Reliable delivery of multimedia over broadband access using FEC and/or retransmission
Agenda

- IPTV QoE issues
- Improving QoE by a Retransmission solution
- Improving QoE by a FEC solution
- FEC Vs Retransmission comparison
- Conclusion
Agenda

- IPTV QoE issues
- Improving QoE by a Retransmission solution
- Improving QoE by a FEC solution
- FEC Vs Retransmission comparison
- Conclusion
IPTV QoE issues

- End-to-end transport is prone to errors resulting in packet loss
  - Most of losses are (burst) packet losses appearing on the xDSL segment

- IPTV (VoD, live TV) service is very sensitive to packet loss
  - Picture freezes
  - Expensive service assurance

- Increasing noise margin and INP value is not sufficient
  - INP 5 would be needed
  - Negative side effects on overall bandwidth

- Application level mechanisms such as FEC and retransmission aim at adapting IPTV to the transport media conditions
Agenda

> IPTV QoE issues

> Improving QoE by a FEC solution

> FEC Vs Retransmission comparison

> Conclusion
Retransmission approach

> Principle: when packet is lost, negative acknowledgement (NACK) is sent to retransmission server

> Retransmissions require:
   - *Sequence numbers (= packet identifiers)*
   - *Return channel and FB protocol*

> RTP/RTCP are a good match to enable retransmissions:
   - *RFC 4585: definition of RTCP FB message (=NACK) and timing rules for RTP MC receivers to issue RTCP FB*
     - Scope restricted to UC and *small* MC sessions (with „active“ participants)
   - *RFC 4588: specification of RTP retransmission payload format*

> Retransmissions give minimal bandwidth overhead
   - *Average Load per „server-client“ = PLR x Video Streaming rate*
   - *Peak BW (for retransmission of a high number of consecutive packets= bursts) can consume BW allocated for Best Effort Services*
Retransmission for Broadcast TV

> Retransmission servers/proxies should be distributed
  • Locate servers in NW sufficiently close to the end-users, e.g. near/at DSLAM
    – Limiting the amount of clients to be serviced
    – Retransmissions are faster (reduced RTT)
    – More BW efficient
  • Hierarchical retransmission server positioning
    – To provide for end-to-end protection (HE up to STB)

> Unicast retransmission request
  • In line with Internet draft: RTCP Extensions for Single-Source Multicast Sessions with Unicast Feedback

> Issue: loss of a (single) MC packet on an aggregated link impacts multiple broadcast TV clients
  • Solution: allowing for retransmission on MC
Retransmission for Broadcast TV

**Legend**
- **O 1/2**: Original packet (MC)
- **O 2**: Retransmitted packet (MC, NO retransmission payload)
- **R 1/2**: Retransmitted packet (UC, retransmission payload)
- **R 2**: Loss of Original packet (MC)

**Uncorrelated Packet Loss**
- HE
- DSLAM
- Service Router/Switch
- MC Service Router
- Access RET proxy
- MC replication
- Access RET proxy
- MC replication
- STB
- IPTV client
- Retransmitted packet (UC, retransmission payload)
- Retransmitted packet (MC, NO retransmission payload)

**Correlated Packet Loss**
- HE
- DSLAM
- Service Router/Switch
- MC Service Router
- Access RET proxy
- MC replication
- Access RET proxy
- MC replication
- STB
- IPTV client
- Retransmitted packet (UC, retransmission payload)
- Retransmitted packet (MC, NO retransmission payload)
- Loss of Original packet (MC)
Agenda

> IPTV QoE issues

> Improving QoE by a Retransmission solution

> FEC Vs Retransmission comparison

> Conclusion
FEC approach

- Target is to recover lost packets at the receiver with the help of redundant FEC information

- An example is the FEC COP#3
  - DVB standard, off the shelf equipment ready, no license fee.

