Advanced Topics in Networking

Content Infrastructure

Part I: Introduction & Home CI Technologies

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Reading List

- "Professional Content Management Systems – Handling Digital Media Assets" by Andreas Mauthe and Peter Thomas, John Wiley & Sons, 2004
  - ISBN 0-470-85542-8

- "Consumer Applications of the IEEE1394 Serial Bus, and a 1394/DV Video Editing System" by Alan Wetzel, Michael Schell, in Proceedings of the International Conference on Consumer Electronics, Chicago, June 1996

- "EBU/ SMPTE Task Force for Harmonized Standards for the Exchange of Programme Material as Bit Streams, Finale Report: Analyses and Results" EBU Technical Review, Special Supplement, 1998

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Introduction

- What are Content Infrastructures?

  Content Infrastructures can be defined as networked systems that specifically support the creation, management, archiving and distribution of content

  - Content has two components: *encoded media* (essence) and *metadata*
  - Content Infrastructures have to support the specific requirements of content
- Content has stringent requirements
  - Support for Multimedia
    - Streaming of (high quality) video and audio
      - "broadcast" and "production" quality media
        - » MPEG-2, DV-Based formats
        - » 4Mb/s -270 Mb/s
    - Discrete and continuous media support
      - Images, graphics, text
    - Partial media retrieval
      - File transfer
      - Media streaming
  - Support for information retrieval
    - Search and retrieval of information
      - Database, full-text retrieval, ontology support, etc.
    - Text-based and multimedia retrieval
      - Image similarity retrieval, "query by humming", etc.

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Content Infrastructures vs. CDN

- Content Distribution Network (CDN)/ Content Networking
  - Networked infrastructure for the (wide) distribution of content
  - Ideally CDN "*should exploit the inherent structural and/or semantic characteristics of content as well as access patterns and delivery modes for effective content handling and distribution*"
  - Technologies
    - Usually overlay networks on top of the Internet
    - *But also* Television networks
  - Types of CDN
    - Professional, e.g. Akamai
    - World Wide Web
    - Peer-to-Peer Systems
- Content Infrastructures
  - Systems to support content processes
    - Home infrastructures
    - Production systems
  - Distributed, networked infrastructures
    - System components linked via IT and specialised networks
    - Components are specialised equipment, server and storage systems

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Home Content Infrastructures: An Example…

Requirements for HCI

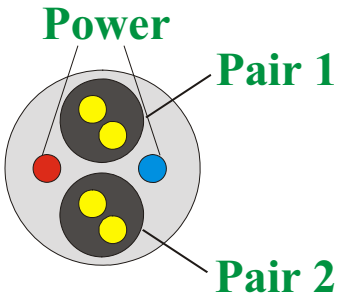
- Atypical requirements
  - Bandwidth
    - High bandwidth requirements
  - Cost
    - Needs to be competitive with traditional communication means
      - TV: terrestrial, satellite, cable
  - Ease of use
    - No special knowledge required
  - QoS Guarantees
    - Ensure continuous good quality
  - Simple protocol and interface
    - BUT still needs provide support for different media types

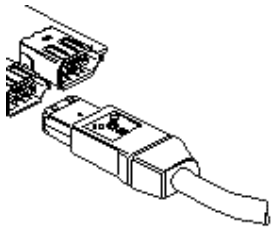
IEEE 1394 - Firewire

- IEEE 1394: Standard for High Performance Serial Bus
  - aka ***Firewire*** and ***I-Link***
  - Rolling standard
    - Current version 1394-1995
  - Supported data rates:
    - 100Mb/s, 200 Mb/s, 400 Mb/s
  - Peer to peer (bus) protocol
    - At endpoint level not system level!
  - Characteristics
    - Dynamic (re)configuration
    - Serial Bus architecture
    - Local area
      - Up to 4.5metre cable runs
      - Max. 16 hops between devices

