# A Multimedia Architecture for Medical Tele-Imaging over ATM

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**Abstract**

The goal of this paper is to present a multi-media telecommunication architecture based on ATM technology, which provides reliable and effective transmission of still and motion high resolution (1024x1024 up to 4096x4096, 16 or 32 bits/pixel) radiological and pathological images or part of them.

The peculiarities of such architecture are the following.

1) Provide Quality of Service (QoS) awareness by means of inter and intra flow synchronization mechanisms.

2) Provide mechanisms of reliable transmission of data.

3) Provide the capability of remote manipulation of a Region of Interest (RoI), defined as a portion of a still or motion picture which is represented and coded with a higher quality than the remaining part of the picture.

## 1 Introduction

In the last decade the communication networks have had an enormous development both in local area networks (LAN) and in wide area networks (WAN). Recently a new mode of data transfer called *asynchronous transfer mode* (ATM) [1], suitable for very fast packet switching and with Quality of Service (QoS) guarantee has been developed. Such technique relies on large bandwidths (of the order of tenths and hundredth of Mbits/s) and allows a reliable transmission of real-time streams such as video and audio data, typical of multimedia applications. From an application point of view the navigation and the consultation of information stored in remote sites is made possible by means of well known and largely employed browsers such as the World Wide Web. Furthermore important progress has been done in the domain of the cooperative work.

The medical community is showing great interest for this evolution in the area of multimedia communications: a significative number of hospitals are already equipped with local ATM

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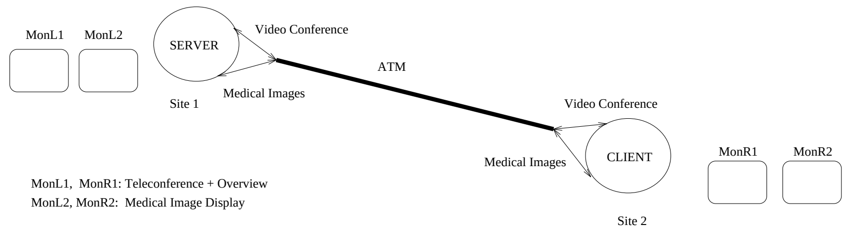


Figure 1: A typical application scenario: MonRi, MonLi represent the monitors available at each site

networks. At the same time a large number of servers make available important medical databases, in particular medical still and motion pictures. Finally the evolution of the production of electronic chips such as microprocessors makes the price of a quite powerful computer accessible to a large number of people.

The real-time transmission and processing of medical image data becomes today possible, opening interesting possibilities in particular in the area of the tele-diagnosis.

In this paper we propose a telecommunication multi-media architecture based on ATM technology, which provides reliable transmission of still high resolution (1024x1024 up to 4096x4096, 16 or32 bits/pixel) radiological and pathological images or part of them. The peculiarities of such architecture are the following:

- provide Quality of Service (QoS) awareness. Inter and intra flow synchronization mechanisms assure a natural event synchronization
- provide mechanisms of reliable transmission of data. Proper packetization mechanisms assure system robustness against network errors, such as cell losses and cell delay variations.
- provide the capability of remote manipulation of a Region of Interest (RoI) called also detail image, defined as a portion of a still or motion picture which is represented and coded with a higher visual quality than the remaining part of the picture.

A typical scenario is shown in Fig. 1. Two remote sites are interconnected by an ATM network. Each site has the following functionalities:

- Teleconferencing: the teleconferencing tool is based on a commercial product and is able to assure a reliable teleconferencing session between the two operators. It is capable of MPEG-1 video and audio coding as well as white board sharing.
- Access and inspection of medical images. Images are stored in an image database in which radiological and pathological high definition images (around 4000 dpi) are stored. Images can be accessed and inspected in real time without previous image file transmission.

The image inspection is performed by means of two windows. A first window, called *overview*, displays the image under inspection at low resolution. On such overview it is possible to dynamically displace a resizable rectangle to select a part of the image for detailed inspection. This sub-image is called *detail* image or *Region of Interest* (RoI). The detail image is displayed in a second window which is updated in real time (max speed 25 frames per second) according to the displacement of the selection rectangle on the overview. Image inspection is assisted by a teleconferencing tool which allows the two operators to interact and to cooperatively perform the analysis of the medical image.

