RC24519 (W0803-112) March 26, 2008
Computer Science

IBM Research Report

Service-Oriented Workflow for Digital Media Broadcasting

JuHee Bae[1], Paolo Dettori[2], DaeRyung Lee[1], Julio Nogima[2], Frank Schaffa[2]

[1]Ubiquitous Computing Lab
IBM Korea

[2]IBM Research Division
Thomas J. Watson Research Center
P.O. Box 704
Yorktown Heights, NY 10598

Research Division
Almaden - Austin - Beijing - Cambridge - Haifa - India - T. J. Watson - Tokyo - Zurich

LIMITED DISTRIBUTION NOTICE: This report has been submitted for publication outside of IBM and will probably be copyrighted if accepted for publication. It has been issued as a Research Report for early dissemination of its contents. In view of the transfer of copyright to the outside publisher, its distribution outside of IBM prior to publication should be limited to peer communications and specific requests. After outside publication, requests should be filled only by reprints or legally obtained copies of the article (e.g., payment of royalties). Copies may be requested from IBM T. J. Watson Research Center , P. O. Box 218, Yorktown Heights, NY 10598 USA (email: reports@us.ibm.com). Some reports are available on the internet at http://domino.watson.ibm.com/library/CyberDig.nsf/home .

Service-Oriented Workflow for Digital Media Broadcasting

JuHee Bae[1], Paolo Dettori[2], DaeRyung Lee[1], Julio Nogima[2], Frank Schaffa[2]
[1]Ubiquitous Computing Lab. IBM Korea
[2]Watson Research Lab. IBM

ABSTRACT

The broadcasting industry is faced with increasing demand for the digitalization of their systems. The growing market for rich media content combined with the high availability of affordable bandwidth and the multiplicity of delivery channels, is leading the enterprises to evaluate how to create, manage and distribute digital media in a more efficient and strategic way. In this context the introduction of a Service Oriented Architecture (SOA)-based workflow system can produce real benefits such as cost savings achieved through a new broadcasting operational model and a more effective usage of the existing content. It can also achieve a direct impact on future revenue by the creation of new on-demand services and content. It not only supports process integration and workflow being managed independently of content and application technology but also provides the transformation to an all digital workflow.

The purpose of our digital media system implementation project was to provide modularity of each process unit and increase the reusability of media contents in the near future. The first step of digital network broadcasting system at OOO TV in Korea was to establish the basic workflow between program planning, editing, transferring, transcoding, archiving and broadcasting over-the-air, and sustaining stable operation of the workflow. In the second phase, we are going to provide scalability and maintenance of the system. For this project, we implemented workflows which deal with media processing. The proposed approach improves the integration among content creation, ingest, management and distribution systems and underlying business systems. Additionally, it removes the media dependency on the application—freeing applications to handle other tasks—and simplifying the management of changing complex workflows. The workflow consists of composite services which are web services and can be invoked programmatically from a web service client.

In this paper, we will describe how we implemented the digital-media business process through a workflow system, specifically in the area of tapeless network broadcasting system with specific examples of workflows.

INTRODUCTION

The broadcasting market is faced with imminent necessity of digitalization of broadcasting system. Due to the growing demand for rich media and the high availability of affordable bandwidth and multiple delivery channels (TV, Web, VOD, Mobile, 3D), enterprises of all types of media are evaluating how they can more efficiently and strategically create, manage and distribute digital media. The benefits of a flexible and dynamic workflow in broadcasting industry are the cost savings through new broadcast programming method and better use of existing

content as well as direct impact on future revenue from the creation of on-demand service and content.

According to Datamonitor's research report[1], digital TV market is growing in most of the Europe countries as well as US. For example, the digital market will take around 65 percent in the US while in EU countries will also reach more than 50 percent of the market, some countries heading to almost 100 percent by 2010.

