Digital Video: Myths and Facts

- **Playfield for extremists**
  - Popular research approach: current hardware and software infrastructure inadequate for digital video or other continuous media. Packet networks and IP protocols not useful; need ATM AAL and radically new protocols to ensure quality of service, bandwidth provisioning, tight real-time protocols and scheduling.
  - Enthusiasts claim: Internet ready for digital video - let's go MBONE!
  - Telco's and CATV: take a disk farm or a bunch of real-time MPEG encoders and connect to hybrid fiber coax.
- **None of these really works today!**
  - ATM technology not ready, QOS not implemented, AAL1 protocol not available. This approach seems to look for a problem to a (hardly existent) solution.
  - Internet certainly not ready for video. MBONE just a demo of IP multicast technology.
  - Telco's and CATV trials plagued by performance and scalability problems.

Digital Video: Middle Ground

- For carefully designed systems, efficient implementation of network digital video is possible today. Existing shared medium LAN infrastructure (both hardware and software) can be used and integrated with ATM switched networks and with WAN technologies. IP framework offers sufficient initial support for serious VOD projects.
- Internet ready only for very low bandwidth digital video. Both infrastructure improvements and new software is needed for Internet video becoming reality.
- For large commercial or educational digital video distribution systems significant basic research is needed. The best architecture of a scalable video server is not known at present, nor are the proven guidelines to build such an installation available.

  Web references: http://spiderman.bu.edu; http://www.tnc.lcs.mit.edu; http://elmer-fudd.cs.berkeley.edu; http://vod.isl.goldstar.co.kr; http://www.netwideo.com; http://www.npac.syr.edu

Video Compression (1)

- **Frameworks (1):**
  - **Video for Windows: Microsoft platforms, proprietary standard, .AVI file format, codecs: Indeo, Cinepak, M-JPEG, MPEG**
    - SW and HW decoders, DCI support, MCI application interface, disk oriented
    - Advantages: easy to integrate with applications; disadvantages: network support requires non-trivial custom programming
  - **QuickTime: Apple (secondary: Windows XX, SGI), proprietary standard, general isochronous delivery framework, codecs: JPEG, Cinepak....**
    - Modest video quality, no explicit network support (integration with OpenTransport pending), SW only
    - Popular Video CD/Games technology, spectacular QT-VR extension
    - Limited acceptance - rarely considered as professional network digital video platform

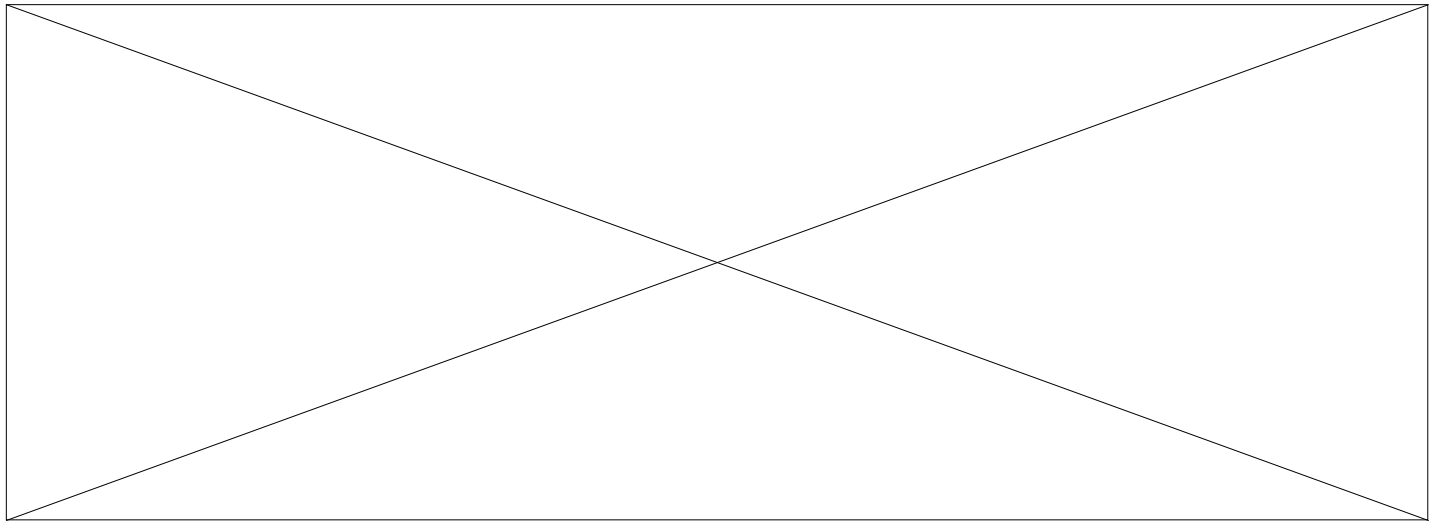
Video Compression (2)