# 2 Dynamical medical image inspection

The system architecture is presented in more detail in Fig. 2. A server provides the flows associated with the detail image. The client gets this flow and supplies the user with the position of the mouse and the dimensions of the detail image. The network support is based on ATM technology, with bandwidth of 34 Mbits/sec. The system sub-blocks are described in detail in the following sections.

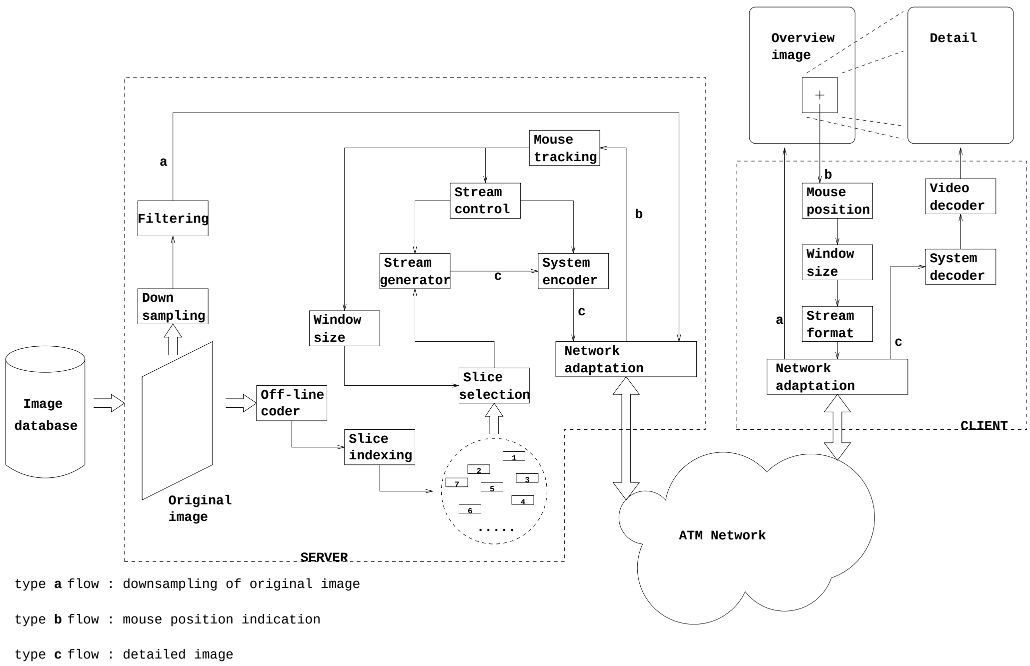


Figure 2: Block diagram of the architecture

# 3 Image Data organization and storage

Each image is stored in the database in two different formats:

- subsampled: typically a subsampling factor of 4 in each spatial dimension is used. Less than 32 bits per pixels are used. The exact subsampling factor and number of bits per pixel depend on the image type. This is the format of the overview image.
- JPEG-like off-line encoded and organized in slices of fixed size (80x16 pixels).

An off-line indexing process labels each slice according to its position on the original image as shown in Fig. 2. The advantages of such data representation are the following.

- It allows a fast access to different parts of the image by different users.
- The coding is performed only once allowing a full software architecture without the need of a hardware encoder.
- The visual quality of the sequence of images generated by dynamic displacement of the reseizable rectangle on the overview is constant because the encoding process is performed only once. The operator has full control of the visual quality of the sequence at encoding

stage. The JPEG coding method has been employed because it is the only compression method validated by the radiologic community [2].

# 4 Real-time Dynamic Image Inspection

## 4.1 Slice selection

The mouse position and the rectangle dimensions on the overview image are updated for each mouse displacement and are taken as input for the slice selection on the server side.

## 4.2 Stream generator

The selected slices are then encapsulated in a video stream by the stream generator. Proper headers (sequence headers, GOP headers, picture headers) are added in order to form an MPEG-2 compliant stream. This MPEG-2 stream is composed by only I-frames, assuring a constant visual quality. As an example, for a detail window of 512x512 pixels, 16 bits/pixel at 25 frames per second, with a compression rate of 10, the bitrate is around $10Mb/s$. The stream generator is under the control of a stream controller which is discussed hereafter.