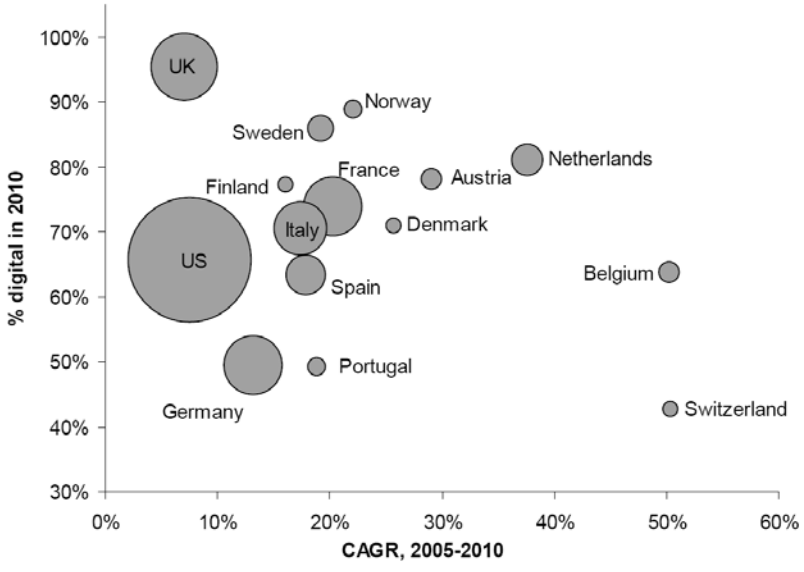

Fig 1. Digital TV market comparison. 2005-2010 (from Datamonitor)

Also, Yankee group estimates that most mobile phone service companies will deliver mobile digital TV in their services in the near future[2]. As a result, a growing number of digital services would require a base framework to support processing of individual digital media assets, by operating as a broadcast center that implements various producing logic for numerous digital media contents.

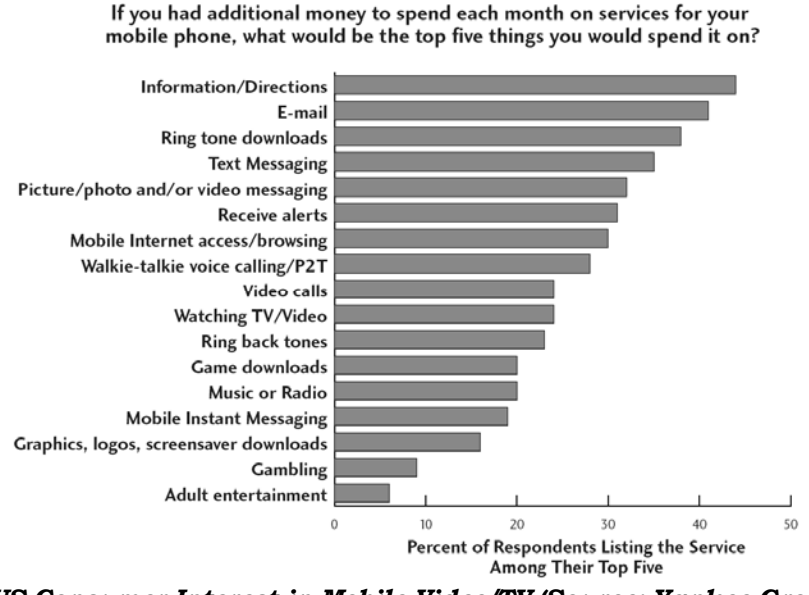

Fig 2. US Consumer Interest in Mobile Video/TV (Source: Yankee Group 2006 US Mobile User Survey)

The idea of how rapid we can develop an application with new digital media, how we compose several digital media asset types into an application, and how we can deliver on time-to-market the output of an application to the business partner is of paramount importance. In this paper, we present a workflow solution specialized in digital media business called Media Hub.

The Media Hub framework (3) is a set of tools and runtime to enable the creation, execution and monitoring of workflows related to media services. It provides a very high level of abstraction for these services and easy creation and management of the workflows. In addition, it supports changes to workflows without code change and redeployment (zero roundtrip). The tools are Eclipse based and the runtime is a set of mediators for routing, logging and compensation deployed on an Enterprise Service Bus (ESB) extending the SOA development environment to the media processing. Each service which is used by Media Hub is implemented as a Web Service.

DEFINITION OF TERMS

CMS: Content Management System, a system used to manage the content of digital or media asset.

MAM: Media Asset Management consists of tasks and decisions surrounding ingesting, annotating, cataloguing, storage and retrieval of digital assets, such as digital photographs, animations, videos and music.

NLE: Non-linear Editing System, modern editing system which involves being able to access any frame in a video clip in order to edit it. The editing method is similar in concept to the "cut and paste" technique used in film editing from the beginning. However, when working with film, it is a destructive process, as the actual film negative must be cut. Non-linear, non-destructive methods began to appear with the introduction of digital video technology.

