ or the ‘*Xerox Publishing Standards: A Manual of Style and Design*’, or the ‘*Web Style Guide, 3rd Edition*’.

The appearance of other media such as: cinema, TV, CD, web, etc. has further increased such complexity as well as the number of needed reference standards. An interesting case is a range of manuals known collectively as the Rainbow Books: Red Book (CD Digital Audio), Yellow Book (CD-ROM and CD-ROM XA), Orange Book (CD-R and CD-RW), White Book (Video CD), Blue Book (Enhanced CD, CD+G and CD-Plus), Beige Book (Photo CD), Green Book (CD-i standard), Purple Book (DDCD), Scarlet Book (Super Audio CD), etc. so, although the technical processes have always been modelled and specified, such effort has rarely been applied to the creative process.

In the film and TV industry a number of standards have been developed and applied to the production, projection/broadcasting, storage and distribution of content. The Internet has brought new formats and scenarios (from IPTV to iDTV, etc) well beyond the availability of cable and satellite distribution. In such a complex scenario the usage of workflow is often limited to the automation of tedious or error-prone processes such as the content annotation (Dorai 2001) or the adaptation for delivery to a different device than that originally expected (Badii et al. 2005, 2006a, 2008).

With the trend towards higher yet affordable computation power and progress in Artificial Intelligence (AI), the number of applications devoted to content processing automation (even in relation to creative aspects such as storytelling, etc) that exploit workflow technology has been constantly growing. Nevertheless, at least as far as content creativity is concerned, the optimisation of the trade-off between efficiency and effectiveness to satisfy a given standard is still an unresolved problem; not least because in the media industry, the result quality and success greatly depends on the “*human factor*” and its ability to create content having some “*artistic value*”.

Despite the number of interesting experiments, mostly carried out by “creative directors” and scientists, it is widely accepted that a computer cannot replace a human in respect of creativity (Theune et al. 2003, Coles and Dautenhahn 2000, Gervás 2000, 2001, 2005). In most such cases at the core of the solution there is some sort of an expert-based reasoning system that enables the simulation of some aspects of “human” creativity. In some of the simplest cases a simple workflow management engine has been adopted and extended or enriched to achieve tasks that usually require a certain degree of creativity (Badii et al. 2005, 2006a, 2008).

In general the perception of decision makers and creative people in the media industry is that ICT-enabled support can facilitate some specific aspects of the end-to-end workflow within well-defined stages and segments of the overall value-chain, provided the ICT is seamlessly integrated with the legacy systems and routine operations. However this work has set out to demonstrate that workflow and decision support, when properly matched to the application domain so as to seamlessly harmonise with and thus support the existing creative processes, can not only support, but even increase the possibilities offered in terms of process management and decision support.

## 2 SCOPE AND OBJECTIVES

In the context of the 2020 3D Media project (dealing with 3D Media Production), as an example of a challenging task we can describe the definition, design, deployment and validation of a collaborative, semantically-enabled workflow system aimed at providing decision support for the production, post-production and distribution in the film industry.

The system should enable designers and decision makers involved in the media production value chain to take sound decisions based on consistent information provided by the process management support system that should in essence work like a Decision Support System (DSS) but operates in process management rather than in the business domain.

Additionally the system should focus on “metadata” handling rather than on the automation of the process. In this, lies both the novelty of the proposed approach that aims to encompass the whole process from process automation to process management support, keeping track of all the information which is often lost during the process (from the original sketch of the idea to its formalisation in a draft storyboard, through to the full implementation of the script and the storyboard). While it is a fact that media production is moving from the analogue to the digital era; from time-to-time the scanning of the analogue source into digital format is still needed when the original source is not digital and much accompanying information (script, storyboard, etc.) is still in the analogue format thus making data loss more of a threat than a remote possibility.

