A Survey of Packet Loss Recovery Techniques for Streaming Audio

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Outline

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- Packet Loss Recovery Techniques
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    - Retransmission
    - Error correction
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Streaming Audio and Multicast

- Recovery techniques target on streaming audio data
- e.g. audio conferencing
- Multicast
  - One to many connections
  - Sending multiple copies along the network
  - Multicast channel has relatively high latency
  - Trade-off between quality and interactivity to be made by receiver independently
Sender-based Repair Techniques

- Active
  - Retransmission

- Passive
  - Interleaving
  - Forward Error Correction (FEC)
    - Media-independent FEC
    - Media-specific FEC
Interleaving

- Out-of-order transmission
- Reconstruct packets at receiver’s side

![Diagram](image)

Figure 6. Interleaving units across multiple packets.
Interleaving

- **Advantage**
  - No increase of bandwidth

- **Disadvantage**
  - Increase latency
  - Not suitable for interactive application
Media-Independent FEC

- Using block or algebraic code
  - e.g. Reed-Solomon code
- k data bits and n-k additional check bits
- Data could be recovered from the check bits
Media-Independent FEC

- **Advantages**
  - Does not depend on the content of the packet
  - Computation to derive the error correction is small and simple to implement

- **Disadvantages**
  - Consume extra bandwidth
  - Difficult on decoder implementation
Media-Specific FEC

- Target on audio in multiple packets
- Primary and secondary encoding
  - Different encoding
  - Usually secondary encoding uses lower bandwidth and quality
Figure 5. Repair using media-specific FEC.
Receiver-based Repair Techniques

- Insertion-based Repair
- Interpolation-based Repair
- Regeneration-based Repair
Insertion-based Repair

- Insert a simple fill-in as a replacement of the loss packet
  - Splicing
    - Zero length fill-in
    - Require an adaptive playout buffer
  - Silence Substitution
    - Fill with a silence substitution
    - Simple to implement
    - Effective for short packet lengths (< 4ms) and low loss rate (< 2%)
  - Noise Substitution
    - A background noise is inserted
  - Repetition
    - Replace with the previous received packet
Interpolation-based Repair

- **Waveform Substitution**
  - Uses audio before or after to find for suitable signal to replace the loss

- **Pitch Waveform Replication**
  - In addition to waveform substitution with a pitch detection algorithm

- **Time Scale Modification**
  - Allows audio on either sides to stretch across the loss
  - Requires more computation
Figure 9. (a) Sample error concealment techniques: original audio signal; (b) sample error concealment techniques: the loss pattern; (c) sample error concealment techniques: packet repetition; (d) sample error concealment techniques: one sided waveform substitution.
Regeneration-based Repair

- Interpolation of Transmitted State
  - Based on the transform coding or linear prediction
  - Use decoder to interpolate between states

- Model-Based Recovery
  - Use a model to generate speech to cover the loss
  - e.g. use autoregressive analysis on the last received set of sample
Figure 8. Rough quality/complexity trade-off for error concealment.
Conclusion

- Non-interactive applications
  - Interleaving, media-dependent FEC, etc
- Interactive applications
  - Need to minimize the end-to-end delay
  - Media-independent FEC