A Digital On-Demand Video Service Supporting Content-Based Queries[1]

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Abstract–Video-on-demand represents a key demonstrative application for enabling multimedia technology in communication, database, and interface research. This application requires solving a number of diverse technical problems including the data synchronization problem for time-dependent data delivery.

In this paper we describe the general requirements of video-on-demand and introduce a system supporting content-based retrieval and playback for the structure and content of digital motion pictures. In our model we capture domain-specific information for motion pictures and provide access to individual scenes of movies through queries on a temporal database. We describe our implementation of this service using existing workstation and storage technology.

Keywords: Multimedia databases, video-on-demand, applications, temporal data management, content-based retrieval.

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1 Introduction

Future multimedia information systems will have a dramatic effect on the dissemination of information to individuals. These systems will provide a plethora of services including games, movies, home shopping, banking, health care, electronic newspapers/magazines, classified advertisements, etc. One manifestation of this view is the development of systems supporting video-on-demand (VOD). In a VOD system, video data, including motion pictures, are provided to a user community on an individual basis. Fig. 1 shows an example of a graphical user interface to a VOD system.

A VOD system must provide mechanisms to access enormous amounts of information, especially as derived from video data. This implies the existence of very large databases and the means of accessing them. On the other hand, individual users require the ability to filter unwanted information in the selection of appropriate programming.[2]

We envision a VOD system that allows the viewing preferences of each individual to be tailored and adapted to the available programming (e.g., one viewer's interest in classic movies, another's restriction to children's programming). Such a system would filter both stored and "live" television broadcasts and would offer these selections to the viewer instead of the plethora of choices possible. Other features would permit more fine-grained information filtering. For example, specific topics of interest could be identified within a set of newscasts or documentaries.

In order to support this vision, we require identification of the content of unstructured audio and video data. In the case of a newscast, the content is readily available from its producer. For motion pictures the content is embedded in the images themselves (in the absence of a script). We ultimately want to provide interesting, useful, and diverse means of accessing such multimedia information from a very large realm of data. This requires searching for specific items in unstructured data (e.g., "find all scenes of a movie with a certain character"). To provide this type of access, we need to model the content of the data when data can be unstructured.

In addition to the modeling of data and queries, we also need the ability to extract data to fit these models from the unstructured data. This requires identifying and classifying information from images, sound and text. Furthermore, timing information is required to support audio and video data delivery, playout, and queries based on temporal ordering.

[2]Cable TV systems with more than 500 channels are proposed [2].