It has to be taken into account that in the present context characterised by hectic timing and high level of pressure, the loss of even a single item of information in certain passages of the (post-) production may lead to subsequent problems in the management of the generated asset or cause needless repeat-work and additional cost. Actually there is a variety of “metadata” that accompanies the output of each stage of the process and not all of it is relevant to all stages that the production will undertake. Moreover the same “person” may play different “roles” and thus should be represented by different “actors” in the process (for example Mel Gibson is the producer, director and writer of *Apocalypto*; director, and leading actor in *Brave Heart*). This is why another layer of information is needed to fully contextualise all steps and aspects of the process and situate it in its proper relationship; such an additional layer has also to take into account the semantics of the given domain in order to properly resolve and disambiguate input received so as to provide a relevant, appropriate and consistent response. The deployment of Topic Map technology additionally enables arbitrary conditional Points-of-Inspection (PoI), (Badii 2006a) to be set; these will be legacy-workflow-agnostic and as such facilitate coordinative monitoring and progression of work in the context of collaborative multi-factory production and distribution.

### 3 METHODOLOGY

To achieve the proposed aim and objectives it is necessary to ground the analysis in the knowledge of state-of-practice and state-of-the art in the related domains as well as market and technology trends and entity, process, and actor lifecycles analysis (Badii 2006b). This will lead to the identification of the reference models and methods to be used in the definition of the framework to be implemented and the related supportive tools. A subsequent phase will comprise a set of interviews with key-stakeholders in the expected application domain to further refine and restrict the set of reference methods and supportive tools (mostly in respect to the usage-contexts to be supported) to a minimum while retaining the maximum flexibility.

Once this initial phase is completed and the framework architecture is defined, associated specifications will be drawn up using formal descriptions and standardised methods and guidelines (including but not limited to UML and MIL). During this phase a number of relevant key-stakeholders will be periodically contacted to review the progress and help to keep all the activities in focus.

Specifications will be initially drafted and then kept constantly updated during development by means of an evolutionary system design and development methodology implemented as a spiral rapidly iterative prototype-and-evaluate process. This will make it possible to quickly finalise the development of a first prototype to be used in the experimental phase to be refined and finalised in due course. Also the experimental phase will be structured in cycles as it is expected that usage will lead to a revision and refinement of what is achieved following comments, remarks, suggestions from involved stakeholders as well as functional / logic bug-spotting.

Results of the process will then be analysed against those expected and collected evaluation metrics (as defined in the initial phase) will be analysed both in terms of absolute value and trends exposed during the overall process. Accordingly after several iterations, the resulting system is expected to meet the user-specified needs at an acceptable level thus allowing some significant level of take-up by the practitioners in the sectorial value-chain.

### 4 THE PROPOSED SOLUTION

To overcome the challenges involved in designing, developing and deploying a collaborative workflow support in the 3D film production domain, the authors started by modelling the underlying semantics. The target system framework architecture (see Figure 1) has been derived taking into account the results of the Domain Knowledge analysis, together with observations made through interviews with practitioners, results of the research into state-of-the-art for modelling and supporting the workflow logic in cinema and television production (van der Aalst and Hofstede 2005, Ouyang et al 2008).

We have started the testing of two open-source workflow engines, i.e. YAWL and JBPM to measure their efficiency and suitability as a core component of the back-end system. To ensure the richest possible semantic representation of the domain process knowledge so as to help create more expressive semantic models of the domain and thereby avoid the above-mentioned lack of contextualisation of the domain processes and relationships it was decided to adopt Topic Maps (ISO/IEC 13250) as a semantic standard that would offer a high level of flexibility and richness of representation.

It is not intended nor expected to develop specific modelling tools or editors to be used to serve the back-end processes; although it is planned to develop a specific integration middleware that will interact with the workflow engine, the Topic Map engine and the data management component.

The arrows in Figure 1 represent the information and metadata flow in the system. Such a flow will be kept separate from the related management information flow. This will be one of the responsibilities of the integration layer and of the service-oriented API that will have to be deployed.

Given the specific aim of the system to provide process management support in a context characterised by a variety of actors and inter-connected systems (not all necessarily belonging to a single entity) we envisage a front-end that will embed the business logic relying on the models and information provided by the integrated back-end. This component will also expose a specific service-oriented API both towards the back-end and the clients (that have to be realised as light clients and inter-connected with the system via networking).

