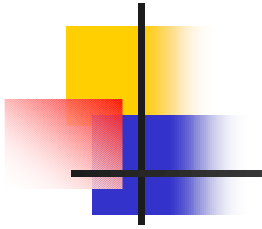


Video Transport over Ad Hoc Networks:
Multistream Coding with Multipath Transport

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Challenges

- In ad hoc networks:
  - links are unreliable :
    - mobility, interference, fading
  - CSMA/CA MAC is designed for best-effort data:
    - no hard guarantees on bandwidth and delay
  - TCP has problem working with IEEE 802.11 MAC
- Video transport:
  - High bandwidth and stringent delay requirements
  - Susceptible to loss: motion compensated prediction (MCP) is used in all modern video coding standards.



Multipath Transport

- Multiple path transport (MPT) has been proposed in the past for wireline networks for
  - Increased connection capacity
  - Load balancing
  - Path redundancy and error control
- MPT has more potential in wireless networks
  - Individual links may not have adequate capacity to support a high bandwidth service
  - High transmission error rate and unreliable links
  - Many routing protocols in ad hoc networks can return multiple paths for a route query
- Resequencing delay: controllable



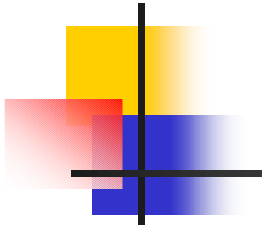
Multistream Coding with MPT

- Existence:
  - The mesh topology of ad hoc networks means multiple end-to-end paths exists
- Availability:
  - Many MANET routing protocols can maintain multiple paths with limited additional overhead
- *Path diversity* : provides an extra degree of freedom in designing video coding and transport schemes
- *Multistream coding* : *enables a novel means of traffic dispersion*



Three Schemes Examined

- Layered coding with constrained ARQ [VTC-F01]
  - Base layer sent on the better path
  - Lost packets in the base layer are retransmitted over the enhancement layer path
- Reference picture selection [ICME01]
  - Even/odd frames sent on separate paths
  - Predict damaged frames based on NACK on each path, and use undamaged frames as reference pictures
- Multiple description coding (MDMC) [MMSP01,CSVT02]
  - Even/odd frames sent on separate paths
  - Each frame is predicted from the previous even and odd frames
  - Mismatch in prediction when only a single description is received is coded explicitly
  - Redundancy controlled by the predictor and quantizer for mismatch signal and can be adjusted based on channel loss statistics



Simulation Settings

- Quarter Common Intermediate Format (QCIF) sequence "Foreman" with 200 frames are used
- 10 frames per second
- Bandwidth of each channel is 57kbps
- H.263+ codec enhanced with the schemes proposed
- 5% macroblock level intra refreshments



Results - Markov Channel Models

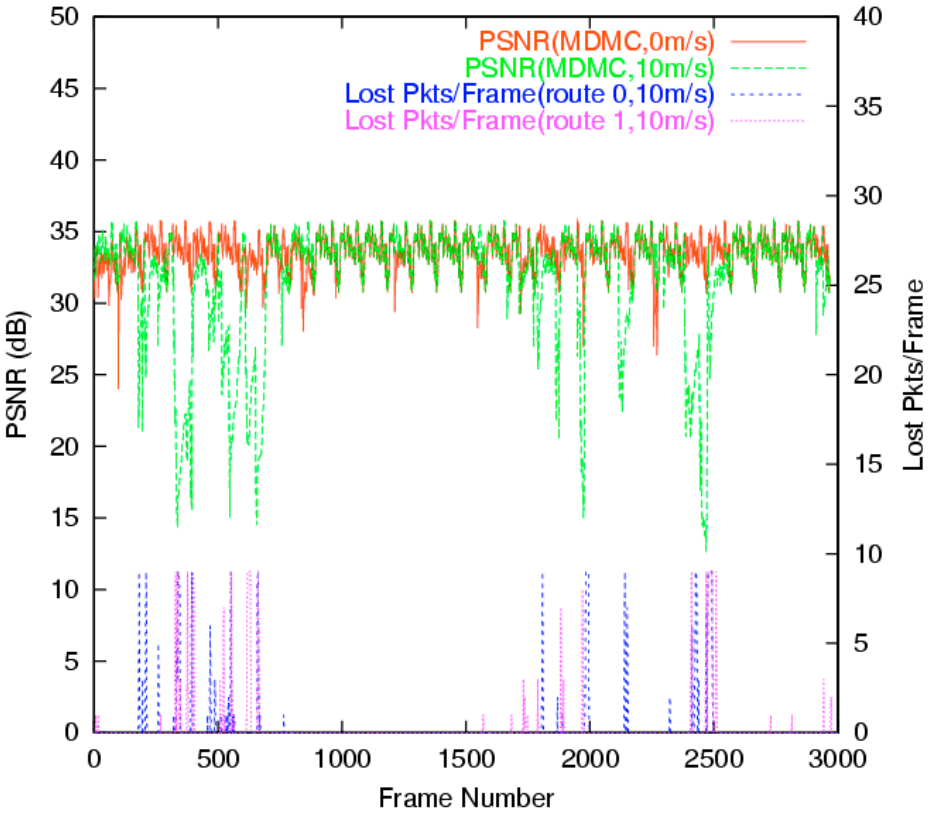
- Average PSNR of reconstructed sequences

