Adaptive Application-Level QoS Management Technique for Multimedia Traffic

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Introduction

• Internet Traffic
  – non real-time traffic [ftp, telnet, mail, snmp, …]
  – real-time traffic [VOD, AOD, …]

• Multimedia applications over TCP/IP-based Intranet or Internet have become popular

• Current Internet Service
  – Connectionless service in IP Layer
  – TCP/IP based Best-Effort routing scheme
  – data transmission using TCP or UDP
  – Flow, congestion control for only TCP packet

• Current network structure is not sufficient for real-time multimedia traffic.
  – can not use TCP flow & congestion control
  – no consideration about time-critical data delivery
Introduction

• How to cope with multimedia traffic on current best-effort based Internet?
• How to change current Internet to deal with real-time traffic well?
• How to guarantee Quality of Service (QoS) of multimedia traffic?
• How to support various requirements for multimedia data of end-users?
Related Work

- Change current Internet structure for QoS deployment
  - RSVP [RFC2205, RFC2208, RFC22096]
  - diffserv [RFC2474, RFC2475,...]
  - intserv [RFC2211, RFC2212, RFC2213]
  - traffic shaping and apply policy to network traffic

- The flow and congestion control for multimedia traffic on current TCP/IP based Internet
  - Recovery from Error Spread using Continuous Update (REACU) [NCSU]
  - Forward Error Correction (FEC)

- The above related work concentrates on network & transport layers, but our work concentrates above the transport layer
QoS for Multimedia Traffic

• Characteristics
  – constant bandwidth
  – soft real-time traffic with transmission time limit
  – capture, encode, compress, transmit [in sender part]
  – receive, decompress, decode, play out [in receiver part]
  – Different style of congestion and flow control is needed for these MM traffic.

• QoS evaluation factors in network level
  – delay, jitter, loss, throughput

• It is also important that Application-Level QoS parameter is guaranteed.
Problem

• There are various users’ requirements for multimedia data quality. For example:
  – The size of video must be CIF form.
  – My audio must be radio quality and stereo.

• It is impossible to guarantee these application-level QoS in current distributed multimedia applications.
  – Constant bandwidth is not guaranteed to a single connection.
  – Flow and congestion control for multimedia traffic does not exist.

• How to guarantee the users’ requirements and flow and congestion control for multimedia traffic on current internet environment?

  → Application-level QoS management is needed!
How to solve this problem

• Application-level QoS management system for distributed multimedia applications

• The Requirements of this system
  – can satisfy the user’s various needs
  – can define the QoS parameter which can be changed by user
  – can guarantee the desired QoS in the current network environment
  – can use the network resources with other application fairly
  – can analysis the current network status and adapt properly to the situation
QoS Parameters at Application Level

• The variables which have an effect on the required network bandwidth
• Video
  – frame rate (frame/sec)
  – precision (bit/pixel)
  – resolution (pixel x pixel)
  – encoding/decoding method (Raw, H.261, H.263, CellB)
• Audio
  – sampling rate (Hz/sec)
  – channel (mono, stereo)
  – precision (bits/sample)
  – encoding method (PCM, ADPCM:G.721, G.723)
QoS Management Functions

• QoS negotiation
  – set application level QoS parameters.

• Multimedia Traffic Monitoring
  – monitor current QoS guaranteed rate by loss.

• QoS Adaptation
  – determine proper bandwidth for current application
  – change application-level QoS parameter
System Layout

QoS Manager
- negotiation
- traffic monitoring & analysis
- qos adaptation

Network

MM Application QoS agent
- negotiation
- traffic control
- status reporting

MM Application QoS agent
QoS Negotiation

• Control sender’s encoding method and bandwidth
• Initial negotiation
  – before stream transmission
  – with QoS parameter
  – by sender and receiver manually or by default set up value
• QoS re-negotiation
  – static negotiation
  – same as initial negotiation
  – during data transmission
  – by sender and receiver manually
MM Traffic Monitoring

