

## Setting up CARNet Media on Demand

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**Abstract:** CARNet Media on Demand (MoD) service aims to provide Croatian academic and research community with tools, resources and knowledge needed for implementation of multimedia technologies in research and educational process. Paper will mostly discuss the architecture and operation of MoD server system and it's XML-based metainformation model that provides content-authors with friendly and usable interface for web-based management of their content and provides end users with easy and transparent access to various formats of multimedia content. Various implementations of metainformation model for multimedia content will also be discussed in order to clarify some decisions taken during the development of content description and management model and tools implemented in CARNet MoD service and server system.

### 1. Multimedia services & infrastructure

With the introduction of more powerful desktop computers and affordable digital media appliances, tools and knowledge needed for creating and using multimedia content comes into reach of more and more users within every environment (company, academic or research institution). Users are discovering the benefits from multimedia services and applications in every day work, which of course creates the need for providing infrastructure for such applications both on network and services level.

New situation arises where everyone is both potential creator and user of multimedia content, so providing multimedia services and infrastructure is both an issue of technology and technical solutions and issue of user education and interaction.

Demands on network infrastructure are quite simple: users require faster connections that can handle the increase of traffic volume and changes of traffic patterns (transfers of very large files which are much more reliant on stability of network than interminant transport which characterizes web and email traffic). Another necessary extension to network infrastructure is implementation and support of multicast transport on which most new multimedia services rely.

Demands for multimedia services are tricky both to define and implement, since it's both important to provide end users with tools and knowledge for production and usage of multimedia content and to create storage and distribution systems which are as transparent as possible for end users who want to produce and publish their multimedia content. When financial, organizational or educational reasons prevent training and equipping (all) end users with tools and knowledge for multimedia production, creation of centralized multimedia production service is necessary, which then handles production for such users.

Currently in most environments, there isn't a dedicated multimedia infrastructure, actually there isn't a clear understanding what would such an infrastructure be comprised of in the first place. This usually leads to confusion and purchasing decisions in which equipment that is not essential is bought or specifications for equipment are set totally wrong which results in underpowered or overpowered but too complex systems.

### 2. CARNet MoD & TV - new media infrastructure

Historically, CARNet both as an organization and as community provides multimedia services (streaming, live event broadcasts, production etc.) and some level of support and consulting, but most of these services were offered as best effort services or special arrangements for coverage of certain events and/or content. CARNet MoD and TV projects and services aim to provide complete solutions to multimedia services requirements in CARNet community.

#### 2.1. MoD - services provided

Though MoD services would imply only on Demand streaming content delivery, MoD server system also provide live Internet broadcast and playlist (program) broadcast. Last two services are actually provided by CARNet TV services, as it will be explained later. Another service that MoD services include is production of multimedia content for those content-authors that don't have capabilities for multimedia production in their institutions.

**On Demand distribution** - providing access to multimedia content stored on MoD server system through streaming technologies using unicast distribution to end clients. Users access content when they want. Content-management system implemented in MoD server system enables transparent and simple access to MM content.

**Live Internet broadcasts** - coverage of events with live encoding systems and live streaming to Internet users, preferably using multicast distribution. This usually includes coverage of various conferences, lectures and concerts with Internet broadcast. Also, Live broadcast services would be shared and offered to others doing live broadcasts within CARNet community.

**Program broadcast** - this service includes creating own program from content stored on MoD servers and distributing it in the form of Internet TV or radio station. Playlist management systems could also enable end users into creating their own "program". In this context, MoD services will provide technical solutions for CARNet TV services that will handle program and content creation.

**Production** - MoD services would also include a production system capable of semi-professional production and also an encoding system for real-time conversion of analog content to digital formats. Production system would be open to other content-creators based on agreements and rules of MoD services.

**Education** - important goal of MoD services is creation of referral center for multimedia production and technologies in CARNet community. Public web site of MoD services aims to provide enough informational and educational content for setting up production or distribution systems, and other texts about multimedia technologies. Arrangements have also been made with other educational content-creators in the fields of multimedia technologies.

Multimedia distribution services (onDemand, live and program broadcast) are implemented in CARNet MoD server system, which is an integrated solution for multimedia content storage and distribution.

#### 2.2. MoD - technologies supported

Ever since the introduction of multimedia services and technologies in CARNet, main notion was to be as informed as possible and not to link and limit ourselves to a certain multimedia architecture. Downside of this approach is existence of various types and formats of content, mostly in MPEG-1 and RealMedia formats which were mostly used respectively, for high and low bandwidths and quality.