- **Frameworks (2):**
  - **Motion JPEG: not really a standard. High-quality frame-preserving codec, relatively low compressions rates**
    - Leading technology for non-linear video editing (AVID), broadcast quality video, mostly SW but HW decoders emerging. AvidNet (a.k.a. MediaNet) network support
    - Limited standardization. Recent initiatives: Digital Media Language (DML) and Open Media Framework (OMF)
  - **MPEG: both a codec and delivery framework; international standard; Telcos and cable TV industry pick for network digital video**
    - complex codec using both intra and inter frame compression; encoding very CPU intensive; encoding algorithm not part of the standard, both Constant Bit Rate and Variable Bit Rate supported; variable quality up to HDTV
    - system stream carries both video and audio (6 channels for MPEG-2); suitable for both disk and network delivery; difficult to handle in interactive titles
    - 3 different flavors: MPEG-1, MPEG-2, MPEG-4
    - Web reference: http://www.crs4.it/luigi/MPEG/mpegfaq.html

Video Compression (3)

- **MPEG flavors:**
  - **MPEG-1 and MPEG-2 use the same base technology but begin with different initial resolutions**

    3 types of frames: I-frames (a.k.a. key frames) use only intraframe compression akin to JPEG; P-frames and B-frames do not contain pixel information but operational description of frame content. To decode a P-frame, decoder needs frames behind; for B-frames both look behind and ahead is needed
  - **MPEG system stream: video and audio interleaved in a complex fashion**



MPEG-1 vs. MPEG-2

- **Is MPEG-2 going to replace MPEG-1?**
  - **No. MPEG-1 and MPEG-2 have been targeted at different bit rates!**

Initial frame sizes:

CCIR 601: 720x480

SIF: 353x240

MPEG-1: decimation prior to encoding

Video Compression (4)

- **Futures:**
  - **MPEG-4: currently in application identification phase. Standard expected end of 1998. Intended for very narrow bandwidth (ISDN). Probably will include speech and video synthesis (compare to MIDI) and artificial intelligence technologies to build high fidelity pictures from minimal data.**
  - **Wavelets: superior data compression technology discussed elsewhere in this tutorial. Potentially can achieve 300+:1 video compression rates in relatively simple algorithmic way. Has potential to eliminate MPEG!**
- **Current digital video on the Web:**
  - **I-frames only MPEG, data rates 500 - 700 Kbit/s, 160x120 pixels (QSIF), software playback (<15 frames/sec). Extremely poor quality, prohibitive download times for POTS users.**
  - **.AVI and QT movies. Even worse quality, usually larger file sizes.**