Packet Loss Rate	(3%,3%)	(10%,10%)	(5%,10%)
RPS	31.3 dB	27.5 dB	28.8 dB
LC+ARQ	31.1 dB	29.4 dB	30.6 dB
MDMC	31.3 dB	27.4 dB	28.2 dB
VRC	30.0 dB	24.8 dB	25.3 dB
Alt-GOB	27.2 dB	23.3 dB	24.2 dB

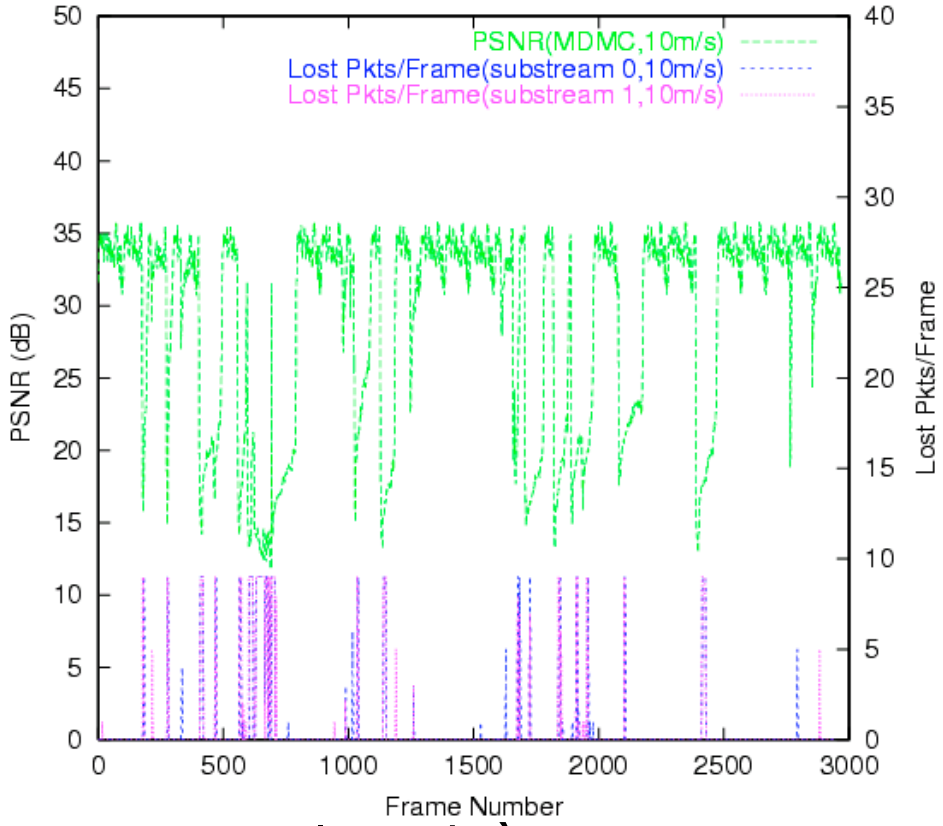
- All three proposed schemes outperform VRC and Alt-GOB (in current standards)