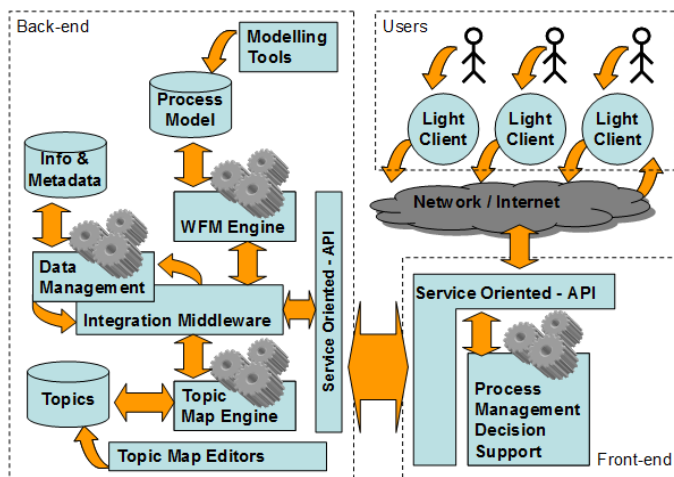


Figure 1. The Framework Architecture of the target system

Topics can be anything yes but typically are actors, objects, story elements, processes/tasks, goals, resources, subjects etc and all their scoping, associational, roles and responsibility relationships etc. Such an approach makes it possible to achieve a high level of re-usability while at the same time ensuring a high level of specialisation of models and data structures used for the monitoring and control of the system. In essence the system will exploit a set of hierarchical models and data structures. The logical workflow will be described using a (fully) connected graph approach in which conditions and constraints can be applied both to nodes and arcs.

For example the action that takes data from a specific node to another will be flagged as “internal” or “external” depending on the relationship existing between the actor performing it and the entity requesting it (i.e. if the actor belongs to the requesting entity then the action is “internal”, otherwise it is “external”). This is a significant distinction since in reality an external action implies a contract with a pre-requisite of an SLA; which has to be in place before the contract can be placed. Additional constraints such as these require the activation of specific sub-processes and may involve several actors spread over several decisional levels, having a number of relationships with other actors and actions that may even establish indirect consequences. An example of this could be if the person that has to take care of the contract / SLA is already busy sorting out other activities, this unexpected additional load, may cause a backlog and either result in a delayed completion of this request or in the delayed completion of other requests, or both, with consequences that may vary significantly depending on which action is delayed.

In some cases an action that is normally internal may have to be outsourced and performed externally for a number of possible reasons e.g. the unavailability, or overload, of the required resources, the need for a higher level of quality than that achievable internally or as a consequence of a specific request of the producer or a major stakeholder. Also in this case even if the higher level stage in the process flow may not be changing in the next cycle (i.e. even if the next stage is still within the same process as the previous one), there may be changes in the lower level processes (at least for the node where an outsourced action is to be completed). In such a context, the workflow for the internal node(s) i.e. for the “internal” operation will have to be replaced “on-the-fly” with one of the service-providers; additionally the flags of the arcs connecting the node will have to be toggled and additional information/metadata will have to be collected (including regular feedback from the service-provider).

All this should be accomplished without the need to re-model the system. This will be realised by the fact that the adopted model for the action has been designed so as to accommodate both cases and has

flags that allow toggling of the usage-context from one case to the other, on-the-fly, thanks to the topic-map-based management support that allows the filtering/aggregation of information in a very effective and efficient manner irrespective of the object under examination. Table 4 below shows a typical analysis base for a digital media production workflow.