BIS: Broadcast Information System, an integrated solution of contents management, program scheduling, CM scheduling, transmission list scheduling and management and interface with Automatic Program Control through automation of all broadcasting work process.

APC: Automatic Program Control System, a system that automatically controls the various transmission/broadcasting devices by responding to event-processing and programming information.

Long GOP: Long Group of Pictures which is a “long” sequence and order of interframes and intraframes.

MXF: Material eXchange Format (MXF), a container format for professional digital video and audio media defined by a set of SMPTE standards. It is a "container" or "wrapper" format which supports a number of different streams of coded "essence", encoded with any of a variety of codecs, together with a metadata wrapper which describes the material contained within the MXF file.

DVCPRO: DVCPRO P2 (P2 is short form for "Professional Plug-In") is a professional digital video format introduced by Panasonic in 2004, and especially tailored to ENG applications. It features tapeless (non-linear) recording of DVCPRO or DVCPRO50 streams on a solid state flash memory card. DVCPRO HD recording on P2 is possible with the Panasonic AG-HVX200.

EDL: An Edit Decision List or EDL is a way of representing a film or video edit. It contains an ordered list of reel and timecode data representing where each video clip can be obtained in order to conform the final cut.

BROADCASTING SYSTEM: AS A CHANNEL OF DIGITAL MEDIA

Digital media content workflow is divided into mainly three stages: ingestion, management, and distribution. Ingesting media contents consists mainly of copying files from camera to shared storage or loading several different sources from stored media such as video tapes or media files from optical disk, flash memory, and hard disk drive. After ingesting to the system, management controller handles the flow of media content while the editor or producer edit and recreate the content by editor application such as NLE as well as the information through the website. The media asset created by the editor is distributed to the video server as it may be archived directly to the tape library. Most of the edited media files are transferred to the appropriate video server to broadcast as the direction of which server is chosen by the format of the file.

USE CASE: DIGITAL BROADCASTING SYSTEM

The use cases deal mainly with the systems used in the digital broadcasting system. The main systems and its function are listed as below.

Device	Function
Ingest agent	Ingest and register media asset into CMS.
Transcode agent	Transcode MXF Long GOP to WMV files.
Catalog agent	Create key frames of WMV files.
Proxy Editor	Edit WMV file created by transcode agent and create EDL file.
Non-linear Editor	Edit and recreate media asset.
Archive agent	Archive content from shared storage to tape library, restore asset from tape library to share storage, and delete asset in the tape library.
Transfer agent	Transfer MXF Long GOP and DVCPRO to and from video server.

For example, the first step of the ingest process is to shoot a video or film to be played out. The camera man takes the video and creates a clip in order to ingest to the IT shared system. The ingester ingests the clip into the shared storage as she or he enters related information about the media asset. The title, content group name, series number, video taker, description, version, shooting place, shooting time, when to be broadcasted are all registered to the content management system and described as metadata in XML format. The management system returns a content ID to control the flow of newly input content which allows for independent workflows, each one for with a respective purpose. If the clip is the final version of edition or if it does not need revision, the content is automatically archived into the tape library. In other cases, news final edition and 'ready-to-play-out' contents are automatically transferred to the video server.

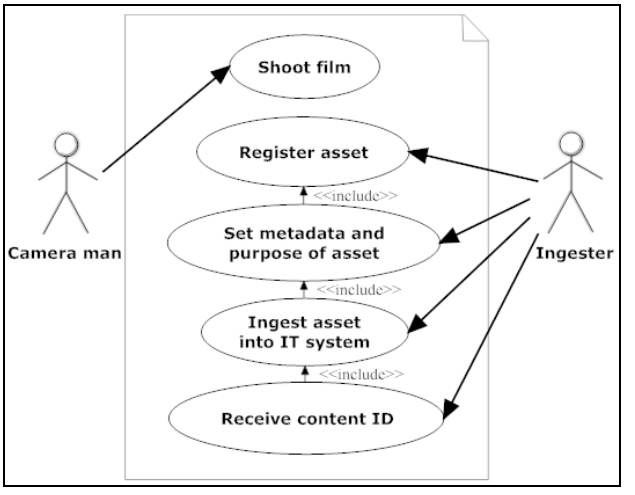

Fig 3. Ingest process in Digital Broadcasting System

CASE STUDY : OOO TV BROADCASTING SYSTEM

OOO TV Broadcasting system is one of the first broadcasters in the world to digitalize the entire process of broadcasting. We call it the tapeless network broadcasting system where standard, non-standard format of files and video tape are ingested into the IT system. The target for the digital television broadcasting system is to support resolution of 1920x1080 for 1080p HDTV standard format. The main source is from the digital video camera supporting MPEG2 Long GOP format. Other formats used in the system are MXF DVCPRO, MPEG4 and WMV. Standard-definition (SD) media content is converted to MPEG2 format which then can be used through the current workflow.