Physical Interface: 1394 Connectors

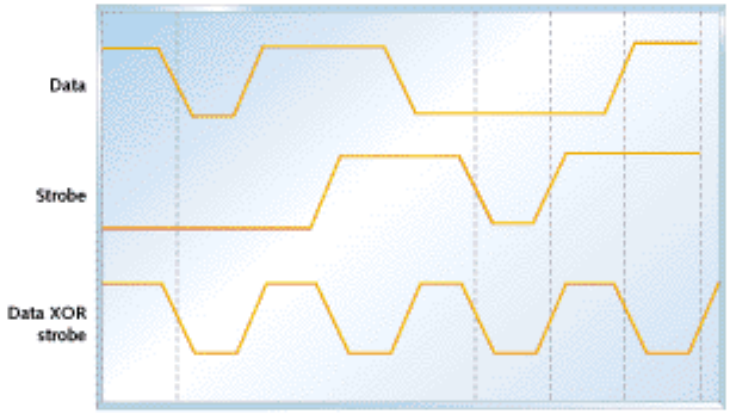
- 4 or 6 wire interface…
  - Power + two data/strobe pairs





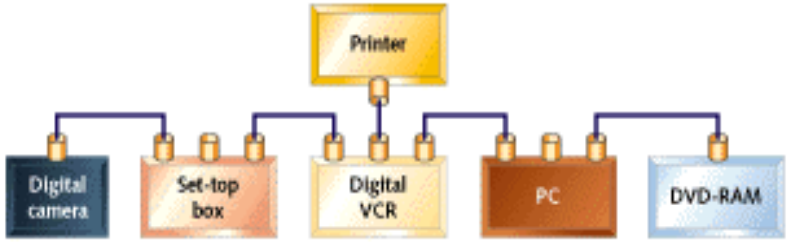
Physical Interface: Modulation

- Clever modulation…



Topology: Example

- Bus architecture
  - Nodes have one or more ports
  - Arranged in a tree structure:



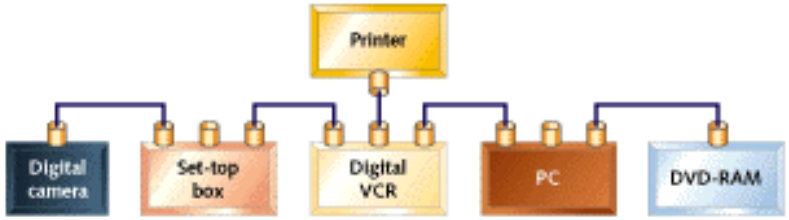
Features

- Auto configuration
  - Self-configuration is vital
    - Minimal user intervention
    - No infrastructure
    - Fast – total reconfiguration of order microseconds
  - Three phases
    - Reset, tree identification, self Identification
- Bus
  - Invoked
    - When a device is added or removed
    - When software deems it necessary
  - Signalled
    - All four data lines go high
    - Replicated throughout the network
  - Remove all topology information

Tree Identification

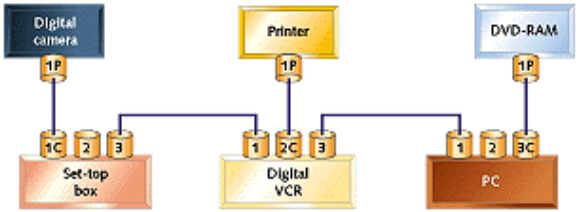
- Calculation of the physical topology
  - Needed for routing of data, loop avoidance
  - Distributed data structure
  - No one node stores the network layout
  - Executed immediately after a bus reset…
- Need to find a root node
  - For arbitration…
- Based on a simple algorithm
  - N is number of neighbours
  - C is number of known children
- If N – C = 1
  - send ‘parent notify’ signal
- Else
  - wait…

Example: Initiation



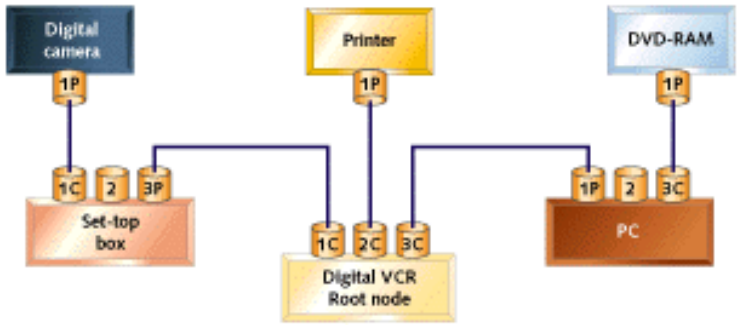
- Leaf nodes send parent notify…
  - Digital camera, Printer, DVD RAM
- Parents then confirm with child notify…