| The Activity                       |                                                                                                                                                                                                                                                                                           | The Roles involved             |                                                                                                                                                                                                                                                                                                                |
|------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Idea (1)                           | Storyboard drafting (2)                                                                                                                                                                                                                                                                   |                                | Author<br>Writer<br>Script editor<br>Art director<br>Director<br>Producer<br>Production accountant                                                                                                                                                                                                             |
| Cost estimation (3)                |                                                                                                                                                                                                                                                                                           |                                | Producer<br>Production accountant                                                                                                                                                                                                                                                                              |
| Go/No Go decision (4)              |                                                                                                                                                                                                                                                                                           |                                | Producer                                                                                                                                                                                                                                                                                                       |
| Title design (5)                   | Storyboard finalising (5.1)<br>Script drafting (5.2)<br>Casting preparation (5.3)                                                                                                                                                                                                         | Cost estimation refinement (7) | Author<br>Script editor<br>Producer<br>Director<br>Casting director<br>Art director                                                                                                                                                                                                                            |
| Design & preparation (6)           | Casting (6.1)<br>Scripting (6.2)<br>Lighting drafting (6.3)<br>Shooting plan drafting (6.4)<br>Effects drafting (6.5)<br>Costumes drafting (6.6)<br>Sound track drafting (6.7)<br>Contracts finalising (6.8)                                                                              |                                | Costume designer<br>Makeup designer<br>Composer<br>Audio Engineer<br>Graphic designer<br>Special effect designer<br>Fight arranger<br>Lighting cameraman<br>Production assistant<br>Location manager<br>Art director<br>Director<br>Casting director<br>Producer<br>Production lawyer<br>Production accountant |
| Production (8)                     | Setting up scenes (8.1)<br>Lighting management (8.2)<br>Audio management (8.3)<br>Shooting (8.4)<br>Daily rushes (8.5)<br>Storyboard revision (8.6)<br>Shooting plan revision (8.7)<br>Costing revision (8.8)<br>Call list revision (8.9)<br>Local effects and stunting management (8.10) | Cost control (12)              | Negotiation, Acquisition, Distribution & sale IPR/©<br>Contracts management (15)<br>Director<br>Casting director<br>Producer<br>Production lawyer<br>Production accountant                                                                                                                                     |
| Post Production (9)                | Mounting (9.1)<br>Sound editing (9.2)<br>Special effects (9.3)<br>Dubbing (9.4)<br>Packaging (9.5)                                                                                                                                                                                        |                                | Censorship approval (10)                                                                                                                                                                                                                                                                                       |
| Marketing (11)                     |                                                                                                                                                                                                                                                                                           |                                | Marketing manager                                                                                                                                                                                                                                                                                              |
| Distribution & rights selling (13) |                                                                                                                                                                                                                                                                                           | Revenue management (14)        | Marketing manager<br>Production accountant                                                                                                                                                                                                                                                                     |

Figure 2. The analysed workflow.

It is worth re-iterating that in this system the object of the monitoring and management is exclusively the information and meta-data used and generated during the process. This implies that the system will have to be able to interact (essentially receive) data from various sources and has to be able to analyse and interpret them. Besides this, the system needs to be scalable so as to accommodate different loads over time depending on the number of productions monitored in parallel, the production stages monitored for each monitored production, the number of actors and models involved and the number of information/metadata sources as well as the size of the received data.

These requirements point to a Service-Oriented and Model-Driven Architecture (SOA-MDA) as the basis of the development of the target system in which components are distributed and interact possibly using services well-established over TCP/IP so to allow a distributed environment regardless of the physical arrangement.

## 5 CONCLUSIONS

In the context of media production, as in many other industrial or business contexts, the term workflow is associated with the automation of tedious, repetitive, potentially error-prone activities. Thus the vast majority of products available on the market aim to simplify and automate certain processes in the value chain and provide support for specific stages of the overall “production” chain. The approach is very often to embed the workflow management directly in the tool, thus hiding it from the user.

There are very few examples of workflow management tools specifically devoted to the media or movie industry with the specific aim of facilitating the process management; one such example is YAWL4Film developed by the Business Process Management (BPM) Group at the Queensland University of Technology (QUT) based on YAWL which presently addresses the automated support to some of the most re-utilised activities of the “production” part of the chain in filming and media production etc.).

Thus the proposed system will enable a significant advance in the current state-of-the-art of process management support in the media production environment. The expected result will exploit a holistic approach to software and system engineering in the design and development of a system that will integrate a workflow management system with a Topic Map engine to provide the back-end for a process management decision support front-end implementing the needed business logic. The system will essentially act like a DSS but in the context of process rather than business management.

