Systematic Lossy Error Protection (SLEP) for Video Transmission over Wireless Ad Hoc Networks

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Introduction

- Video streaming over ad hoc networks:
  - No need for fixed infrastructure, flexible deployment
  - Error-prone transmission over wireless channel
  - High rate and low latency for video streaming
- Conventional error control methods:
  - ARQ: introduces additional delay
  - FEC: cliff-effect when error rate too large
- Proposed SLEP scheme:
  - Graceful degradation with error rate
  - Dynamic selection of protection level and route

Systematic Lossy Error Protection (SLEP)

Distortion Model

- RD model: \( D_i = \frac{\theta}{R_i - R_0} + i, \theta = 0.1 \)
- Three possible scenarios:
  - Main desc. correctly received: \( D_{EE} = D_{EE}^{\text{EE}} \)
  - Main desc. lost, WZ desc. recovered: \( D_{EE}^{\text{WZ}} = D_{EE}^{\text{EE}} + \beta D_{EE} \)
  - Both descriptions lost: \( D_{EE}^{\text{WZ}} = D_{EE}^{\text{EE}} + \text{MSE}(n, n - 1) \)
- Expected end-to-end distortion is a combination of the above

Scenario

- Network of 25 nodes in an 800m-by-800m square
- Signal propagation model: log-normal shadowing
- Link quality fluctuations due to node mobility
- Estimate PLR and maximum throughput via ACKs
- Foreman CIF video with MPEG2 codec

Description Selection

- Avg. PSNR: FEC: 30.6 dB; SLEP: 32.7 dB
- PLR and PSNR Trace

Candidate Descriptions

<table>
<thead>
<tr>
<th>Desc. #</th>
<th>( R_0 )</th>
<th>( (n,k) )</th>
<th>( R_{\text{total}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEC 0</td>
<td>1.0 Mbps</td>
<td>(19, 16)</td>
<td>1.27 Mbps</td>
</tr>
<tr>
<td>FEC 1</td>
<td>800 Kbps</td>
<td>(18, 12)</td>
<td>1.35 Mbps</td>
</tr>
<tr>
<td>FEC 2</td>
<td>700 Kbps</td>
<td>(21, 12)</td>
<td>1.39 Mbps</td>
</tr>
<tr>
<td>FEC 3</td>
<td>600 Kbps</td>
<td>(24, 12)</td>
<td>1.43 Mbps</td>
</tr>
<tr>
<td>FEC 4</td>
<td>500 Kbps</td>
<td>(19, 6)</td>
<td>1.49 Mbps</td>
</tr>
</tbody>
</table>

FEC Descriptions

<table>
<thead>
<tr>
<th>Desc. #</th>
<th>( R_0 )</th>
<th>( (n,k) )</th>
<th>( R_{\text{total}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLEP 0</td>
<td>1.0 Mbps</td>
<td>(19, 16)</td>
<td>1.27 Mbps</td>
</tr>
<tr>
<td>SLEP 1</td>
<td>500 Kbps</td>
<td>(22, 16)</td>
<td>1.30 Mbps</td>
</tr>
<tr>
<td>SLEP 2</td>
<td>400 Kbps</td>
<td>(23, 16)</td>
<td>1.32 Mbps</td>
</tr>
<tr>
<td>SLEP 3</td>
<td>370 Kbps</td>
<td>(24, 16)</td>
<td>1.32 Mbps</td>
</tr>
</tbody>
</table>

SLEP Descriptions (\( R_0 = 1.0 \text{ Mbps} \))

Network Simulation

- Avg. PSNR: 30.6 dB; SLEP: 32.7 dB
- Path Selection

Conclusions

- Proposed the systematic lossy error protection (SLEP) scheme for error-resilient video transmission over wireless ad hoc networks
- Better average and instantaneous visual quality compared to FEC
- Dynamic selection of appropriate description according to fluctuating wireless channel quality
- Effective path selection based on distortion model

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[1] Rane and Girod, PCS'04