Multimedia Data Transmission over Wired/Wireless Networks

Bharat Bhargava
Gang Ding, Xiaoxin Wu, Mohamed Hefeeda, Halima Ghafoor

Purdue University
Website: http://www.cs.purdue.edu/homes/bb
E-mail: bb@cs.purdue.edu
Phone: 765-494-6702
Research Issues

- Multimedia transmission
  - High data rate
  - Time sensitive

- Networks
  - Variable or limited bandwidth
  - Time delay
  - Packet loss

- Multimedia over wired/wireless networks
  - Error resilient data transport control
  - Seamless transmission over hybrid networks
Multimedia Data Transport Control

- Cross-layer rate control
  - Match multiple data streams to the available bandwidth
- Cross-layer error control
  - Adaptively update upper layer error control parameters based on the current network condition

B: rate control, S: sender’s rate control, R: receiver’s rate control
## Multimedia Data Transport Control

<table>
<thead>
<tr>
<th>Movie</th>
<th>Original Peak Signal Noise Ratio (dB)</th>
<th>Regular approach: Link layer rate control</th>
<th>Our approach: Cross-layer rate control</th>
<th>Our approach: Cross-layer rate + error control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sent enhancement layer (%)</td>
<td>Sent PSNR (dB)</td>
<td>Sent enhancement layer (%)</td>
<td>Sent PSNR (dB)</td>
</tr>
<tr>
<td>Star Wars IV</td>
<td>37.225</td>
<td>80.055</td>
<td>35.711</td>
<td>98.222</td>
</tr>
<tr>
<td>Citizen kane</td>
<td>37.791</td>
<td>88.333</td>
<td>36.825</td>
<td>97.556</td>
</tr>
<tr>
<td>Jurassic Park I</td>
<td>36.661</td>
<td>64.444</td>
<td>33.941</td>
<td>88.444</td>
</tr>
<tr>
<td>Silence of Lambs</td>
<td>37.975</td>
<td>30.665</td>
<td>33.697</td>
<td>40.887</td>
</tr>
<tr>
<td>Star Wars V</td>
<td>36.595</td>
<td>62.611</td>
<td>34.386</td>
<td>89.000</td>
</tr>
</tbody>
</table>
Multimedia Data Transport Control


  Video transmission over wireless networks is challenging due to the time-varying bandwidth and the error-prone wireless channel. This paper reviews the state-of-the-art research on video compression algorithms and network protocols to improve quality of service. The cross-layer network control algorithms are proposed, in which the lower layers of wireless networks cooperate with the application layer to adjust error control strategy and transmission rate. The theoretical analysis and simulation results show that, with the inter-layer communication, the proposed algorithms can significantly improve the efficiency of error control and the accuracy of transmission rate selection. The implementation issues of applying the proposed algorithms to 3G mobile networks and IEEE 802.11 wireless local area networks are discussed.


  Proposes an error resilient video transmission architecture over mobile wireless networks. Radio link layer, transport layer, and application layer are combined to deal with high error rate in wireless environments. The algorithms for both sender and receiver are given. An adaptive algorithm is further presented to automatically adjust parity data length in error control. The performance of the proposed algorithm is analyzed by both theory and experimental results.
Multimedia Data Transport Control

References

Multimedia Transmission over Hybrid Networks (Planed Research)

- To transport multimedia data over both back-bone and wireless networks, an intermediate Proxy or agent can be used
  - Located at the junction of backbone wired network and wireless networks
  - Performs media format transformation
  - Dynamically collects network condition from various wireless links
  - Makes adaptive QoS control, scheduling, and caching of multimedia data transmitted at different rates
Adaptable Video Conferencing

Video conferencing systems (VCS) have become practical in commercial and research institutions because the advances of technologies in networking and multimedia applications. A video conferencing session involves multiple parties, possibly geographically interspersed, which exchange real-time video data. However, anomalies such as site failure and network partitioning affect the effectiveness and utilization of the communication capabilities. Video conferencing systems lack the ability of dynamically adapting themselves to the variations in the system resources such as network bandwidths, CPU utilization, memory and disk storage. In VCS, changes in parameters such as frame sizes, codec schemes, color depths, and frame resolutions can only be made by users. They cannot be made based on the system measurements of currently available resources. We need to limit the users' burden in keeping the system running in the most suitable mode to current environment and make it possible to provide the best possible service based on the status of the system. Incorporating adaptability into a video conferencing systems minimizes the effects of the variations in system environments on the quality of video conference sessions.