The tapeless digitalized network environment is based on the three stages of digital broadcasting system described before. The media content workflow is divided into the three main stages: ingestion, management, distribution. The digital video camera produces numerous copies of shots which initially go into the shared storage. Several other kinds of stored media such as SD video tapes or media files from optical disk, or flash memory, or hard disk drive are also ingested into the system. They are transcoded to MPEG2 and MPEG4 files in order to be used in the workflow. This includes the process of registering the media asset to CMS, and cataloging. The ingested files are registered to CMS which issues the content unique ID and related metadata. CMS controls the flow of media content by the unique ID, issued before, as files are edited by the NLE user. The editor or producer edit and recreate the content brought into the NLE as they export the final work that the NLE may create in MPEG2 MXF long GOP or DVCPRO. When the asset is finalized or it is ready for play-out, the recreated content runs through the transfer process in order to be placed on the video server to be delivered. Once the completed clip is finalized for play-out, the media file is distributed to the video server as it is archived directly to the tape library. Most of the edited media clips are transferred to the appropriate video server for broadcasting. In order to search on the information of the media file and its status, the BIS website and applications are provided to view the information and status of the media content. Figure 4 shows the basic functions of content management system which includes the process described before. The diagram shows that the media assets used are ingested from various kinds of sources while new content may also be created by editing them through a NLE process.

