Media Adaptation for Ubiquitous Computing

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Overview

- Motivation
- Media Adaptation Mechanisms
- Media Adaptation Frameworks
- Ubiquitous Computing
- Ubiquitous Adaptation?
Motivation

- Multimedia streaming will be key issue in the future Internet

![Graph showing the number of streaming end-points from 2001 to 2007 across different categories: Business, Residential, Mobile. Source: Ovum, Streaming Media: Commercial Opportunities, Forecast, 2002]
Motivation

- Hugh potential revenues for streaming provider

Source: Ovum, Streaming Media: Commercial Opportunities, Forecast, 2002
Motivation

- Typical Examples

- IP-Telephony
- Online Gaming
- Internet Television
- Video Distribution
- Video-on-Demand
- Distance Learning
- Audio/Video-Conferencing
Motivation

- Heterogeneous **Multimedia Applications/Services**
  - Varying requirements (interactive/non-interactive, realtime/non-realtime, unicast/multicast, low delay/high bandwidth, etc.)

- Heterogeneous **Devices**
  - Varying screen sizes, CPUs, memory, power supplies, interfaces, etc.

- Heterogeneous **Access Networks**
  - Varying characteristics for loss, bandwidth, reliability, etc.

- Heterogeneous **User Policies**

  - *Normal User* likes to have an *on/off* button
  - *Cyborg* wants to specify the importance of certain parameters
Motivation

Additional challenges in *Mobile Networks*

**Challenge: Heterogeneity**
- Differing access technologies
- Differing network characteristics
- Differing device capabilities
- Java performance issues

**Challenge: Network Congestion**
- Shared network scenarios
- Unpredictable join / leave
- Fluctuating network load

**Challenge: Radio Access**
- Signal interference
- Propagation problems
- Uneven network coverage
- Network handoff
Adaptation Mechanisms

Where should media adaptation be performed?

Adaptive Applications
- Specific requirements of the Applications are well-known
  - Adaptivity mechanism has to be 're-invented' by each application
  - No global view for fairness, no inter-operability

Adaptive Middleware
- Combines advantages of both
  - Allows for fairness as well as application-specific treatment

Adaptive Operating Systems
- Global view allows for optimized utilization and fairness
  - Application semantic is unknown

Adaptive QoS (Networks)
- Active power control on the physical layer
- Error control and adaptive reservation at the data link layer
- Dynamic re-routing at the network layer
- Dynamic re-negotiation of connection parameters at transport layer (IntServ, DiffServ)

Vertical Coverage?
Optimal Strategy covers all layers
Adaptation Mechanisms

Where should media adaptation be performed?

Optimal Strategy is end-to-end

Horizontal Coverage?
Adaptation Mechanisms

Sender
- File Switching
  - Source
  - Filter
- Codec Switching
  - Size
  - Framerate
  - Colors
- Size
- Datarate
- Quality
- Framerate
- Color
- Encoding Manager

Channel Coding
- Channel Coding with priorities
  - Frame Re-ordering
  - Forward Error Correction

Packetization
- Packetizer
  - Packet-size Adaptation

Post-Processing
- Error Concealment
- Jitter
- Buffer

Receiver
- Selective Re-transmission
  - (SR-RTP)
- Adaptive Session Control Protocols
  - (RTP/RTCP, RTSP, SIP)
- Post-Processing Error Concealment
- RLM: Base + Enhancement Layers
- Simulcast: Independent Layers of varying Quality
- Heterogeneous Multicast: Min/Max/Quorum
- Codec Switching
- RTCP

Sender
- Encoding Parameter
- Congestion Manager
- RTP

Receiver
- Buffer
- Jitter Buffer
- Renderer

Multimedia Technology

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INTERNATIONAL SCHOOL OF NEW MEDIA
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## Adaptation Mechanisms

- **References and Surveys (a very small collection ...)**

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<th>Author(s)</th>
<th>Title</th>
<th>Journal/Publication Details</th>
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Adaptation Frameworks

- **MASA Qos Framework**
  - Co-operation between NEC, Siemens and University of Ulm (2001-2003)
  - Adaptive middleware between applications and networks
  - Dedicated adaptive *Media Manager*

- C. Niedermeier, C. Fan, D. Carlson, A. Schrader, A. Kassler, A. Schorr
  - MASA - A scalable QoS Architecture
  - 7th IASTED International Conference on INTERNET AND MULTIMEDIA SYSTEMS AND APPLICATIONS, Honolulu, Hawaii, USA, August 13-15, 2003