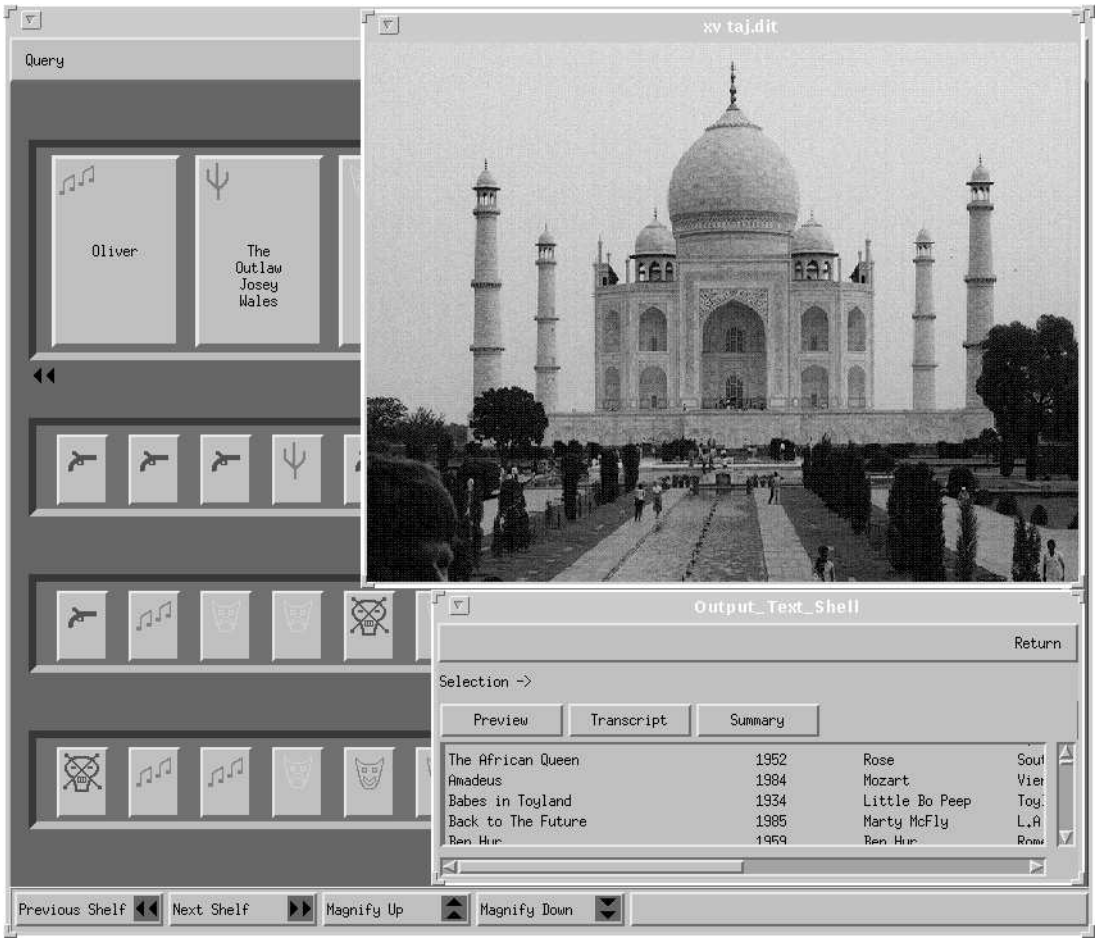

Figure 1: A User Interface to VOD Services

Our objective in this work is to demonstrate the utility of our models for time-dependent multimedia data [19] in the construction of a VOD system. In this process we have sought to develop interesting access approaches to the retrieval of motion pictures. The prototype system, called the Virtual Video Browser (VVB), is designed to support *temporal access control* operations based on data structures describing the digital movies. Content-based retrieval is achieved by using a domain-specific model for motion pictures. The VVB application characterizes motion pictures and their attributes to the level of movie *scenes* by using a movie-specific data schema. This schema interfaces to our temporal model to provide temporal access control (TAC) operations such as fast-forward and reverse playout.

Research related to this effort includes modeling of unstructured data for content-based retrieval [26, 25, 39, 41, 42, 46], modeling of the temporal component of multimedia data [8, 9, 19, 16], modeling of application-specific multimedia data (movies) [11, 23, 24, 31, 35, 36], systems support for delivery of audio and video and video servers [1, 29, 43], and network-based VOD system design [14, 13, 27, 33, 34].

The remainder of this paper is organized as follows. In Section 2 we overview VOD network services. In Section 3 we describe domain-specific attributes of motion pictures and our base temporal modeling facility. Section 4 describes the design and operation of the VVB system. Section 6 concludes the paper.

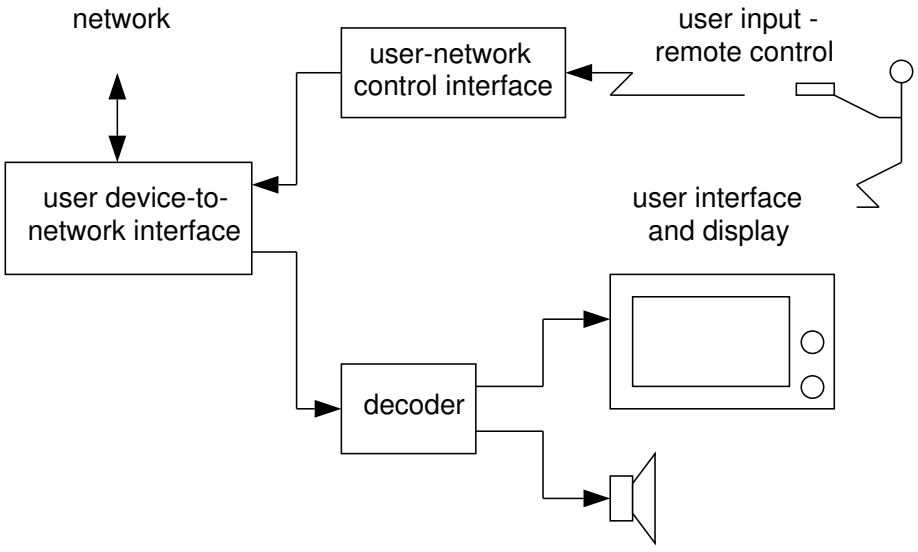

Figure 2: CPE for VOD

2 VOD Network Services

Video-on-demand promises tremendous change in information distribution. Envisioned features of the simplest systems provide services to allow selection, delivery and viewing of movies through interaction with a viewing device such as a television with remote remote control. This type of device, or customer premises equipment (CPE), is illustrated in Fig. 2 (adapted from [13]).

VOD differs from existing video rental services in its potential to deliver many additional services such as interactive learning and information retrieval. In its basic form, a VOD interaction scenario consists of a movie database perusal or query, a request for a feature presentation, and movie interaction through TAC operations. Current VOD systems are described by a scale of interaction capability as follows [13]:

- Pay-Per-View (PPV)
- Quasi Video-On-Demand (Q-VOD)
- True Video-On-Demand (VOD)

PPV represents an incremental change from broadcast television supporting prescheduled programs selected by a user, and is easily supported by simple VCRs and network communication. Q-VOD provides additional interaction by grouping requests for individual programs and scheduling them at regular intervals. This provides the ability to pause a program and resume by restarting the program within a separate group at a constant time offset. This scheme requires an independent data source for each group request. True VOD does not have these limitations and assumes total interaction capability. It is also the most expensive to implement with current technology as each user can require a unique data source.

A typical architecture for VOD services is shown in Fig. 3 (adapted from [21]). Here, a set of video databases are interconnected with a set of servers which perform routing of VOD traffic to individual users. Users connect to the VOD service through access points typical of a central office (CO) exchange. It is envisioned that each server manages connection-oriented VOD traffic for multiple sessions.

The requirements of a VOD service are primarily data transport, data packaging, and billing, but also include the provision of *information warehouses (IW)* [13]. These IWs can be part of the VOD service or be complementary, provided by information vendors.

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