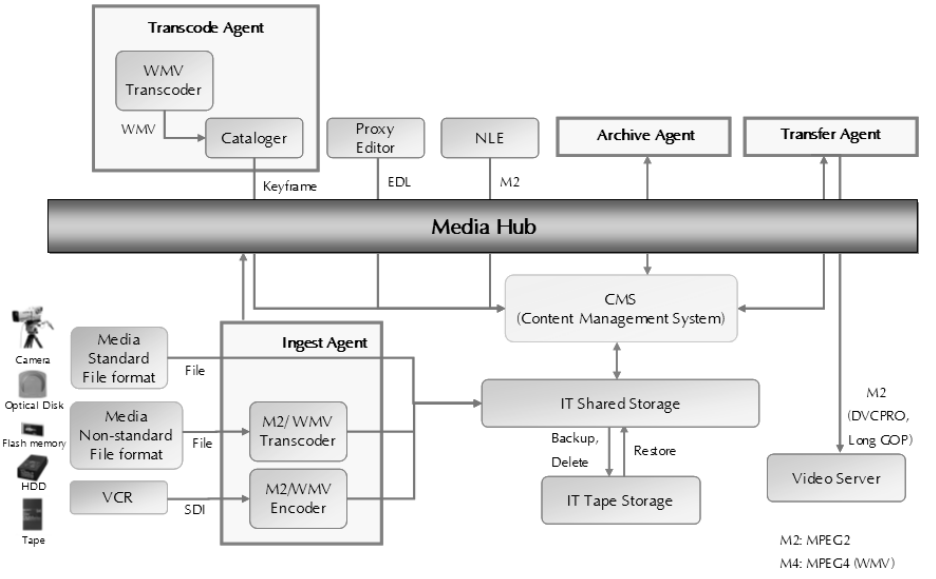

Fig 4. Tapeless Network Broadcasting System

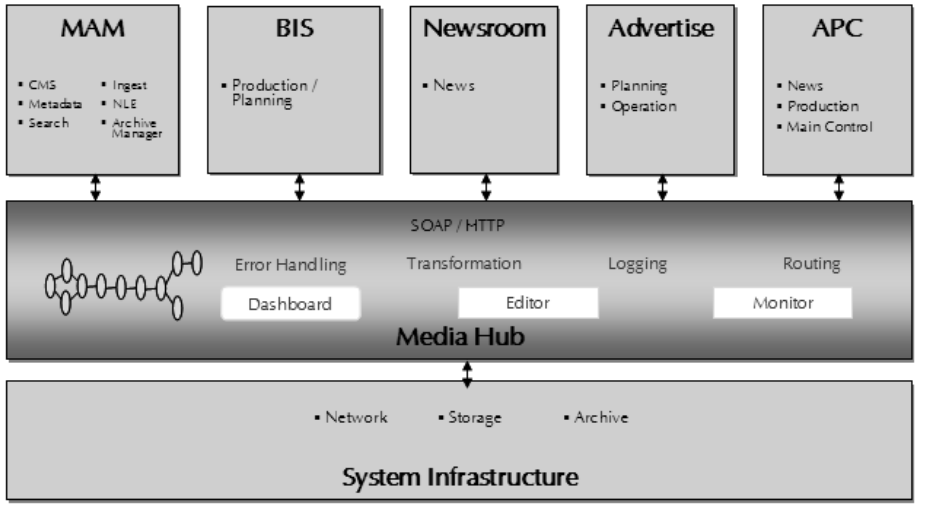

Fig 5. Components of Tapeless Network Broadcasting System

The nine workflow services used in the Broadcasting System are the following: DB Application, DB Common, DB Metadata, DB State, Archive, Catalog, Transcode, Transfer, News service. Each service is implemented as a web service and can be used to in the orchestration process. We defined four services related with the main database which needs DB insert, update, and delete. The DB application is used for the non-linear editor and the proxy editor. The DB Common is used to request content unique ID or set its information. The Metadata service deals with the metadata of archive, catalog, ingest, proxy editor and transcode system in order to manage the process of allocation, retrieval and deletion. The DB State service is used for displaying the status of each system such as archive, catalog, ingest, news service, transcode, and transfer. The Archive service provides archive, restore, delete process interacting with the tape library. The Transcoding service transforms the format of various delivery channels for high/low quality video content and different formats such as MPEG2 and MPEG4. The Catalog service is

used to extract key frames for the required media content in order to skim it before restoring the file or rescheduling the news queue sheet. The Transfer service controls and supports moving media content as well as metadata if required for play-out. The News service is used for connecting news APC with CMS. The nine services are the main categories for detailed stand-alone services. For instance, archive service consists of three stand-alone services: archive_set_content for saving contents into the tape library, archive_get_content for restoring media assets from tape library to the shared storage, and archive_del_content for deleting media assets in the tape library.

There are around fifty composite services used for media workflow that are composed of stand-alone services. One example of composite service is as follows: content_loc_set_meta is a service comprising content_set_loc and ingest_set_meta. Content_set_loc service requests a unique ID to register to CMS and sets the information such as the location of the content. The input and output message going in and out of a digital media workflow is a XML file that includes such information as transfer required, ingesting, archiving, restoring, transcoding or cataloging the content, program ID, content unique ID, format, device name, source location, target location, duration, format, bit rate, resolution, frame per second, audio format, audio bit rate, start time code, end time code, register date and time, and total frame number. An example of the input xml file is shown below.

```
<workflow>
  <trsf_req_yn></trsf_req_yn>
  <ing_req_yn>Y</ing_req_yn>
  <arch_req_yn>N</arch_req_yn>
  <rsto_req_yn></rsto_req_yn>
  <trcd_req_yn>N</trcd_req_yn>
  <kfrm_req_yn></kfrm_req_yn>
  <metadata>  <![CDATA[
       <tb_cti>
         <ct_id>P0000000F7F4</ct_id>
         <cti_id>00000002FF8B</cti_id>
<cti_fmt>0000000000</cti_fmt>
         <mda_dvc_id>SING02</mda_dvc_id>
         <dest_from>IT01</dest_from>
<fl_nm>00000002FF8B.mxf</fl_nm>
         <fl_typ>application%2fmxf</fl_typ>
         <fl_sz>3018166</fl_sz>
         <fl_loc>%5c%5c10.30.40.66%5cNP_M%5cPROD%5cC071200030</fl_loc>
         <cti_dur>00103921</cti_dur>
         <vd_cdc>MPEG2HD35_1440_1080_MP%40HL</vd_cdc>
         <bit_rt>35840</bit_rt>
         <frm_per_sec>29.97</frm_per_sec>
         <vd_vresol>1440</vd_vresol>
         <vd_hresol>1080</vd_hresol>
         <aud_cdc>LPCM16</aud_cdc>
<aud_chl_sec>4</aud_chl_sec>
         <som>00%3a00%3a00%3a00</som>
         <eom>00%3a10%3a39%3a21</eom>
<reg_dtm>2008-01-09 00:07:33</reg_dtm>
<asp_rto>16%3a9</asp_rto>
         <tot_frm_nums>19173</tot_frm_nums>
</tb_cti>
    ]]>
  </metadata>
</workflow>
```

Ingest_set_meta sets the metadata of the ingested media file. By distinguishing each service with its unique functionality, there are several benefits when it is necessary to reuse the service and reconfigure the workflow. Content_set_loc service can be used by itself when the original file is already registered to CMS or may be reused with the transfer process if the media file needs to be transferred to the video server to be played out.