- H. Hartenstein, A. Schrader, A. Kassler, M. Krautgärtner, C. Niedermeier
  - High Quality Mobile Communication
  - Proceedings of the KIVS’2001 Conference (Kommunikation in Verteilten Systemen), German Informatic Society (GI), Hamburg, Germany, February 2001

- See also IEEE SoftCOM’2000, IEEE ASW’2001
- http://masa.ccrle.nec.de
Adaptation Frameworks

MASA Media Manager
- Analysis comprehensive monitoring values
- Performs locally and globally optimized adaptation strategies
- Decides for parametrization of attached Media Controllers and QoS reservations
- A number of algorithms have been developed

User QoS Policy
Monitoring Results
Movement Detection
Resource Availability

- QoS Parameters
- Codec Selections
- Filter Selections
- Etc.
Examples

- **Some Implemented MASA Media modules**
  - **WaveVideo Filtering**
    - Christian Kücherer: Master thesis
    - (University of Applied Sciences Mannheim, 2001)
  - **Audio Adaptation**
    - Hyung-Woo Kim: Master thesis
    - (University of Stuttgart, 2001)
  - **MPEG-4 Filtering**
    - Philipp Bostan: Master thesis
    - (University of Applied Sciences Mannheim, 2002)

Christian Kücherer, Andreas Kassler, Andreas Schrader, Oliver Haase
*End Device and Network Adaptation of WaveVideo Streams*
Proceedings of the Conference on Advances in Infrastructure for Electronic Business, Science, and Education on the Internet (SSGRR) L'Aquila, Italy, August 6-12, 2001

Andreas Kassler, Christian Kücherer and Andreas Schrader
*Efficient Wavelet Video Filtering*
2nd International Workshop on Quality of future Internet Services, (QoIS) Coimbra, Portugal, Sep. 24-26, 2001
Examples

Traditional Adaptation Approach

1. Chain teardown
   - Data Flow: DATA LOSS!

2. Chain rebuild
   - Data Flow: DATA LOSS!

3. RTP reconnect
   - Data Flow: 

Problems:
- Data loss during chain teardown & rebuilding
- Long adaptation time interrupts stream

Seamless Adaptation Approach

1. Parallel chain build
   - Old chain: filter 'A' codec 'A'
   - New chain: filter 'B' codec 'B'
   - Data Flow:

2. RTP reconnect
   - Old chain: filter 'A' codec 'A'
   - New chain: filter 'B' codec 'B'
   - Data Flow:

3. Old chain teardown
   - Old chain: filter 'A' codec 'A'
   - Data Flow:

Advantages:
- No loss during chain reconstruction
- Reduced adaptation time
Examples

- **Seamless Codec Switching**
  - Realized in Java (JMF/RTP/RTCP)
  - Pluggable Adaptation Modules
    (Frame Filter, Quality, Datarate, Codec Switch)
  - MPEG-4 Packetizer / Depacketizer / Frame Filter (DivX4.12)
  - Results:
    - *Gap time below 1 ms* (measurement accuracy)
    - *Zero packet loss* (proved with packet sniffer)
    - *Codec and media type independent*

Darren Carlson and Andreas Schrader
Seamless Media Adaptation with simultaneous Media Processing Chains
Proceedings of the ACM Conference on Multimedia
Juan-les-Pins, France, December 1-6, 2002
(International patent pending)
Examples

Adaptive Multimedia on Small End Devices

Coffee Shop Hotspot Network

Public Access Network

Current Clients

NEC Device Available Bandwidth

NEC Seamless Adapter

Sender Data Rate | Quality Factor | Frame Rate | Loss Ratio | Jitter
--- | --- | --- | --- | ---
1000 | 100 | 25 | 100 | 2000
0 | 0 | 0 | 0 | 0

Status:
- Unloaded
- Sequential, MPEG4, Smooth
Adaptation Frameworks

- Where should media adaptation be performed?

- Service? Messaging, Download, Streaming, Conversational
- Receiver? Single-user, Many users
- Access? DAB/DVB, GPRS, UMTS, WLAN
- State? Offline, Inactive, Interactive
- Device? TV, PC, PDA, Multimedia Phone, Mobile Phone

Content access and delivery methods
User context
Adaptation Frameworks

- Adaptive Overlay Content Delivery Network
  - *Hiding the complexity* of the underlying heterogeneous transport networks to operators and content providers
  - Providing *new and enhanced services*
  - Supporting *communication as well as consumption-oriented services*
  - Supporting *multi-provider, multi-domain scenarios* using different business models
  - Managing *routing* (coarse-grained modification), *adaptation* (fine-grained modification) and *caching* of multimedia in an integrated manner
  - Providing configuration means for providers and recipients
  - Interaction with underlying QoS and mobility management system
Adaptation Frameworks

