Issues in Distributed Multimedia Systems

Slides courtesy of Tay Vaughan - "Making Multimedia Work"
What is a distributed multimedia system?

- Networks of personal devices that deliver different types of content (audio, video, web, etc) [1]
  - Cell phones, MP3 players, PDAs, etc.
  - Must consider devices beyond traditional “computers” (Marculescu et al.)
A Real-World Example:
Broadcasting *The Price Is Right* over TV, the Internet, and Mobile Phones

TPIR image courtesy: http://i.imgur.com/imagetv.yahoo.com/tv/us/img/site/72/33/0000037233_20070118115905.jpg
VCast image courtesy: http://www.geniusdv.com/weblog/archives/Vcast.png
Comcast image courtesy: http://www.wnry.com/comcast.png
Innertube image courtesy: http://www.cbs.com/innertube/
Networking Issues

• We have the problems that exist in pervasive networks [4]
  – Devices may be mobile and their connection may change during transmission
  – The environment is dynamic
  – Heterogeneous devices that may be running different architectures

• We have streaming data [4]
  – May need to synchronize multiple feeds to achieve QoS
Networking Issues continued

- **Minimize Latency** [3]
  - Time delay to send a packet
- **Minimize Jitter** [3]
  - Variance in the latency of each packet
- **Maximize Bandwidth** [3]
  - Amount of data which can be sent/received at once
What are some of the challenges in distributed multimedia?

- **Power [3]**
  - Personal devices have a **finite** power supply, unlike traditional personal computers
  - Two processes that consume power
    - Computation on the device
    - Receiving and sending data from device

- **QoS [3]**
  - Different data have different needs
  - Connection quality can change rapidly
  - Power consumption vs. QoS must be considered
What are some other challenges in distributed multimedia?

• Device Architecture [3]
  – What types of chips are appropriate for mobile media-playing devices?
  – Standard computer chips may be excessive and a power drain

• Security/Copyrights [2]
  – How do media providers ensure that their content is not abused or misused once it is delivered to clients?
Challenges continued...

- **What is the scale of the network? [3]**
  - Large networks may require distribution of servers to maintain QoS

- **Direction flow of media [3]**
  - Will media always be requested from a known source, or is every node a potential server of media?
Real World Example
iPhone w/ Youtube

• Challenges [1]
  – Designed for desktops
  – Limited power
  – Variable network quality
  – Flash based multimedia
Real World Example

iPhone w/ Youtube

• Solutions [1]
  – Convert videos to H.264 on Youtube servers (Apple)
  – Use hardware H.264 decoder on iPhone
  – Buffer data as it arrives, delay start of video stream
Copyright Enforcement in Distributed Multimedia [2]

- This paper primarily addresses the issue of distributing media to clients while also ensuring this distributed media is only used in ways agreed to between the client and the administrator of the media.
The Pitfalls of Media Distribution

- COPIES: 5
- PRICE/COPY: $100
- EXPECTED REVENUE: $500
- ACTUAL REVENUE: $100

Illegal Acquisition
An Alternative: Distributed Multimedia with Enforceable Contracts

• Owner and end user agree on contract terms.
  – What kinds of operations (read, alter, save) may be applied to the media?
  – How many times may be operations be executed?
  – What are the costs of the operations?

• Owner sends the end user the media, along with a special tool to use the media.
  – The tool enforces the rules agreed to in the contract.
  – The media is very difficult for the end user to use without the tool.
Distributed Media with Enforceable Contracts in Action
Securing Distributed Multimedia Components [6]

• We may have an array of multimedia sources (input devices) and sinks (output devices) on multiple nodes within a network.

• There are multiple security concerns:
  – We must keep the user’s connection to the system secure.
  – We must keep the communication between devices on the distributed system secure.
  – We must ensure that users can only use and connect the devices they are authorized to access.
An Example of Using Components in a Distributed Multimedia System: A Videoconference

This example was also introduced in the original paper; we are illustrating it here.
The Need for Authentication: Preventing the Improper Connection of Components

This example was also introduced in the original paper; we are illustrating it here.

Conversations can only be broadcast to the same level

The broadcast should have never reached this machine!!!
The Need for Authentication: Preventing Unauthorized Access to Information

An unauthorized user should not be able to access secured components!