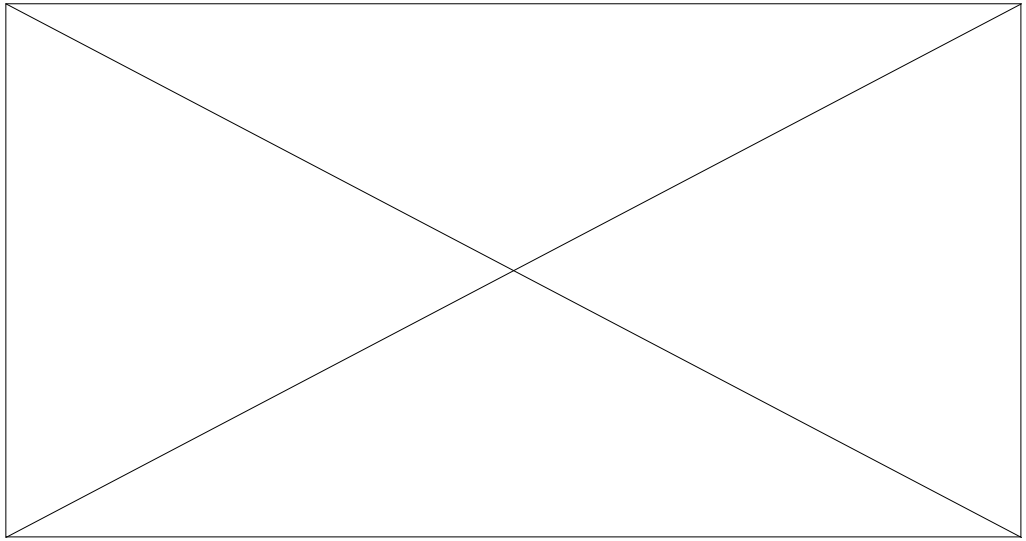
Encoding and Content Preparation

- Video for Windows: easy access to inexpensive capture, encoding, and editing tools. HW assisted real-time encoders available in <$500 price range (Intel Smart Recorder). Non-linear editors (Adobe's Premiere, ATI's Media Merge, Digital Media's Splice...) and video production tools (Assymetrix, HSC Software, Macromedia...).
- QuickTime: less abundant but readily available products. Many products available for VfW have a QT version.
- Motion JPEG: HW encoders mostly available for UNIX workstations (Parallax, SGI). At the high end, AVID products provide superb, professional capture, encoding, and editing tools. System of choice for postproduction houses. Unmatched quality and functionality.
- MPEG: HW real time encoders pricey (MPEG1) or very pricey (MPEG2). Non-linear editing systems rare and limited by non-frame preserving nature of the codec. HW encoders adequate for educational applications, SW encoders used for broadcast quality digital copies.

Decoders: Current Technology

- **Software decoders available for all codecs; performance ranging from adequate (VfW, QT) over moderate (M-JPEG) to very poor (MPEG).**
  - Only fastest RISC CPUs can decode MPEG in real time.
  - For VfW and QT, full screen 30 fpu video requires HW support as well.
- **Hardware playback options:**
  - MPEG: (1) decoder cards for external monitors only; (2) MPEG decoder cards using VGA feature connector to integrate MPEG & VGA; (3) proprietary integration of MPEG and VGA (VESA Media Channel)

- VfW: Display Control Interface architecture; DCI API allows for off-loading color space conversion to HW accelerator. Resulting performance improvement allows for larger final picture and less demanding network protocol handling.



Digital Video: Network Delivery Options

- **Most of the digital video frameworks are local mass storage (CD-ROM, hard disk) oriented. So is standard Web video technology (download first, then play). Telco's and CATV technology is mostly not IP-based. Interactive TV standards (DAVID - Digital Audio/Video Interactive Decoder) seem orthogonal to Web technology at present and will not be discussed in this tutorial.**
- **Network delivery options: shared file access and audio/video servers**
  - Shared file access: NFS, Samba (NetBios (SMB) servers for Unix) , AppleShare, LAN Manager .....
    - **disadvantages: not really continuous media protocols, some slow (NFS, AppleShare), no development path for QOS support, security problems, do not fit Web model although may be useful when used internally on LANs.**
  - "middle of the road" solutions like NetWare Video.
  - Audio/video servers: custom servers providing real time continuous media streams.
    - **Examples: RealAudio Internet audio server, Oracle's Media Server**

Media Servers: RealAudio server

- **RealAudio (http://www.realaudio.com) is a suite of programs to produce, serve, and play audio files over the network. The playback is instantaneous - no file downloading to local disk is involved.**
  - Software: custom player (free software) is needed to use Real Audio. Encoder is available for a nominal fee or as a part of server package
  - Architecture: an independent compressed audio server (ppn:/) delivers the audio. An audio link on a Web page only provides a URL of the audio server and audio file. The audio player is capable of locating, pooling, and interactively playing audio files from any server on the net even without an http browser.
  - RealAudio files require only 10Kbit/s to play and can be accessed using POTS. Compression technology is proprietary. Audio quality corresponds to AM radio. Encoder converts all popular audio file standards.
  - dozens of Web sites use RealAudio, including large broadcasters.
- **RealAudio represents a new wave of real-time, interactive Web services for continuous media.**