Example: Parent Notification



- Now next level nodes send parent notify
  - Set-top box, PC

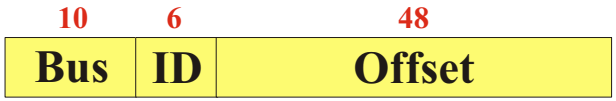
Example: Finale Process



- VCR has all ports as children
  - Elected as the root node
- What is missing?
  - Loop detection…
    - Remember – zero configuration and knowledge
    - What if we have a cycle?
    - Solution…
      - Timers

Self Identification

- i.e. *Addressing*
  - Devices need a unique identifier…
  - Static address bad
    - No routing information
  - Dynamically generated based on the network hierarchy
  - Assigned linearly in depth first fashion
- 1394 Addressing
  - 64 bit address:
    - 10 bit bus ID
    - 6 bit node ID
    - 48 bit offset…
  - **Why?**



Transfers

- Isochronous
  - Time critical
  - Prioritised over asynchronous transfers
  - Reserved access to the bus
  - Isochronous Resource Manager…
    - c.f. bandwidth broker
  - Characteristics
    - 80% of the cycle time for isochronous traffic
    - 64 isochronous channels on one bus
- Asynchronous
  - 20% for asynchronous traffic
  - Best effort
  - Error corrected + Acknowledged
  - Guaranteed delivery

What else?

- IEEE 1394b
  - Up to 3.4Gbps
  - Also fibre for longer cable runs…
    - Goal: 25-50 meters
    - Initial solution: repeater, half-bridges
- Many protocols run on top of 1394
  - HAVI
  - U P'n'P
  - Jini

Questions?

Content Infrastructure

Part II: Professional Content Infrastructures

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Professional Content Infrastructure

- System Infrastructure
  - Physical structure of the system
  - Components
    - Hardware, i.e. IT and broadcast equipment
      - Server
      - Encoders
      - Storage systems
    - System software for the different components
    - Communication sub-system
  - Using IT based technology
    - More flexible
    - Better cost/ performance ratio

- Software Architecture
  - Specifies the characteristics and functionality of a CMS by defining
    - A generic framework
    - The functionality of individual components
    - The interfaces between components
  - Deals with software modules that run on top of the System Infrastructure

Infrastructure: Components & Sub-Components

- Servers
  - Computation platforms that run parts of the system software
    - Standard CMS servers
      - PC based, running MS Windows or Linux
      - Unix servers
    - Special broadcast servers
  - CMS servers host the different Core and Services software modules
- Storage
  - To host media and metadata
  - Disk based systems
  - Mass storage (tape based, tape libraries, DVD & CD juke boxes)
- Networks
  - Communication links between
    - Servers-to-servers
    - Servers-to-storage
    - Clients-to-servers
  - Network types
    - LAN, WAN
    - Dedicated networks & connections
    - Broadcast networks
      - Serial Digital Interface (SDI)
      - Serial Data Transport Interface (SDTI)

Key Issue: Resilience

- Basic Idea
  - Increasing System Reliability
  - Requirements
    - 24 hours a day, 7 days a week operation
    - Minimise down times
  - Approach
    - Prevent and compensate from (complete) system failures
- Types of Redundancy
  - Component redundancy
    - Adding vital hardware components
      - Redundant power supplies
      - Redundant network interfaces
    - Mirrored system disks
      - Redundant Array of Independent Disks (RAID)
  - Clustering
    - To support software that requires very high level of availability
      - E.g. databases
  - Service groups
  - Stand by server
    - Hot stand by
    - Cold stand by