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When creating MoD server system we again didn't want to limit ourselves to one technology, since MoD servers would distribute content created by others within CARNet and CARNet community, where MoD services doesn't have direct influence on production process used. Therefore, in order to be able to distribute both old content (in MPEG-1 and RealMedia) and content created by other producers (who have their own decisions on preferred multimedia formats and technologies), CARNet MoD servers support streaming and broadcast of all dominant multimedia architectures.

- **Apple QuickTime**
- **Microsoft Windows Media**
- **RealNetworks RealMedia**
- **MPEG-1**

Though MoD production system defines Windows Media as preferred multimedia architecture, it will still be capable of production in other three architectures. MPEG-1 support is mostly due to existence of old content in this format, though streaming distribution of this content will be transferred from existing Xing StreamWorks server to QuickTime Darwin Streaming Server.

### 2.3. MoD & TV relationship

When thinking about multimedia infrastructure provided by CARNet, at some point it was decided that for practical reasons implementation of multimedia services would be covered and achieved through two projects. First project is CARNet MoD with the goal of creating server and production infrastructure for multimedia services, while second is CARNet TV with the goal of organizational handling, promotion and support of multimedia services and creation of multimedia content in and about CARNet and CARNet community.

So, CARNet TV and its services would rely on the infrastructure of MoD services (to avoid unnecessary duplication of infrastructural equipment) but will be more content-creation oriented. CARNet MoD services are now starting it's operation (some segments have been in testing operation for last few months), while CARNet TV project will be slowly built running on top of CARNet MoD infrastructure, gaining its partners and content from users of MoD services.

### 2.4. MoD elements

In order to support and implement services provided, Media on Demand service builds and maintains several key elements, all of which are designed to be fully dedicated to support of MoD services.

- MoD server system - an integrated multimedia storage & distribution system with XML-implemented metainformation model and content-management system to support both end-user interface and content-author interface. This server system implement both MoD and TV services (onDemand, Live and Program broadcast)
- MoD production system - production service capable of both real-time capture (RT) and digitizing of analog content and DV-based non-linear editing (NLE); this system would be open to others within CARNet community.
- MoD consulting - knowledge base for supporting end-users, content-authors and creation of production and distribution systems within CARNet members.

Key philosophy in defining access rights and access mechanism to both MoD/TV server and production system is minimizing MoD administrators involvement in those procedures. This approach (dubbed "shoot first") would i.e. enable content-authors from various institutions within CARNet community to create their "accounts" at MoD server and upload their content without waiting for administrator to enable or allow access. Another example of this operation is enabling live streams to be broadcasted through MoD server without any involvement of MoD administrator (all necessary interaction would be between content or stream authors and MoD server through web interface).

### 3. MoD server system architecture

MoD server system is designed to be an integrated solution for storage and distribution of multimedia content. Basic requirements put before server system are support for all multimedia architectures supported by MoD services and ability to create interfaces to all concerned parties (end-users, content-authors, administrators) from a single content-management data.

To support all four supported media architectures (Windows Media Technologies, Apple QuickTime, MPEG-1 and RealNetworks RealMedia) server system is implemented through a pair of coupled servers, one running GNU/Linux OS, and one running Windows 2000 OS. This solution was required due to lack of all necessary tools on one single platform. Together these two servers will provide both CARNet MoD and TV functions (onDemand, Live and Program Broadcast) and be an Internet home to both MoD and TV services. Also this architecture provides easier way of scaling server system since if one of two servers (with functions it implements) runs into performance problems certain functions can be moved or replicated to other computer in the server system.

#### 3.1. Multimedia services

Primary multimedia service server computers implement is streaming distribution of stored multimedia content or live multimedia streams, through four installed multimedia servers: Windows Media Services 4.1, Darwin Streaming Server v3.0, RealServer Basic 8.0 and Xing StreamWorks 3.1. Additional capability in multimedia content distribution is ability to download certain content (if allowed by content-author) through ordinary Apache web server.

To support communication between server system and production systems, Samba/CIFS sharing is installed enabling content-authors to add their content to their designated directories on storage server. Combining Samba access and several server-side administration applications, content-authors can add metainformation information about their content (content description and content management information) that is formatted in XML and stored on the server alongside the content.

#### 3.2. End-user services

Main goal of server systems is of course enabling end-users to access the multimedia content stored and distributed from MoD server. Though content-authors can create their own web interface to content on MoD server, MoD server builds a generic interface to multimedia content from metainformation descriptions of the content.

Quality of this interface depends much on content-authors taking time to add metainformation about their content, and MoD services intend to encourage content-authors to create complete and detailed metainformation constructs of their content.