LAN Video Servers in NPAC

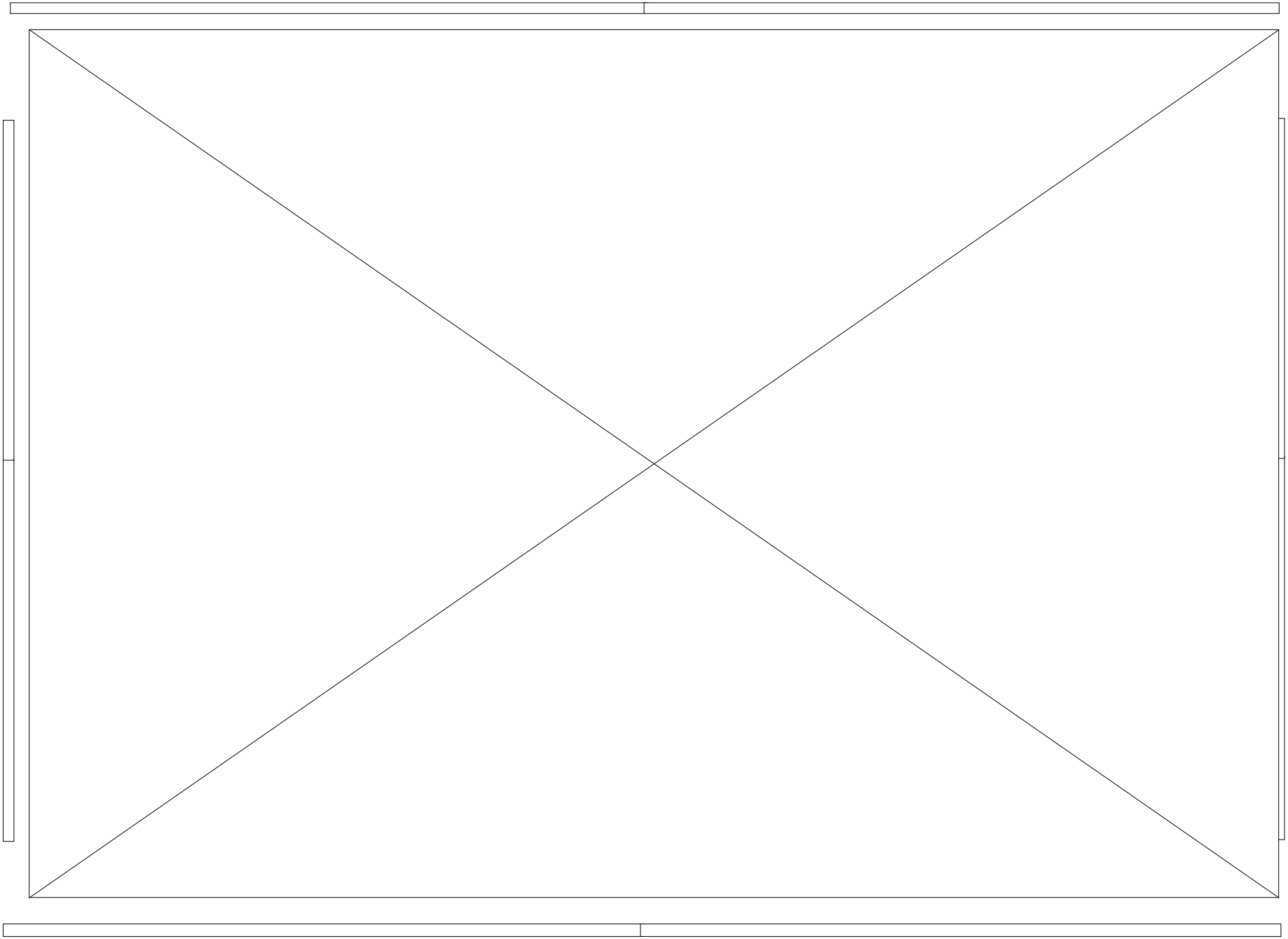
- **Digital video is much more challenging than digital audio!**
  - **much higher bandwidth required; audio/video sync critical, decoding process CPU-intensive and hence imposing very strict real time constraints on both server and player.**
  - **Interactive VOD servers implemented in NPAC: concurrent interactive IP VOD servers**
    - PC based Windows NT server (target: small corporate video installations): up to 4 MPEG-1 streams from single CPU/single disk
    - UNIX based server (target: larger corporate video and educational installations): scalable to few tenths of concurrent video streams
    - MPP servers (target: community video servers): scalable to 100s of concurrent video streams
  - **Common features: unified server protocol; video format independent; interactive, support for HW and SW decoders, high performance via multithreading and asynchronous I/O**