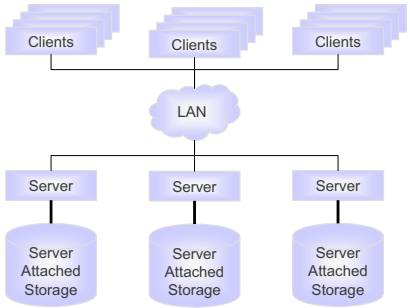
Hardware Design & Configuration Principles

- Deciding on Server Configurations
  - Classification of servers
    - Application Server
    - SAN Server
    - Database Server
- Deciding on Redundancy
  - Component Redundancy
    - Add redundancy to the sub-components of the various system components, especially in the area of power supplies, cooling fans, system disks, network and host bus adapters.
  - Cluster
    - Use server clusters only where necessary to support the availability of a very sensitive application.
  - Stand by servers
- Deciding on Storage
  - Online storage
    - High availability
  - Near-online storage

HW Design & Configuration Principles (cont.)

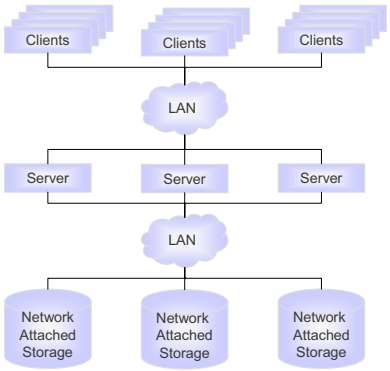
- Isolating Interfaces
  - Issue
    - Integration of broadcast specific devices into a generic IT infrastructure
    - Specific broadcast features are example video server:
      - SDI, AES/EBU input/ output
      - Linear Time Code (LTC), Virtual Interval Time Code (VITC)
      - RS-422 control connection
  - Approach
    - Many broadcast servers have standard IT connections
      - ➔ Interface Server between the two worlds
    - Isolate domain specific interfaces by employing Interface Servers as gateways between the CMS and other systems wherever possible
- Designing the Networks
  - Network types
    - FibreChannel networks (SAN)
    - A SAN communication network
    - A CMS communication network
      - Depending on the size of the operation:
        - » Fast Ethernet
        - » GB Ethernet
    - For some time to come also broadcast networks
      - I.e. SDI, SDTI
  - SAN private networks
  - Server/ SAN networks
  - QoS Guarantees
    - Might be replaced by dedicated networks

Server Attached Storage (SAS)



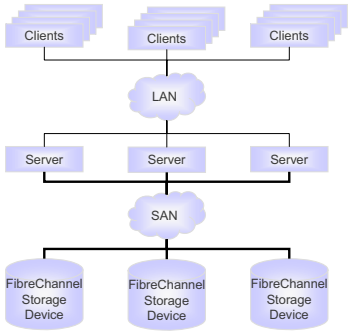
- SAS Characteristics
  - Features
    - Storage directly attached to server
    - Server controls storage access
  - Issues
    - Operating system (i.e. file system) dependency
    - Performance issues
      - Servers tasks, e.g. serving applications, data base read-write operations, providing file and print services
    - Interconnection links limited to shared network bandwidth
  - Low-cost alternative in small scale solutions

Network Attached Storage (NAS)



- NAS Characteristics
  - File centric IT paradigm
  - Features
    - LAN attached disk arrays
    - File level I/O commands over LAN
      - NFS, CIFS
    - Support multiple OS in parallel
  - Issues
    - LAN bandwidth can become bottleneck
    - Lack of QoS provisions
    - TCP/ IP features

Storage Area Networks (SAN)