## 6 FUTURE WORK

The development is currently in the second analysis phase of the domain specific state-of-the-art as well as a literature survey performed in parallel to the Software Requirements Engineering activity based on the UI-REF framework (Badii 2006b) to classify, resolve and prioritise requirements. The analysis of the process, its layers, involved actors, actions, triggers and relations is also being performed to model the system appropriately and further refine the initial draft architecture. Once this second phase is complete a first implementation will be drafted exploiting either YAWL or JBPM and Topic Maps.

The workflow management system and the Topic Map management engine will be progressively integrated thanks to a purposely developed middleware that will also allow the connection to the data management system. Models for the various entities to be managed will be progressively edited, validated and stored, starting with the most relevant and enabling one then progressing towards the optional ones. In a similar fashion every model will be iteratively refined and adjusted in response to field verification that will take place in the context of real small-scale 3D interactive productions.

## References

- Badii A, Sailor M, Marangoni C, Neglia A, and Pearce L. 2005. ‘Object Life Cycles & Interaction Environments for Cross Media Production & Distribution’. Proceedings of the *1st AXMEDIS International Conference 2005*.
- Badii A, Sailor M, and Nair R. 2006a. ‘Profiling Management for Personalised Multimedia Delivery On-Demand within the AXMEDIS Framework’. Proceedings of the *2nd AXMEDIS International Conference, 2006*, 35-44, IEEE Press.
- Badii A 2006b: FastMatch System Requirements Resolution Document, FastMatch Project Technical Report and Deliverable D2.1, May 2006.
- Badii A, Khan A, Adetoye A, and Fuschi D. 2008a. ‘High Resolution Digital Media Personalisation for All Delivery Context Device Agents’. Proceedings of *The 14th International Conference on Distributed Multimedia Systems (DMS '08)*.

- Badii A, Khan A, Adetoye A, and Fuschi D. 2008b. 'Personalised Digital Media Adaptation and Delivery to Mobile Devices'. Proceedings *Third International Workshop on Mobile and Networking Technologies for Social Applications (MONET'08)*.
- Coles S, and Dautenhahn K. 2000. 'A robotic story-teller'. *8th International Symposium on Intelligent Robotic Systems (SIRS-2000)*, Reading, United Kingdom, 18-20
- Dorai C. 2001. 'Bridging the Semantic Gap in Content Management Systems: Computational Media Aesthetics'. in *COSIGN 2001*, 94-99, Kluwer Academic Publishers.
- Gervás P. 2000. 'Wasp: Evaluation of different strategies for the automatic generation of spanish verse'. University of Birmingham, 93-100.
- Gervás P. 2001. 'An expert system for the composition of formal Spanish poetry'. *Journal of Knowledge-Based Systems*, 14: 200-1.
- Gervás P, Díaz-agudo B, Peinado F and Hervás R.2005. 'Story Plot Generation based on CBR'. *Journal of Knowledge Based Systems*, 18: 2-3.
- Ouyang C, La Rosa M, Hofstede A.H.M., Dumas M, Katherine Shortland K. 2008a. 'Toward Web-Scale Workflows for Film Production'. *IEEE Internet Computing*, 12(5): 53-61.
- Ouyang C, Hofstede A, La Rosa M, Rosemann M, Shortland K and Court D. 2008b 'Camera, Set, Action: Automating Film Production via Business Process Management' *Proceedings of International Conference "Creating Value: Between Commerce and Commons" 2008*.
- Theune M, Faas S, Nijholt A, and Heylen D. 2003. 'The Virtual Storyteller: Story creation by intelligent agents'. Proceedings of the *Workshop on Storytelling in Collaborative Virtual environments at ACM Collaborative Virtual Environments*, 204-215.
- van der Aalst W.M.P. and Hofstede A.H.M.. 2005. 'YAWL: Yet Another Workflow Language'. *Information Systems*, 30(4):245-275, 2005.