This example was also introduced in the original paper; we are illustrating it here.
Logistical Concerns

• Securing Communication Between Devices
  – Use hardware-implemented encryption algorithms instead of software for speed

• Authentication Between Devices
  – A distributed authentication scheme such as Kerberos can be used.

• Authentication Between the Server and the Client
  – Can use established authentication algorithms.
The Switchboard Matrix

- Each node maintains an access control matrix for its components
  - Components can be both physical (cameras, microphones) and software (duplication, compression algorithms, etc)
- The matrix entry for a particular component has two portions
  - Attributes – What features of a component is a client allowed to access?
  - Operations – What actions is a client allowed to take with a given component?
- Connection beyond the server hosting the component is considered an “operation”
  - Allows easy access checking for information export.
Example of a Switchboard Entry

Device_1 … Device_i … Device_m

User_1

…

User_k

Professor

…

User_n

Attributes
TV In
DVD In
Computer In

Operations
Power ON
Power OFF
Focus
Shift Image
Enlarge Image

This example is adapted from the original paper.
Example of a Switchboard Entry

Device_1 \ldots \text{Device}_j \ldots \text{Device}_m

User_1 \ldots \text{User}_k \text{Technician} \ldots \text{User}_n

- Attributes
  - TV In
  - DVD In
  - Computer In

- Operations
  - Power ON
  - Power OFF
  - Focus
  - Shift Image
  - Enlarge Image

This example is adapted from the original paper.
Multimedia Based Content Distribution Networks [6]

- Distributed network with servers spread out geographically
- Network is established to store and send content to clients
- When a client requests content, the 'best' server in the network with the content must be chosen for handling the request
Issues with a Multimedia CDN

- A higher QoS demand than CDNs for static files (i.e. images, documents)
- A server does not only need to be able to host content, but must also be able to provide content in a format usable by the client
Solutions to issues

• Chosen server must satisfy a clients QoS requirement
• Store multiple copies of the content in different formats
• Support format transcoding on the fly
• Grid based CDN may be utilized to manage requirements
Grid Architecture

- A grid network is a network composed of grid ‘nodes’
- A node contains a number of different elements which can be composed of numerous servers
- Common elements include: Server Element, Computing Element, Worker Element
Grid Architecture cont...

- Server Element generally hosts data
- Worker Element handles execution of processes
- Computing Element manages Workers
- Client initiates communication with network via a resource broker which selects a grid node to service the client
Grid Architecture for a Multimedia CDN

- SEs host media content, usually in multiple formats
- WEs can handle transcoding of the content into different file formats to provide to the client and then store result on the SE for later requests
- Select Grid node based on content availability, speed to client, and ability to provide file in correct format (via stored data or real time transcoding)
Further Complications

- The closest grid node with the content may not be best to transcode the content
- Allow for one node to act as a content server and a different node to handle transcoding
- In addition to content availability and speed to client, workload and intranode speed must be considered
Node Selection Architecture

- Incorporate multiple monitors to facilitate selection process
- Transcoder Hub stores latency distances between node elements and node elements to UI
- Content Tracer finds SE with desired content
- Transcode Monitor finds free available transcoders
- Computing Element Tracer monitors load of active transcoders
- Transcode Selector chooses best pair of SE and CE for transcoding
Sequence of Events for Request which Requires Transcoding
1. Request is made from a Client’s Grid Interface
2. Transcode Selector queries Content Tracer for content servers with desired content
3. Transcode Selector queries Transcode Monitor for available transcoders
4. Transcode Selector queries Transcode Hub for distances between available nodes and between client interface.
5. Transcode Selector queries CE Tracer for the loads of all transcoders including ones too busy to respond to the transcode monitor (useful if all transcoders were busy).
6. Transcode Selector chooses best pair of SEs and CEs for request and has CE Tracer allocate the task to the chosen CE and update its load status
7. Chosen CE will inform Transcode Hub if it is now too busy for additional requests
8. Chosen CE will retrieve content from the chosen SE, initiate processing of it and return the result to the client interface and store the new format for later requests.
Sources

Questions?
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