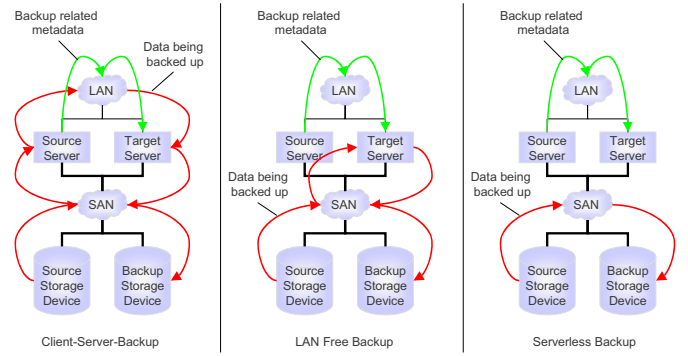


- SAN Characteristics
  - Dedicated High-speed network for data transmission
  - Features
    - Based on FibreChannel Multi-Layer Network Architecture
      - Optimised for different distances
      - Bandwidth of about 800 Mb/s
    - Hardware structure
      - First level: Server and client systems
      - Second level: A SAN fabric composed of gateways, hubs, etc.
      - Third level: Storage devices (online and near-online)
  - Advantages
    - Sharing of resources

SAN Management

- SAN Management
  - Task
    - Providing a central control to all geographically distributed components
      - GUI access for administrator
  - Technologies
    - Control
      - Using Simple Network Management Protocol (SNMP)
      - Inband
        - » Using SAN interconnection
      - Outband
        - » Existing LAN interconnections

SAN-based Backup



- Backup Steps
  - Exchange of metadata between target server and source server
  - Reading of user data from disk and subsequent transfer to source server
  - Data transfer from the source server to the target server via LAN
  - Securing of user data within library system connected to the server

Mass Storage Solutions

- Requirements
  - Example: Video archive with 100,000 hours
    - 4 Mb/s = 180 TB + 25 Mb/s = 1.125 PB + 1,5Mb/s = 68 TB
  - Tape base mass storage considered most efficient
- Videotape Based Systems
  - Video Library Management Systems (LMS)
    - Host video tapes only
  - Advantages
    - Streams can be used directly in broadcast environment
    - Timcode-based partial file retrieval
  - Disadvantages
    - Tight to video formats and recorders (separate solution for audio and data)
    - No file transfer support
    - Costs
- IT Based Systems
  - IT based Mass Storage Systems (MDS)
    - Host data tapes (can be mixed media, i.e. video- and data tapes)
  - Advantages
    - Format agnostic
    - File transfer and streaming (no SDI streaming)
  - Disadvantages
    - No timecode partial file retrieval