Results - OPNET Models (1)

- 16 nodes, 600m by 600m, 10m/s, transmission range=250m:



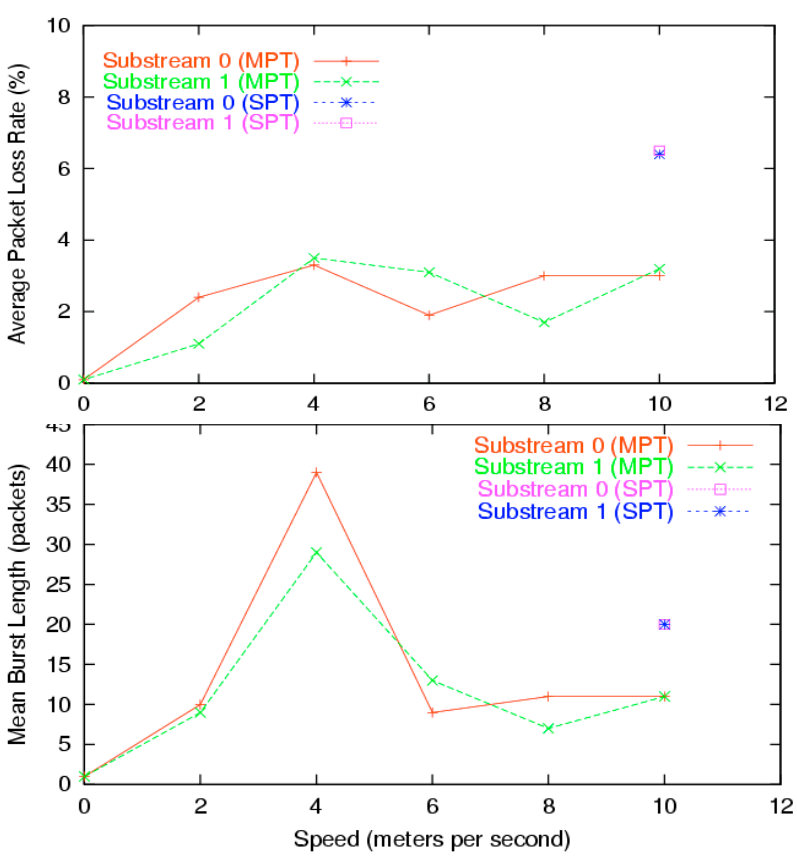
Multipath Routing DSR

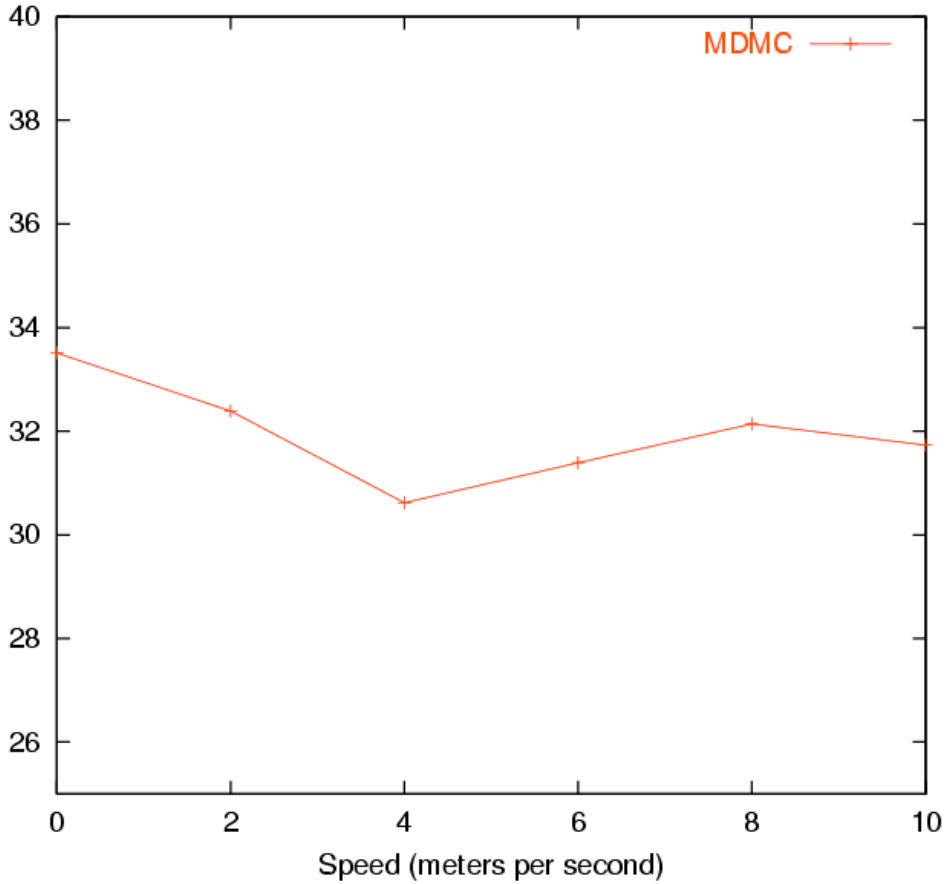


Single Path `Routing DSR

Results - OPNET Models (2)

- 16 nodes, 600m by 600m, 10m/s, transmission range=250m, multipath routing DSR:





Work in Progress and Future

- A multipath-multistream video transport ad hoc testbed
- A multi-flow realtime transport protocol
- Investigate the time scales of multi-mode codec, the routing process, and the multi-hop wireless path in an ad hoc network
- Build a theoretic model on optimal traffic dispersion: rate distortion theory, link availability models, queueing, ...