Based on XOR

\[ A \oplus B \oplus C = D \]
\[ A \oplus B \oplus D = C \]
### 1/ Characterization of burst loss

**RS super trame**

<table>
<thead>
<tr>
<th>RS Super Trame (x ms latency)</th>
<th>RS Super Trame (x ms latency)</th>
</tr>
</thead>
</table>

**Impulsive noise**

ADSL: interleaved mode

Several consecutive IP packets can be corrupted

The maximum burst size depends on:
- the bitrate of the stream
- the latency of the line
- the duration of the impulsive noise

### 2/ Sizing the COP#3

**COP#3 matrix**

<table>
<thead>
<tr>
<th>01</th>
<th>02</th>
<th>03</th>
<th>04</th>
<th>05</th>
<th>06</th>
<th>07</th>
<th>08</th>
</tr>
</thead>
<tbody>
<tr>
<td>09</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>17</td>
<td>18</td>
<td>19</td>
<td>20</td>
<td>21</td>
<td>22</td>
<td>23</td>
<td>24</td>
</tr>
<tr>
<td>25</td>
<td>26</td>
<td>27</td>
<td>28</td>
<td>29</td>
<td>30</td>
<td>31</td>
<td>32</td>
</tr>
<tr>
<td>33</td>
<td>34</td>
<td>35</td>
<td>36</td>
<td>37</td>
<td>38</td>
<td>39</td>
<td>40</td>
</tr>
</tbody>
</table>

- Column FEC only is used
- Column FEC packets are interleaved with the following matrix

The number of rows is defined according to acceptable bandwidth overhead.
Agenda

> IPTV QoE issues

> Improving QoE by a Retransmission solution

> Improving QoE by a FEC solution

> Conclusion
## FEC Vs Retransmission

<table>
<thead>
<tr>
<th>Buffer size depends on FEC matrix size</th>
<th>Buffer size depends on network RTT, available bandwidth overhead and proxy processing time</th>
</tr>
</thead>
<tbody>
<tr>
<td>In both cases, the need of bufferisation translates into delay, especially impacting the zapping time</td>
<td>Constant bandwidth overhead</td>
</tr>
<tr>
<td>Easy COP#3 implementation</td>
<td>Easy RTP/RTCP implementation</td>
</tr>
</tbody>
</table>

- The size of the line of a matrix is the maximum size of burst that can be recovered. What can be guaranteed is only the recovery of one line every two matrixes.
- RET is able to correct any Packet Loss Ratio (PLR) within a specified protection time provided the required bandwidth (average and peak) is available and RTT is reasonably smaller than the specified protection time.
- Constant bandwidth overhead, depending on number of channels and protection level
- Bandwidth overhead only needed in case of retransmission
- Adding of FEC encoding functions
- Adding of retransmission function (optional location)

---

**Diagram:**

- STB
- RGW
- DSLAM
- ADSL
- Regional network
- National backbone
- TV
- Broadcast Head-end

**Network Components:**

- STB (Set-Top Box)
- RGW (Remote Gateway)
- DSLAM (Digital Subscriber Line Access Multiplexer)
- ADSL (Asymmetric Digital Subscriber Line)
- National backbone
- Broadcast Head-end

**Network Flow:**

- Data transmission from STB through RGW and DSLAM to ADSL, then to the Regional network, and finally to the National backbone and Broadcast Head-end.

---

**Network Profiles:**

- Compatibility with existing xDSL profiles
- Need the deployment of RET proxy functions
Agenda

- IPTV QoE issues
- Improving QoE by a Retransmission solution
- Improving QoE by a FEC solution
- FEC Vs Retransmission comparison
Conclusion

- FEC and retransmission mechanisms are two efficient solutions to improve QoE of IPTV services.

- Which solution to choose?
  - Answer narrowly depends on each service provider context
    - Current QoE levels, target QoE levels
    - Legacy architecture and engineering rules
  - FEC is a quite light solution for an immediate improvement of QoE
  - RET has more impacts on architecture (new features to deploy, scalability potential issues) but enable to expect an higher correction efficiency compared to FEC

- Some contexts where single-packet losses are a significant amount of total losses could usefully benefit from a combination of FEC and Retransmission