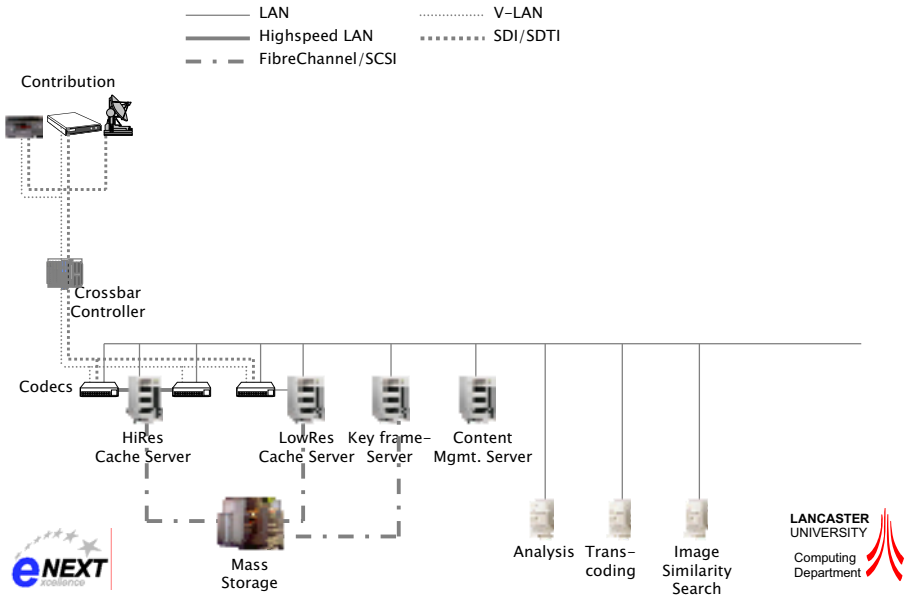
Broadcast Networks

- Serial Digital Interface (SDI)
  - ITU-R BT 656, SMPTE 259M
  - Carries uncompressed video according to ITU-R 601
    - 270Mb/s
  - Characteristics
    - Unidirectional, point-to-point, synchronous interface
    - Streaming only (no re-transmission)
  - Physical Layer
    - Serial connection
      - Coaxial cable (75 Ω), fibre optics
      - 27 MHz serialisation clock @ 10 bit word length (i.e. 270 Mb/s)
    - Length:
      - Coaxial ≤ 200m, single mode optical fibre ≤ 20 km
    - Scrambling and inversion to adapt bit sequence
- Serial Data Transport Interface (SDTI)
  - SMPTE 305M
  - Universal transport layer over SDI
    - Can transfer compressed video (e.g. MPEG-2 or DV)
      - Source stream (e.g. MPEG-2 TS, DIV) are mapped onto SDTI packets
    - Payload rate 200 Mb/s
  - Characteristics
    - Real-time and faster than real-time streaming
    - Point-to-point, point-to-multipoint

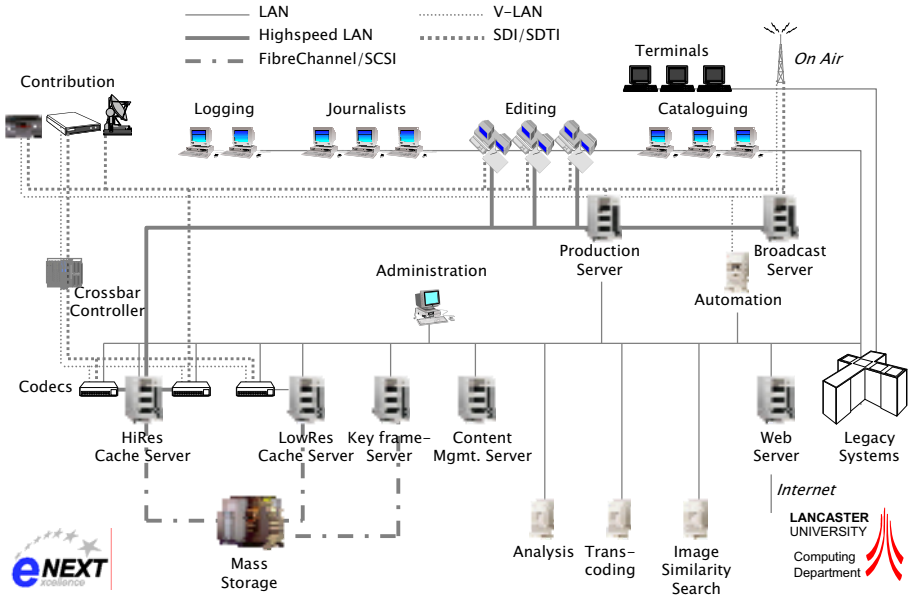
Further CI Networks

- Computer Networks
  - Conventional LAN technology
    - Fast Ethernet, GBit Ethernet, etc.
  - High-speed networks
    - SONET, ATM, etc.
- Others
  - Fibre Channel
    - FC-PH (X3.230-1994) and other standards
    - Characteristics
      - Bandwidth 1 Gb/s gross (payload 760 – 800 Mb/s)
      - Local area only
      - IP over Fibre Channel possible (though clumsy)
    - Allows streaming of content
  - Small Computer System Interface (SCSI)
    - Connecting computer peripheral devices
    - Characteristics
      - Bus architecture
        - » 8-bit parallel data transfer (nowadays 16-bit as well)
      - Bandwidth: 10-20 Mb/s, Ultra-SCSI up to 320 Mb/s
  - RS-422
    - Device control interface
    - Often used with Broadcast devices
  - V-LAN/
    - Virtual LAN