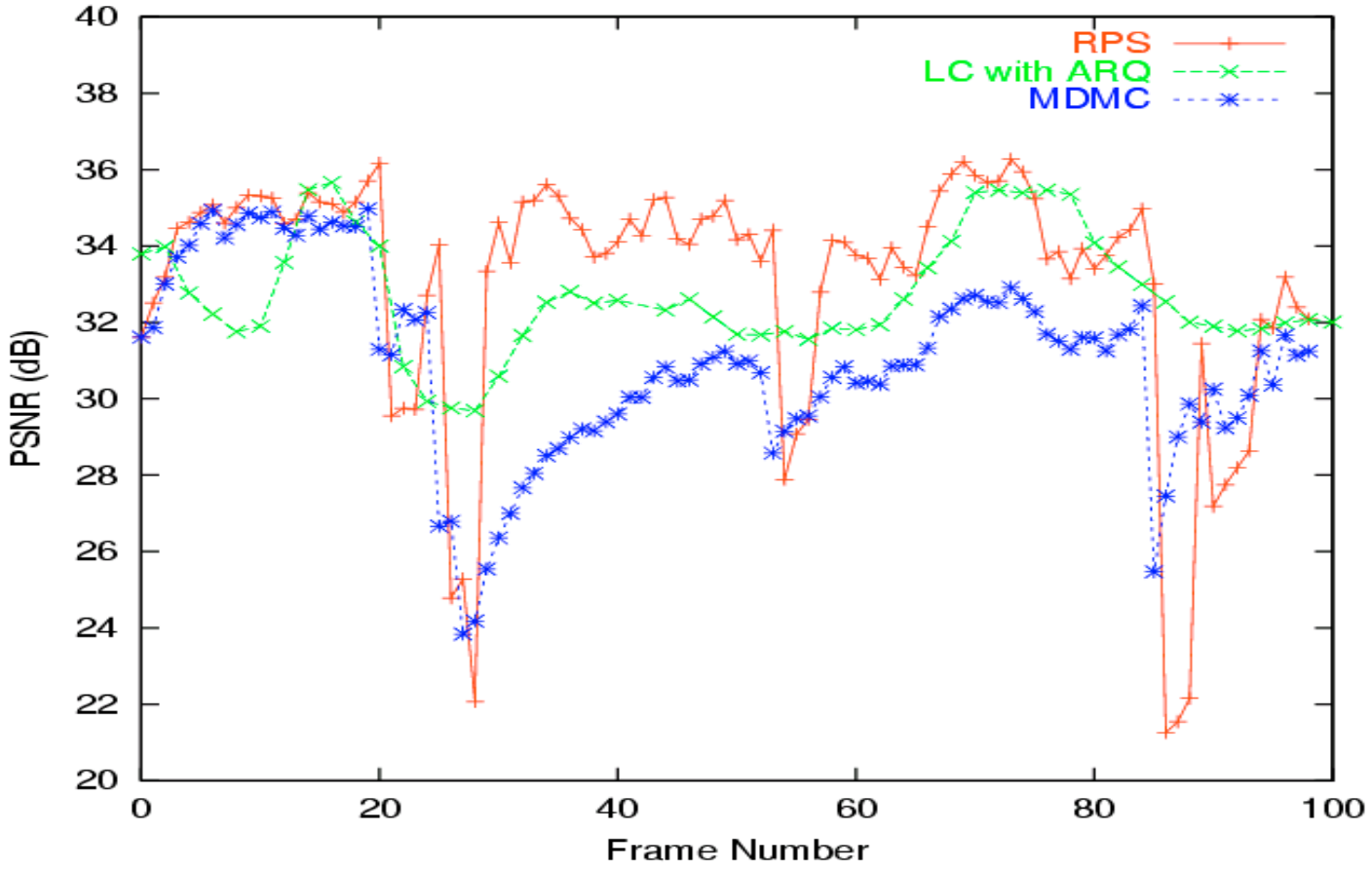


An Ad Hoc Video Transport Testbed

- We are developing an ad hoc video streaming testbed to demonstrate the schemes and test their performance
  - Each mobile node is a Thinkpad notebook computer equipped with IEEE 802.11b cards working in the ad hoc mode
  - H.263+ codec, enhanced with the new multipath coding schemes, is running on the mobile nodes
  - We are interested to see how the schemes works and how the large parameter set affects the video display quality

Results - Testbed

- Four nodes, two 2-hop paths, in building and not in line-of-sight



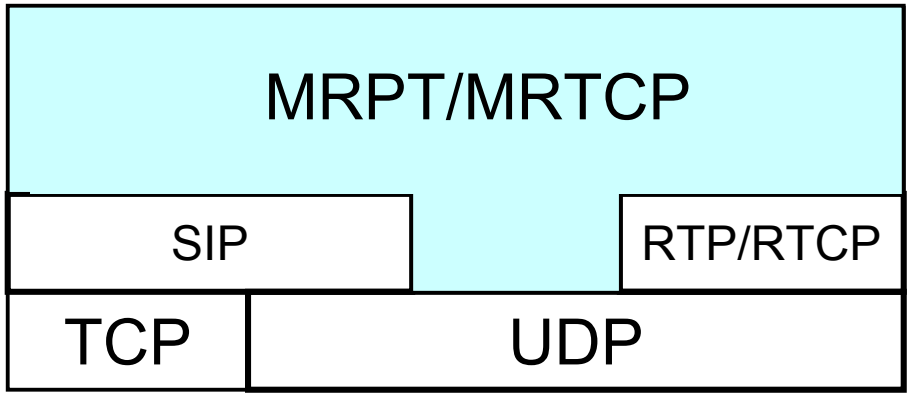


A Proposed Protocol

- Multi Flow Real Time Transport Protocol
  - Real time data transport over multiple flows
    - Path diversity (if supported by an underlying routing protocol, and support of multihoming)
    - Fault tolerance (including path redundancy)
    - Load balancing
    - Improved per-flow traffic characteristics
    - Hiding from application complexity of flow resources, sequencing, etc.
  - End-to-end transport service utilizing association of multiple flows
  - Flexibility in data partitioning at the application level

A Proposed Protocol (2)

- Shuffling, thinning and striping could all be supported as data partitioning methods
  - Multiple protocol modes have to be made available for a multimedia communication session
  - Modes can be combined / provisioned / dynamically changed
  - Parameters should be programmable and dynamic if possible
- Protocol's placement:





Conclusions

- Video transport over ad hoc networks poses great challengers
- We propose *multistream video coding* with *multipath transport*
- Performance study of the schemes:
  - Markov channel models
  - OPNET models
  - An ad hoc video transport testbed
- A multipath video ad hoc testbed
- Proposing a new multipath realtime transport protocol