In the report, we discuss the concept of adaptability and the basic idea for achieving adaptability in a video conferencing system, give a description of common anomalies encountered in a distributed system, review the NV video conferencing system, the testbed of our experiments, describe the extension and modification to NV and discuss some reconfiguration issues. A summary of experimental data analyses and observations are presented.
Adaptable Video Conferencing

- A video conferencing system should provide some policies and mechanisms to make it adaptable to the anomalies based on the available resources. The advantages of the adaptability schemes for VC system include:
  - **Heterogeneity**: A VC system will adapt to heterogeneous environments. That is, a video conference session can be held on different hardware platforms and different networks.
  - **Scalability**: A VC system will adapt itself as more users, more sites join a video conference in progress.
  - **Anomaly Management**: A VC system will adapt to anomalies and degrade gracefully when available resources decrease or become unavailable.
  - **Resource Management**: A VC system can make efficient use of resources like storage, CPU time, and communication bandwidth.
Adaptable Video Conferencing

Timeliness/Accuracy/Precision (TAP) cannot be maintained at the highest level simultaneously during anomalies. We must trade among these attribute values. The policy to trade among these attributes can be described as follows:

- **Maintaining Timeliness when Bandwidth Decreases**
  - Reduce frame size (The accuracy is maintained unless the frame size is below a certain value).
  - Reduce frame resolution (Both accuracy and precision are reduced).
  - Dither color frame to black and white.
  - Compress color depth.
  - Switch to a codec scheme that has a higher compression ratio (Side effect: CPU utilization increases. This can be compensated by frame resizing and resolution reduction).

- **Maintaining Accuracy when Bandwidth Decreases**
  - Switch to a lossless codec scheme with reduced frame size.
  - Dither color frame to black and white.
  - Compress color depth (compress Y and UV no more than 2 bits each).
  - Do not use lossy codec schemes.
  - Do not reduce frame size or resolution by a big factor.

- **Maintaining Timeliness when CPU Utilization Increases**
  - Switch to a codec scheme that requires less computation (usually with lower compression ratio).
  - Reduce frame size.
  - Dither color frame to black and white.
  - Do not compress color depth.
  - Do not reduce frame resolution.

- **Maintaining Accuracy when CPU Utilization Increases**
  - Switch to a lossless codec scheme
  - Reduce frame size.
  - Dither color frame to black and white.
  - Do not compress color depth.
  - Do not reduce frame resolution.
  - Do not use lossy codec schemes.
Adaptable Video Conferencing

References

- B. Bhargava, “Adaptable Video Conferencing”.
- B. Bhargava and S. Li, “Exploring Adaptability for Video Conferencing”. 
Peer-to-peer Multimedia Streaming

- PROMISE: Peer-to-Peer Media Streaming Using CollectCast
  - Peer lookup
  - Peer-based aggregated streaming
  - Dynamic adaptation to network conditions

- PROMISE is based on a new application level peer-to-peer service: CollectCast
  - Inferring and leveraging the underlying network topology and performance
  - Monitoring the status of peers and connections and reacting to peer/connection failure or degradation with low overhead
  - Dynamically switching active senders and standby senders so that the collective network performance out of the active senders remains satisfactory
Peer-to-peer Multimedia Streaming

Distributed Streaming Application (PROMISE)

Rate/Data Assignment
- Redistribute rates
- Active, Rates

Monitoring and Adapation

Peer Selection
- Switch peers
- Active set
- Annotated topology

Topology Inference and Labeling

CollectCast

Peer-to-Peer Lookup Substrate (Pastry)

Candidate set
Peer-to-peer Multimedia Streaming

References

More Issues

- Multicast and broadcast of multimedia data
- Multimedia communication over next generation wireless networks
  - Wireless local area network
    - IEEE 802.11n of 100 Mbps
  - Wireless personal area network
    - IEEE 802.15.3a of 55 Mbps or higher