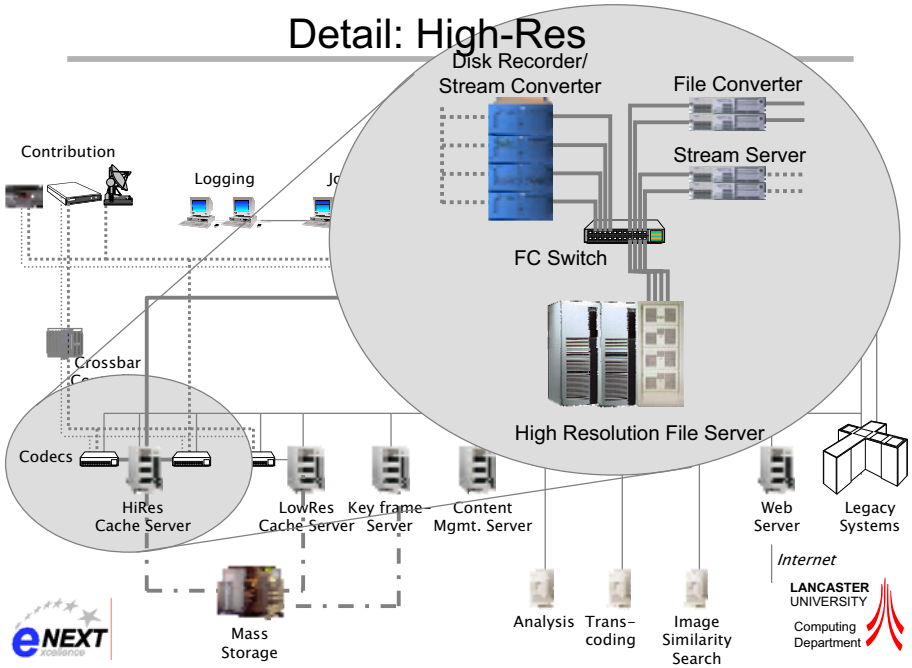
CMS Baseline System Infrastructure



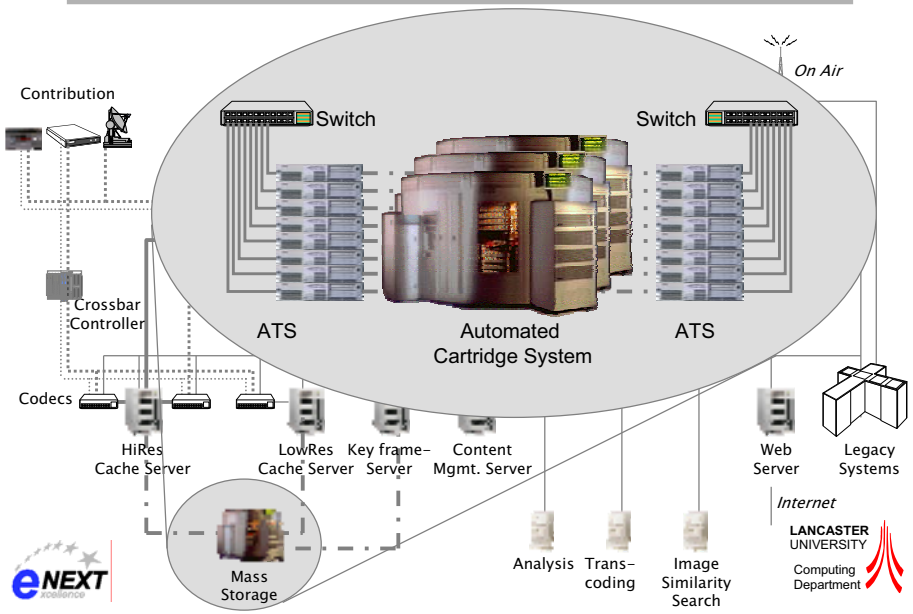
CMS Baseline System Infrastructure



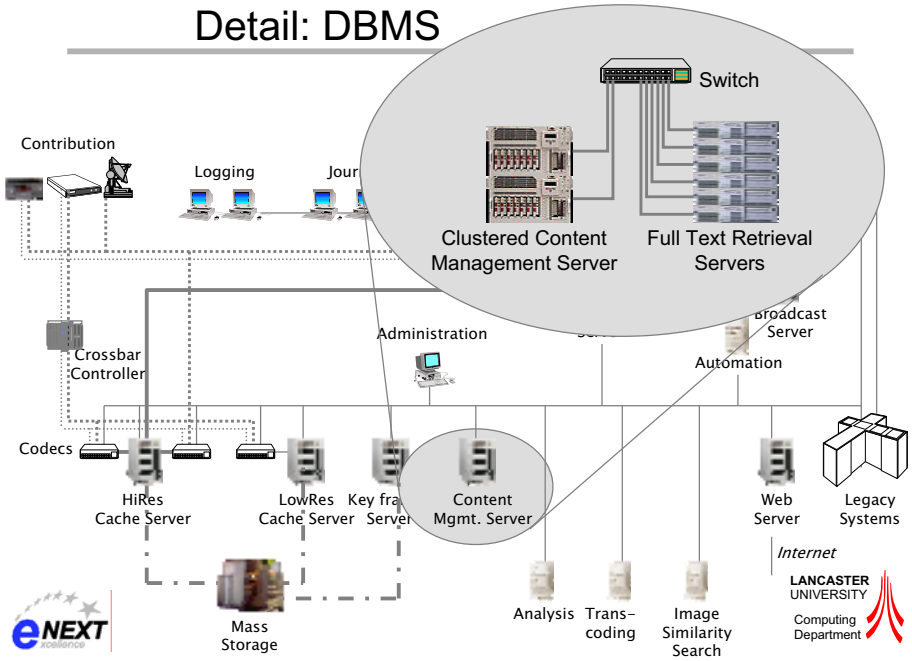
Detail: High-Res



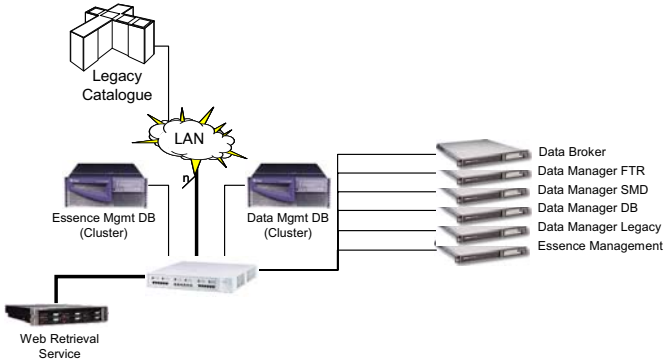
Detail: Mass Storage



Detail: DBMS

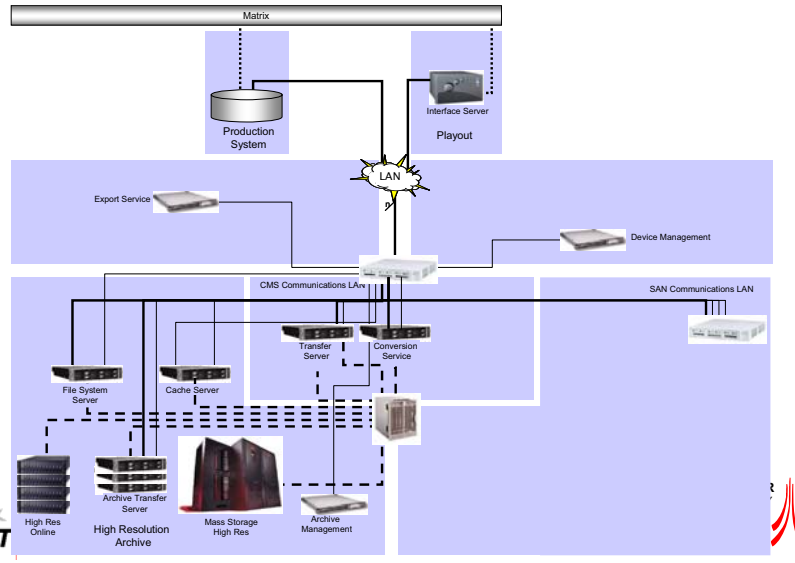


Query & Retrieval



- **Core Elements**
  - Web Retrieval Services run on an Application Server
    - High-Res, Low-Res, Keyframes
  - DBMS Clusters
  - Data Manager Elements
  - Essence Management DB

Interfaces to Production and Playout



Technology Convergence?

- Will there ever be one single Network?
- Will IT based devices mean easier and better integration?