Additional tools provided to end-users include search capability both for multimedia content and for other documents stored on MoD servers. Quality and success of this context-based search depends on quality of metadata stored with multimedia content. Also provided are instructions and common tools for reproduction of multimedia content.

#### 3.3. Management services

Management services provide MoD administrators with detailed reports and tools for control over elements of multimedia server (various media and access services) and comprehensive log analysis to enable statistical analysis of end-user behavior and content-quality. Tools providing control and administration of multimedia content on MoD server enable administrator to control whether content-authors follow the procedures and policies defined and imposed by MoD server system. Since MoD server aims to enable operation without administrator intervention (shoot-first), it is important to be able to react quickly in events of users and content-authors failing to comply with pre-defined policies.

### 4. MoD production services

Due to various limitations, which are more often issue of user education, habits and tools than financial, it's unlikely to expect large number of users producing their own content and preparing it for distribution through MoD services. Therefore, a centralized production service (studio) is created to provide production services to users both inside CARNet and in CARNet community.

Functions of such service would be digitizing and processing analog content created or obtained by users and also production of multimedia content both for analog and digital distribution. Even when large number of users became capable of their independent production, it is still important to have such production service for support of content-authors and for higher quality production that can't be achieved with consumer digital video solutions.

#### 4.1. All-digital production workflow

With the price drop of DV-enabled video appliances (DV and miniDV camcorders) it becomes possible to create all-digital production systems based on DV format. Primary advantages of all-digital production workflow over hybrid or analog productions workflows are ability to create high quality production system at much lower price-point and also to have very scalable production systems based on same input and output content: from entry-level amateur production to high-end DV-based editing system.

Production services implemented in MoD include both ability of real-time converting analog content to finished streaming-ready formats, and the ability of prosumer (professional consumer) and even professional non-linear editing (NLE). These services and this equipment would be shared with some MoD services partners and also MoD would provide production services for those who don't have their own production equipment.

#### 4.2. Non-Linear Editing System (NLE)

High-end (almost professional) non-linear editing (NLE) system is created around Matrox RT2500 card (and Pentium 4 computer) for DV production with support for real-time effects and transitions. Actually main problem expected with this system is complexity of this system (which is based around Adobe Premiere) so it becomes important to also install and utilize some entry-level production application (like ULead VideoStudio) when power and features of full DV real-time NLE isn't really required.

#### 4.3. Real-time encoding (RT)

Built around Osprey 500WM and very powerful Pentium III computer, real-time encoder is mostly used to convert existing analog content to streaming-ready digital content. Though it is also capable of real-time conversion of analog content to MPEG-1 and RealMedia formats, only conversion to Windows Media format is hardware-implemented and accelerated. Though system itself isn't built to be very portable, this computer can be used for encoding live Internet broadcasts due to hardware-based real-time capture & encoding capabilities. This computer can also be used (to some extent) for editing purposes but on consumer/prosumer level.

#### 4.4. MoD/TV media studio

To support and implement services provided by MoD and TV services, idea of creating more-or-less formal media studio comes in mind, to provide on one place all equipment necessary for multimedia production and administration of MoD services. MoD/TV studio would include: Real-time (RT) encoding system, Non-Linear Editing (NLE) system, MoD & TV server system, administration and testing computers and collection of audio/video equipment needed for production purposes: audio and video mixers, VHS player/recorder, DV cameras and other necessary equipment.

### 5. Metainformation models for MM content

Existence of integrative element between various elements in multimedia infrastructure is crucial to normal operation and synergy of such components. Production systems are required to communicate with storage and distribution systems, distribution and storage systems must talk to end-user in order to deliver required content in required quality or format. Systems without such integrative element are bound to develop problems with tracking and management of both production and usage of multimedia content.

This has been experienced in CARNet, where both content-authors didn't know how to promote and deliver their content and likewise, end-users didn't know or weren't aware of existence of some media content. Also, distributed nature of multimedia servers further distanced content-authors from end-users.

Usual common denominator, or common language in such systems is a metainformation model, which spans from content-authors, through storage and delivery servers all the way to end-users and consumers of multimedia content. In such a model, information about content and distribution right, methods and principles can be described and stored, and thus can be shared between various elements of media infrastructure.

Especially with XML-implemented models, crossing the borders between even different systems and even metamodels has become relatively easy to implement. It is important to note that XML has only "transport" function, and is basically unaware of content stored in it (which usually complies to some metainformation vocabulary, either standard or proprietary), but XSL transformations enable metadata to cross from one scheme and vocabulary to another (if separate elements of multimedia infrastructure use different models or we want to communicate with any outside system).