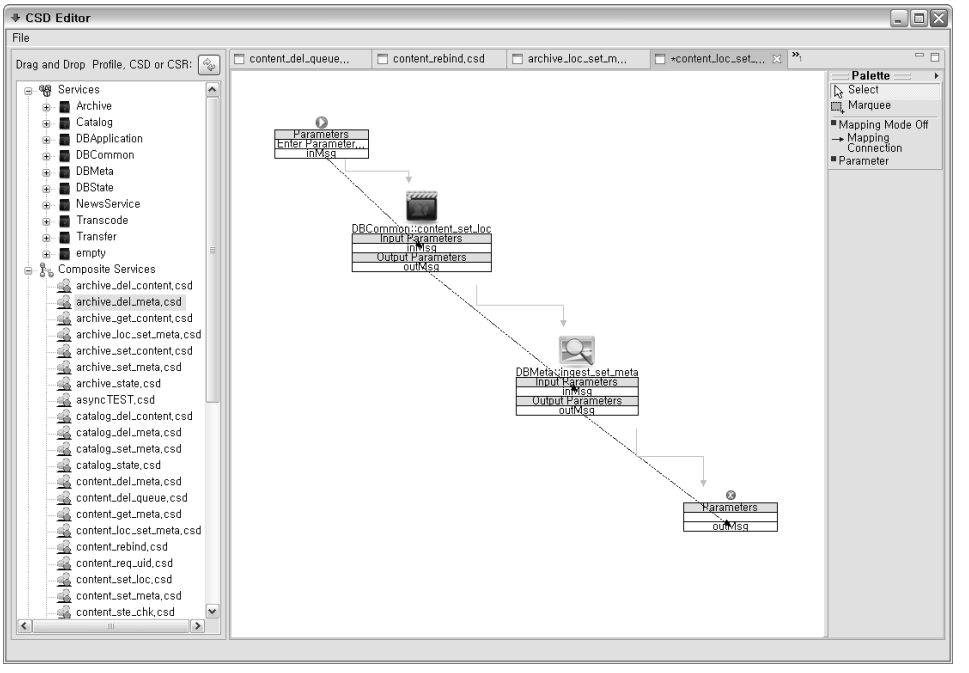

Fig 6. Sample of workflow registering content to CMS from editing tool: content_loc_set_meta

With this approach we can achieve effectiveness and process flexibility by separating the content and workflow. Services could be created into groups which not only have similar functionality but also could be reused as a module. Coping with various changes of workflow of production system and media content is comparably easier than traditional broadcasting environment because of the nature of evolving changes of the media market. For example, at the first stage of planning the media workflow, XML creation followed the process of creating the unique ID of media content; however, the process changed in the second stage because of the necessity of unification with other processes so that metadata creation followed after the creation of content's unique ID. Also, a digital media workflow is open to the format of media content since the data that flows in and out the hub is an XML file which enables process orchestration for supporting multiple media formats and protocols with adaptive media flows. It maximizes integrity of bottleneck of process and minimizes delay and factors of failover. It cuts production times and overhead costs.

