Cooperative Recovery in Heterogeneous Mobile Networks
OUTLINE

- Introduction.
- System architecture.
- Protocol design.
- Performance evaluation.
- Further works & Conclusion.
INTRODUCTION

- Compare Multicast with Unicast over wireless networks.
  - Benefits:
    - Distribute data efficiently.
    - Improve throughput.
  - Defects:
    - Difficult to guarantee the reception reliability of multiple recipients.
    - No reverse communication channel.
INTRODUCTION

- **FEC (forward error correction).**
  - Increase transmission bandwidth requirements or message delay.

- **Multiple antennas.**
  - High cost.

- **The Cooperative Recovery Protocol.**
  - Peer cooperation.
SYSTEM ARCHITECTURE
SYSTEM ARCHITECTURE

- Two radio interfaces in device:
  - Connect to principal network, for receiving multicast data from BS to wireless devices.
  - Connect to assistant network, over which the messages and packets for recovery can be transmitted.
Source S is multicasting data to devices A and B. P1, P2 << 1, so the recovery rate: \((1 - \Pi Pn) \approx 1\)

• **Related work**
  - Use relay nodes in assistant network: Big load.
PROTOCOL DESIGN

- Peer Discovery and Partnership Establishment.
- Partnership Maintenance.
  - Periodically check by exchanging Keep-Alive(KA) messages between them.
- Data Recovery.
Peer Discovery and Partnership Establishment

Requester

Helper

PREQ

PREQ ID

SESSION ID

PREP

PREQ ID

ORG PREP ID

SESSION ID

PACK

PACK ID

ORIGINAL

PREP ID

SESSION ID

ACK

CONF

PCOM

PCOM ID

ORG PACK ID

SESSION ID

TTL

broadcast

Admit?

Partner?
Partnership Maintenance

- Requester’s view:
  - A Keep-Alive (KA) unicast message is sent periodically with period K_INTERVAL.
  - The peer replies with a unicast Keep_AliveReply (KAR) message.
  - KAR_TIMEOUT after sent KA.
  - KEEP_ALIVE_RETRIES_LIMIT.
Partnership Maintenance

- Partner’s view:
  - Has not received the KA message from the requester device for a time interval KEEP_ALIVE_LIMIT.

- IF one partnership is ended, find a replacement partner.
Data Recovery

Packet list

Decide
PERFORMANCE EVALUATION

- Methodology:
  - 3G multicast principal network.
  - 802.11b WLAN assistant network.
  - OPNET Modeler with PDUs simulating the reception of 3G multicasts session.

- Compare the before recovery and after recovery PDU drop rates at the wireless devices.
PERFORMANCE EVALUATION

1) Dependency on PDU drop rate.
2) Dependency on the number of helpers.
3) Effect of Recovery Network Size.
4) Throughput Improvement and Fairness.
5) Multi-hop Scenario.
6) Recovery Delay.
7) Video Encoder/Decoder Simulation.
PERFORMANCE EVALUATION

Dependency on PDU drop rate:

Effect of requester

Effect of helper
PERFORMANCE EVALUATION

Effect of number of partners

Effect of recovery network size
Throughput improvement in a dense environment
PERFORMANCE EVALUATION

Multi-hop Recovery Scenario
PERFORMANCE EVALUATION

Peak Recovery Delay
PERFORMANCE EVALUATION

- Video Encoder/Decoder Simulation

**TABLE I: PSNR Values**

<table>
<thead>
<tr>
<th>PSNR(dB)</th>
<th>Y</th>
<th>U</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before Recovery</td>
<td>21.31</td>
<td>24.23</td>
<td>25.27</td>
</tr>
<tr>
<td>After Recovery</td>
<td>35.62</td>
<td>38.49</td>
<td>39.54</td>
</tr>
</tbody>
</table>

$$PSNR = 10 \times \log \left( \frac{255^2}{MSE} \right)$$

$$MSE = \frac{\sum_{n=1}^{FrameSize} (I_n - P_n)^2}{FrameSize}$$
FURTHER WORKS AND CONCLUSION

- **Mobility of Wireless Devices**
  - Discover a new partner or find a relay node relay the packets to the requester.

- **Partner Selection**
  - According to various criteria to optimize this partner selection process.
Hierarchical ad hoc recovery network with dedicated proxies
FURTHER WORKS AND CONCLUSION

- Cooperative Recovery Scheme, which is a novel method to enhance QoS support for multicast services over a principal network (3G).
THANKS !