- **Adaptive Multimedia Routing Strategies**
  - Selecting optimal path(s) through the 'wireless world' regarding resources and preferences from users and operators
  - Disjoint path delivery for individual media streams
  - Optimal selection of delivery means (broadcast, multicast, unicast)

- **Multimedia Adaptation Strategies**
  - Optimizing the transmission parameters during a running session
  - Optimization of the mix of available adaptation means
  - Support of adaptive network nodes and adaptive end-systems
Still there?
Ubiquitous Computing

- Invented by Marc Weiser in 1988 (Xerox Parc)

"Ubiquitous Computing enhances computer use by making computers available throughout the physical environment, while making them effectively invisible for the human user."

- Goal: Making the computer invisible to enhance the real world (opposite of virtual reality!)

Philips HomeLab: Mirror with integrated Displays
Dimensions of Ubiquitous Computing

- **Level of Embeddedness**
  - **Pervasive Computing**
  - **Ubiquitous Computing**
  - **Traditional Business Computing**
  - **Mobile Computing**

- **Level of Mobility**

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<tr>
<th>Embeddedness</th>
<th>Mobility</th>
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<tr>
<td>high</td>
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<tr>
<td>low</td>
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- **Integration of large-scale mobility with pervasive computing functionality**
- **Obtain information about environment and build model of computing**
- **Moved from insulated and sealed rooms to offices and homes.**
- **Mobile devices, like Laptops (laps), PDAs (pockets), wearables (clothes&body)**

© Kalle Lyytinen and Youngjin Yoo, Communications of the ACM, December 2002
Ubiquitous Computing

- **Wearable Computers**

  Digital Jewelry (IBM)
  
  Source: http://www.ibm.com

  Steve Mann: Cyborg

  Source: http://www.i4u.com/article407.html

  Electronic Display in Jacket (Pioneer)
  
  Source: http://www.i4u.com/article407.html

- **Foldable Display**

  The foldable display (Carnegie Mellon)
  
  Source: http://www.ices.cmu.edu/design/FoldableDisplay.html
Ubiquitous Computing

- **Human-Computer-Interfaces**

  **Augmented Reality (Eyetap)**
  Source: http://eyetap.org/research/medr/rwm.html

  - Dynamic Shader Lamps: Painting on Real Objects

    D, Bandyopadhyay, R. Raska, H. Fuchs:
    Dynamic Shader Lamps: Painting on Real Objects

  **Tangible Media (MIT)**
  Source: http://tangible.media.mit.edu/
Ubiquitous Computing

- Ubiquitous multimedia in *Minority Report*

  - Personalized Public Commercials
  - Electronic Ink Newspaper
  - 3D Shop Assistant
  - Buildings and Walls as Displays

Copyright: Steven Spielberg (20th Century Fox/Dreamworks), 2002
Ubiquitous Adaptation?

- New Challenges in Ubiquitous Environments

  - Pervasive devices will be used for different tasks, by different users, in different environments, locations and contexts.

  - Pervasive Devices
    - *Very limited* in capabilities
    - In extreme cases, sensor nodes are covering the environment (smart carpet, intelligent brick, smart cups)
      Can we use them as proxies or caches?
      How to delegate/distribute?

  - Context Information
    - Location awareness of content, user and stream provision entities
    - *Session mobility* with context transfer
    - Proximity awareness through user recognition systems
    - Supporting fluctuating *sparse and dense user concentrations*
Ubiquitous Adaptation?

- New Challenges in Ubiquitous Environments
  - Human-Computer Interfaces
    - Support of *disabled and handicaped persons* (e.g. color blindness)
    - New transcoding mechanisms for *tangible media interfaces*
    - Ambient content adaptation to environment features (e.g. style)
    - Intelligent adaptation algorithms considering *subjective and objective*
      aural and visual quality *perception*
  - General
    - Automatic decisions for best presentation device (or means)
    - *Privacy and security* aspects (e.g. media streaming in public displays)
    - Generalized placement strategies for proxy server
    - Power Management
    - Optimizing the mix of available adaptation means (e.g. file switching, codec switching, codec parameter changing, pre- and post-codec filtering, FEC, layered transmission, selective re-transmission, adaptive playout buffers, jitter compensation buffers, etc.)
    - Multiple media tracks (e.g. different camera positions)
    - Etc.?
International School of New Media
Affiliated Institute of the University of Lübeck
Master of Science Program (Digital Media)
18 months program (ECTS), focus areas:
- E-Business
- Work Design
- Digital Media Development
- Mobile Communication and Computing
http://www.isnm.de

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Any Questions?