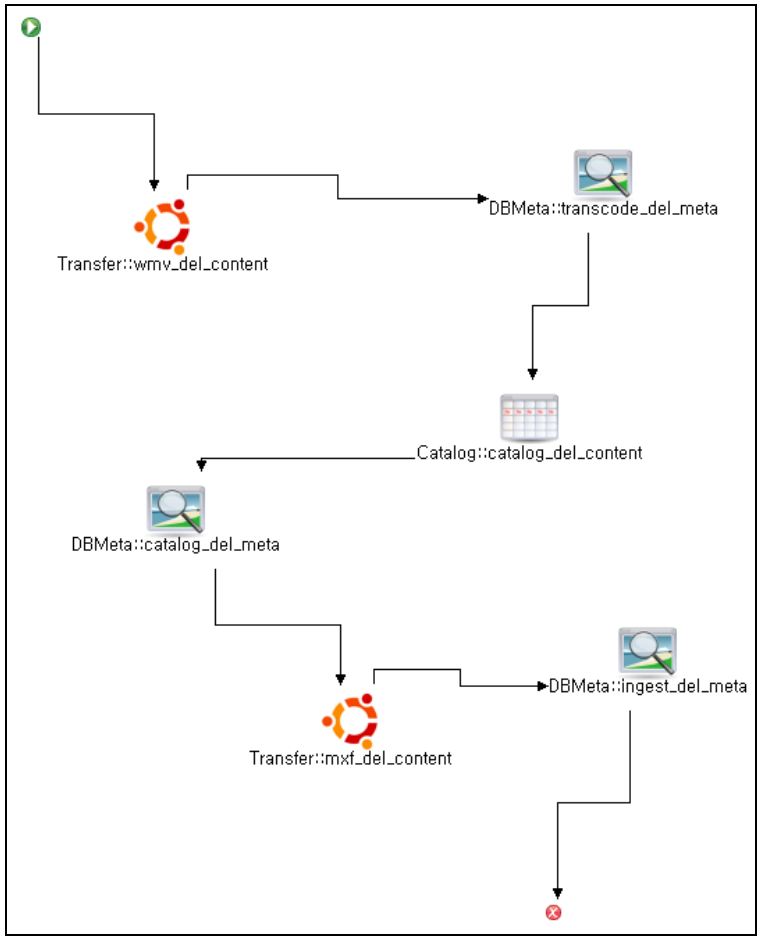

Fig 7. Sample of workflow deleting media file and metadata from monitoring tool: delete_all

The stability of broadcasting procedure by minimizing operation system for live program and operation cost reduction are other benefits. For example, the usage of physical storage such as video tapes and storage rooms is greatly reduced. Moreover, digitalizing the entire broadcasting process would provide the base of content life cycle management and separate content process of planning, producing and sending contents without system change.

CONCLUSION AND SUMMARY

In this paper, we have presented an overview of a digital media system implementation project built using a digital media workflow system. The stand-alone services are implemented as web services which facilitates the integration without modification of the original workflow. In addition, we provide a method for creating new services which ensures consistent quality of service utilizing a coarse-grained approach. It supports modularity of each process unit and increases the reusability of media content. When a new type of media is added into the workflow, the logic to handle the media asset would be added by workflow editing tool. In this case, the original stand-alone service that helps registering the content to IT system could be reused in order to issue a new content ID for a different type of media. We have also shown how we can integrate digital media tasks, content

creations, ingest, management and distribution systems and underlying business systems with easy development of connectors to system components.

REFERENCES

1. Datamonitor—2007 Trends to Watch: Media & Broadcasting Technology

2. Yankee Group Report - 2006 Mobile Video/Broadcast TV Market Assessment

3. IBM Media Hub Framework –

http://www-03.ibm.com/industries/media/doc/content/solution/2096213111.html

4. Dettori, P. Nogima J. and Schaffa F. Extending the Enterprise Service Bus for Digital Media. In IBM Research Reports at http://domino.research.ibm.com/library/cyberdig.nsf/index.html - RC24274 2007.

5. Nack, F. Capture and Transfer of Metadata during Video Production. In Proceedings of the ACM Workshop on Multimedia for Human Communication - From Capture to Convey (MHC 05), November 2005.

6. Hardman, L. Canonical Processes of Media Production. In Proceedings of the ACM Workshop on Multimedia for Human Communication - From Capture to Convey (MHC 05), November 2005.

7. Papazoglou, M. P. and Georgakopoulos, D. Service-Oriented Computing. In Communications of the ACM, October 2003/Vol. 46, No. 10.

8. Min Luo, Benjamin Goldshlager, and Liang-Jie Zhang. Designing and implementing Enterprise Service Bus (ESB) and SOA solutions", Tutorial, IEEE International Conference on Services Computing, SCC 2005, Orlando, FL, USA, July, 2005, p. xiv.

9. Ueno, K., Michiaki Tatsubori. Early Capacity Testing of an Enterprise Service Bus. In Web Services, 2006. ICWS '06. International Conference on, Sept. 2006 Page(s):709—716

10. Devlin B., MXF—the Material exchange Format. EBU Technical Review, July 2002.