- In Sender part
  - encoding rate
    - frame rate, sampling rate
  - transmission rate
- In Receiver part
  - latency (transmission delay)
  - transmission rate
  - loss rate / retransmission rate
  - delay-jitter
- monitoring protocol
  - real-time transport protocol (RTP/RTCP)
  - data transmission between sender and receiver using RTP.
QoS Adaptation

- QoS mapping between application level and network level
  - user level parameter
  - network level parameter [bandwidth, loss rate]
- QoS threshold
  - bandwidth threshold
  - loss threshold (Loss_th1, Loss_th2)
  - time(T_th)
- determine proper application-level parameters according to the current traffic status
QoS Adaptation Scheme

• Desired Bandwidth
  - \( D_{audio} = A_s \times A_c \times A_p \times A_e \)
  - \( D_{video} = V_f \times V_p \times V_r \times V_e \)
  - \( D_{total} = D_{audio} + D_{video} \)

• parameter priority in ascending order
  - video < audio
  - \( V_f < V_p < V_r < V_e, A_s < A_c < A_p < A_e \)

\[
\begin{align*}
\text{If ( } &\text{Loss}_c \geq \text{Loss}_{th1} \text{ )} \\
&\text{decrease bandwidth by assign a new value to a user parameter;}
\end{align*}
\]

\[
\begin{align*}
\text{else if ( } &\text{Loss}_c \leq \text{Loss}_{th2} \&\& \text{Dcurrent} < \text{Dtotal} \&\& \? \text{T} > \text{T}_{th} \text{) } \\
&\text{increase bandwidth by assign a new value to a user parameter;}
\end{align*}
\]

\[
\begin{align*}
\text{else if ( } &\text{T}_{current} > 0 \&\& \text{Loss}_c > \text{Loss}_{th2} \text{) } \\
&\text{T}_{\text{start}} = 0;
\end{align*}
\]

\( A_s \): audio sampling rate  \\
\( A_c \): audio channel  \\
\( A_p \): audio precision  \\
\( A_e \): audio encoding method  \\
\( V_f \): video frame rate  \\
\( V_r \): video resolution  \\
\( V_p \): video precision  \\
\( V_e \): video encoding method  \\
\( T_{trans} \): transmission time
Management Architecture

Host A

MM application

QoS Agent

QoS Manager

QoS Control Data

Host B

MM application

QoS Agent

MM data
QoS Manager

- QoS Manager
- Negotiation Manager
  - configuration
  - agreement
- Traffic Analyzer
  - log
- QoS controller
- QoS Agent

1999. 12.17
QoS Agent

QoS Agent

Traffic controller

QoS Negotiator

agreement

QoS Manager
Implementation

- Environment

<table>
<thead>
<tr>
<th></th>
<th>QoS Manager</th>
<th>QoS Agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine type</td>
<td>Sun enterprise server 450</td>
<td>Pentium II 266MHz</td>
</tr>
<tr>
<td>Operating System</td>
<td>Solaris 2.6</td>
<td>Windows 95</td>
</tr>
<tr>
<td>CORBA</td>
<td>Orbix 2.3_MT solaris version</td>
<td>Orbix 2.3c windows version</td>
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<tr>
<td>Compiler</td>
<td>Sun C++ compiler 4.2</td>
<td>Visual C++ 6.0</td>
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<tr>
<td>Video capture card</td>
<td></td>
<td>Ospery-1000</td>
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</tbody>
</table>

- Implementation

QoS parameter setting

Video/Audio conferencing

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Conclusion and Future Work

• A technique to support user’s various requirements and congestion and flow control for multimedia traffic transmission.

• proposed an Adaptive Application-Level QoS Technique and Management System for Multimedia Traffic
  – QoS manager
  – QoS agent
  – Application-Level QoS parameter

• Future Work
  – determination of appropriate loss and time threshold by experimentation
  – transmission to more than two receivers.
  – Error recovery