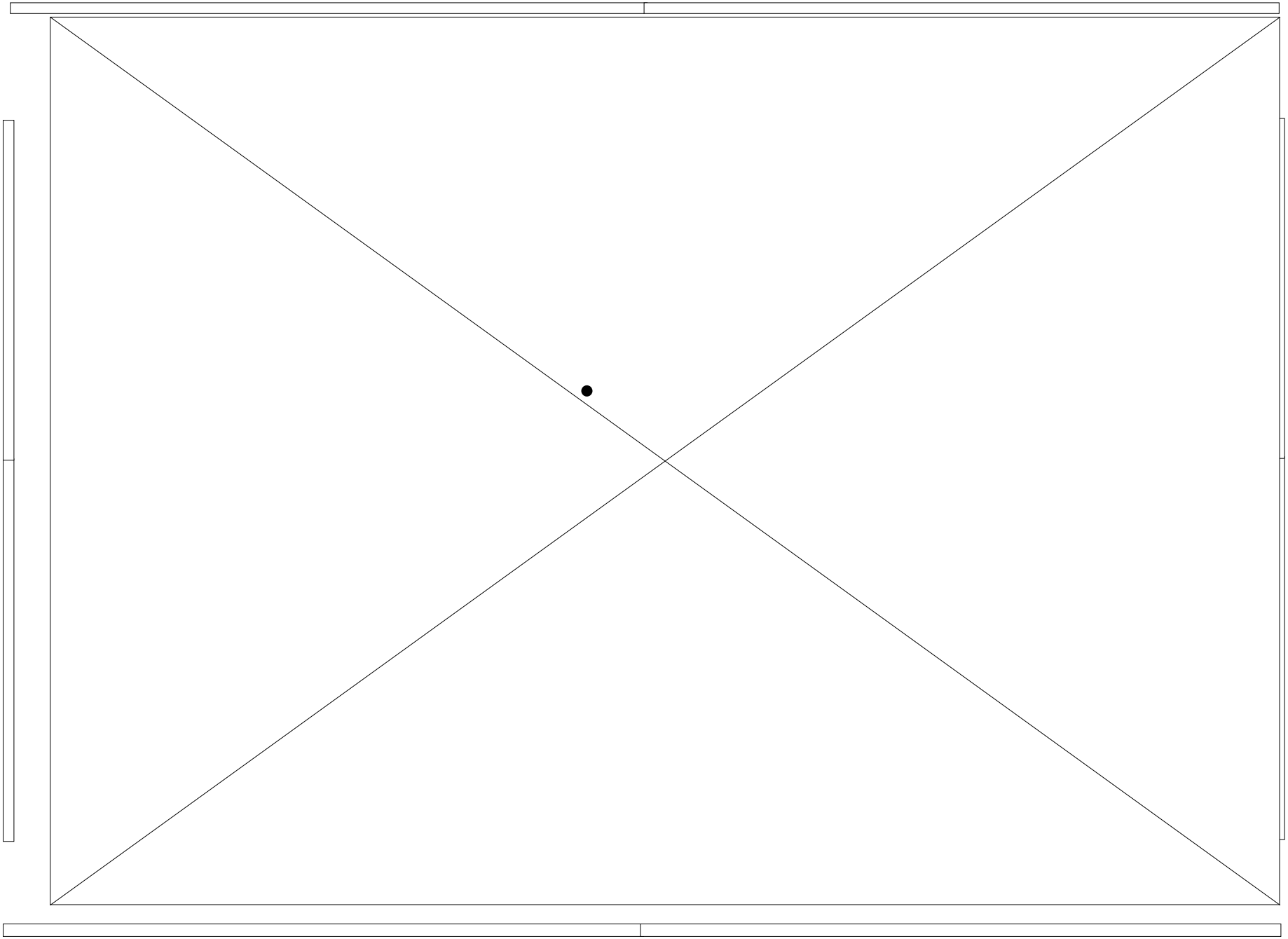
Interactive Video on Demand Servers

- **Challenging research issues:**
  - **Low bandwidth (ISDN) Internet VOD**
    - wavelet video compression
  - **Video Internet Protocol (VIP)**
    - new IP protocol with low overhead, guaranteed ordered packet arrival, and support for interactive video
  - **Contents indexing**
    - unification with text databases (metadata), automatic caption capture, conversion, storage
    - speech recognition with automatic video indexing via text-converted audio layer
  - **High-volume servers with ATM trunk: Variable Bit Rate (VBR) to Constant Bit Rate (CBR) conversion, optimized bandwidth provisioning, multiple audio/video stream scheduling (discussed later in this tutorial)**

Interactive Video on Demand Servers

- **Challenging research issues:**
  - **Design of scalable SMP and MPP VOD architectures**
    - Balanced and scalable CPU processing power, internal bandwidth, disk I/O, and network I/O
    - Data allocation procedures and performance impact
    - Multistage buffering schemes
    - Server management: data load, tertiary storage, hot cache
    - Scalability evaluation of SMP and MPP architectures for VOD
    - Criticality of server components performance for scalability and performance of entire system: simulation studies
    - Distribution network architecture and performance issues
    - System integration, cost, and maintenance issues





Video Server Simulation

- **prerequisite to software implementation**

VBR to CBR work (slides from Mike)

- related to high-volume servers with bandwidth limitations