## 4.3 Stream control

The stream controller performs a regulation on the stream generator. It takes as input the mouse tracked position and determines whether or not to generate and send the video stream. If the mouse is not moving for a given interval of time, the detail image is still, thus transmission is not needed. In that case, the stream generation and packetization are suspended.

Finally the elementary video stream is mapped to ATM by the system encoder in a similar way as specified by the ATM Forum and ITU [3, 4, 5].

## 4.4 System encoder and decoder

The system encoder creates an MPEG-2 [6] compliant Transport Stream (TS) [7] taking as input the video stream. The output is a sequence of 188 bytes long TS packets. The system decoder performs the inverse operation at the receiving end.

## 4.5 Network adaptation

The Network adaptation block maps incoming TS packets (188 bytes) into outgoing AAL-5 PDU packets (376 bytes).The inverse operation is performed at the receiving end.

## 4.6 Video decoder

One of the advantages of formatting the image material on an MPEG-2 compliant video stream is that it can be decoded with a standard MPEG- 2 video decoder. In the case of slow mouse movements software video decoder can give satisfactorily performances if sufficient computation power is available. Best performances may be obtained using a hardware MPEG-2 video decoder.

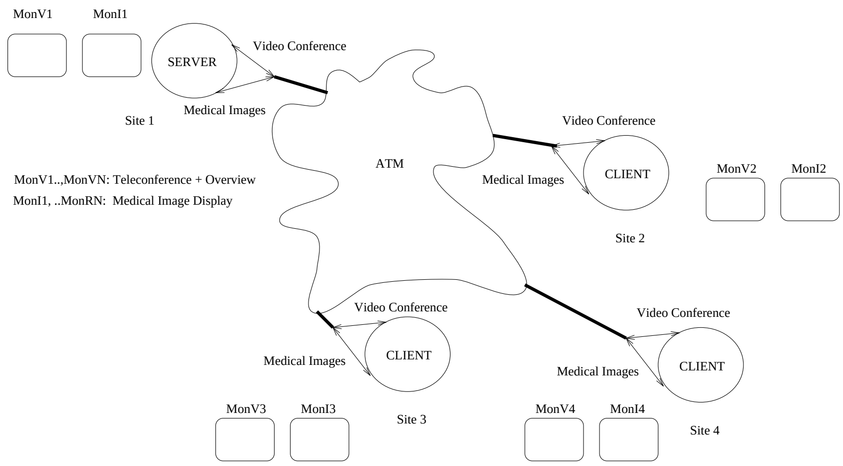


Figure 3: Advanced Scenario: MonVi,MonIi indicate the monitors available at each site

### 4.7 Mouse Stream generation, formatting and handling

The mouse position is sampled on the overview image and mapped in the corresponding position in the high definition image.

There are three components for each sample: 2 spatial coordinates and 1 temporal coordinate (time stamp). Time stamps have the role to keep this flow synchronized with the video.

An error concealment method at the receiver end is used to recover from mouse position losses, which can be very annoying. It is based on mouse speed and acceleration estimation.

## 5 Future Developments

Future developments of this architecture will go in the following directions:

- Extension to multi client architecture: to allow more that two users to interact as indicated in Fig. 3.
- Synchronization between different clients. In the current architecture interaction between two users is possible only by means of the teleconferencing tool. A possible extension is to allow to share also the detail image window.
- Real time acquisition and coding of the input image. In the current architecture the acquisition of the images and their storage in a proper format is performed off-line.
- Telemanipulation of the acquisition device (typically a remotely controlled microscope).
- MPEG-2 based video conferencing.

## 6 Conclusion

We have presented a real-time multimedia architecture for medical teleimaging over ATM. The work has been focused on two main aspects: the quality of service awarness, from a joint video and network point of view and the confidentiality aspect, from a medical point of view. A multimedia architecture allowing teleconferencing as well as the real-time inspection of high resolution medical images has been discussed. Future development of such architecture are foreseen, which will allow an extension to more users and improved handling of the Region of Interest.

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