CARNet Media on Demand services implement their own metadata model, based on simple metainformation model stored in XML and then processed on their way (ideally) from their source (content-authoring) to their destination (end-users of multimedia services).

#### 5.1. Existing models

Metainformation model inherent in currently dominant multimedia architectures (Real Media, Windows Media Technologies, QuickTime and MPEG-1) do not provide any or enough room for storing content descriptions and content management information within media files (due to container model of media files introduction of metainformation "track" could be possible, but since file formats are usually proprietary there aren't any tools which would provide extracting and storing metainformation inside media files themselves).

Therefore there is a need for metainformation models that are defined outside current multimedia architectures, and such models are usually an implementation of existing metainformation storage, retrieval and processing solutions but adjusted to operate with multimedia content.

Current activities in that area are converging mostly to usage of DublinCore (DC) metainformation vocabulary through XML-implemented RDF (Resource Definition) framework and around upcoming MPEG-7 standard. Complexity of these solutions makes them more-or-less unimplementable when designing multimedia content storage and distribution system.

#### 5.2. Proprietary XML implementation in MoD

When designing multimedia services, sometimes existing metacontent models can't provide satisfactory level of functionality, even though such models are extensible and customizable to some specific needs.

Usually, biggest problem is implementing mechanism for parsing and analyzing metainformation written i.e. in RDF scheme and XML syntax (due to problems with XML parsing and XSL translating engines). Other important issue is problem in storing server system specific information (content management information), which instruct storage and server functions.

In CARNet Media on Demand we opted for our proprietary XML scheme since it was easier to implement non-standard description in our own XML language than to create XSL's that would translate RDF descriptions to our HTML interface. Also, XML was used to build complete interface, not only metacontent for multimedia content, so we needed functionality for both storing metacontent and interface building content within same XML documents.

Usage of Apache Software Foundation (ASF) Cocoon XML publishing system provided us with very flexible user interface, since we formulated two languages one of which described content folders (groups) and other to describe metacontent for multimedia content (internally dubbed MDL and FDL (Media and Folder Description Languages)).

### 5.3. Metamodel interoperability

To achieve interoperability with other metadata-enabled systems, transcoding of metadata from one to another scheme/format/vocabulary to another is very offer a key requirement. Also since currently there isn't a monolithic solution for distribution of multimedia content, all distribution systems are created out of several mutually depended components that require communication between their (meta)data models.

CARNet MoD server system (multimedia distribution) currently provides interoperability with DublinCore model to support DC enabled web search engines (such as CARNet CROSS), but interoperability with other metadata models is also possible and implementable, and is already planned for next version of MoD content-management system which would be based on some more standard and formal scheme.

### 5.4. XML as foundation of interoperability

Main reason why most current models are interoperable is usage of XML in all of them (or at least, existence of XML implementation for the model). When we create or have two data models (schemes) in XML and if we define which are matching fields and entities, translation between models is quite easy and straightforward (and achievable with XSL).

XML was natural choice for "transport framework" for metadata structures and models, since it can both support flat and hierarchical data, and set of supporting standards and tools is provided to work with and on data stored in XML syntax. It is important to note that XML doesn't really have nothing to do with metadata itself or our metadata model (as XML usually isn't aware of data stored in it, it simply defines ways of storing and formatting structured data).

### 6. Conclusions

When finalized, CARNet Media on Demand services would provide CARNet and CARNet community with very powerful system for production and distribution of multimedia content. Experiences gained with metadata-powered integrated multimedia distribution servers and workflows will be used to enhance the operation of MoD services with the goal of becoming more transparent to end-users, content-authors and administrators.

Next planned version of CARNet MoD server system would include support for multi-type content and internationalization of the system, since we aim to have our server system developed with the support of TERENA (Trans-European Research and Education Networking Association) and offer it to other academic and research networks and institutions.

But success or failure of CARNet MoD services depends on acceptance of both MoD services and multimedia in general in CARNet community.

So, there's a big work ahead, to encourage and support institutions, research projects and individuals within CARNet community in usage of multimedia in their work, both as users of multimedia content as content-creators. Goal of MoD services is to provide tools and knowledge needed for multimedia production, which should then encourage others into usage of multimedia content.

Next big battle ahead is fight for content. The shiny servers and computers and nifty technical solutions don't define usability and value of MoD services, but by the quality of content provided, both content created by CARNet community itself, and content which we manage to provide for CARNet community (i.e. various educational content).

Fight for content will be led together by CARNet MoD and TV services, with the aim of both creating and providing (from other sources) quality content for CARNet community.

### 7. Literature & References

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- And internal project documentation (parts of which will be publicly available at MoD web site)