1. Overview

"On Improving Delivery Ratios for Application-Layer Multicast in Mobile Ad-hoc Networks"

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1. Overview
2. Application Example
3. Multicast Mechanisms
4. NICE-MAN
5. Simulation Results
6. Summary and Future Work

2. Application Example

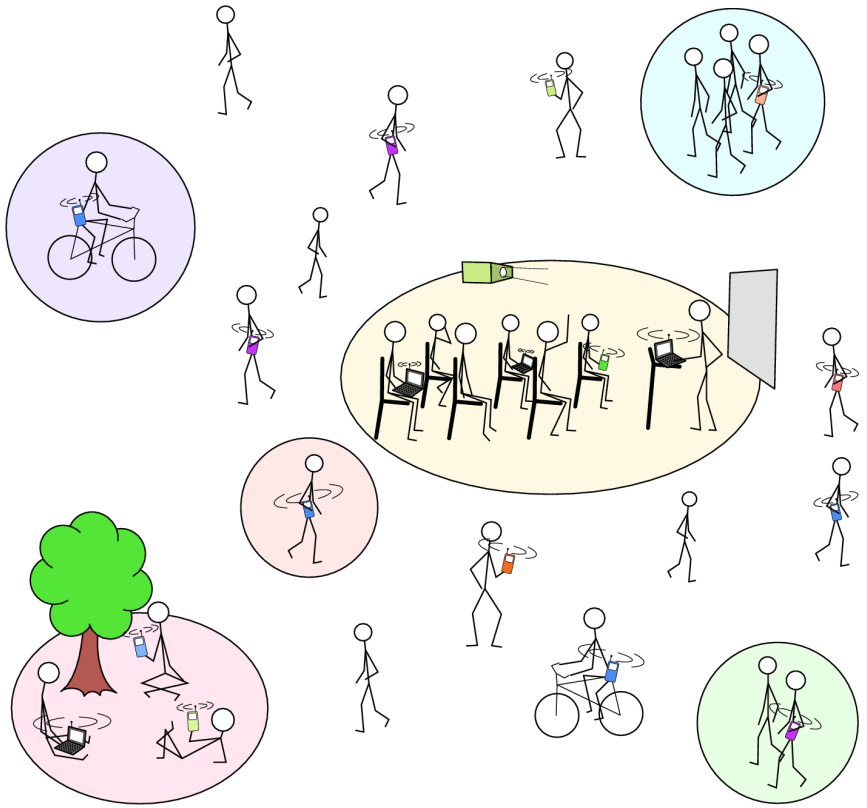
Campus-Wide Wireless Multicast-Services

Potential applications:

- Whiteboard / Audio streaming
- Distribution of learning materials
- Cooperation via chat

Impact of MANETs on services:

- Node mobility
- Shared medium
- Frequent packet losses
- Highly sensitive to network load



2. Application Example

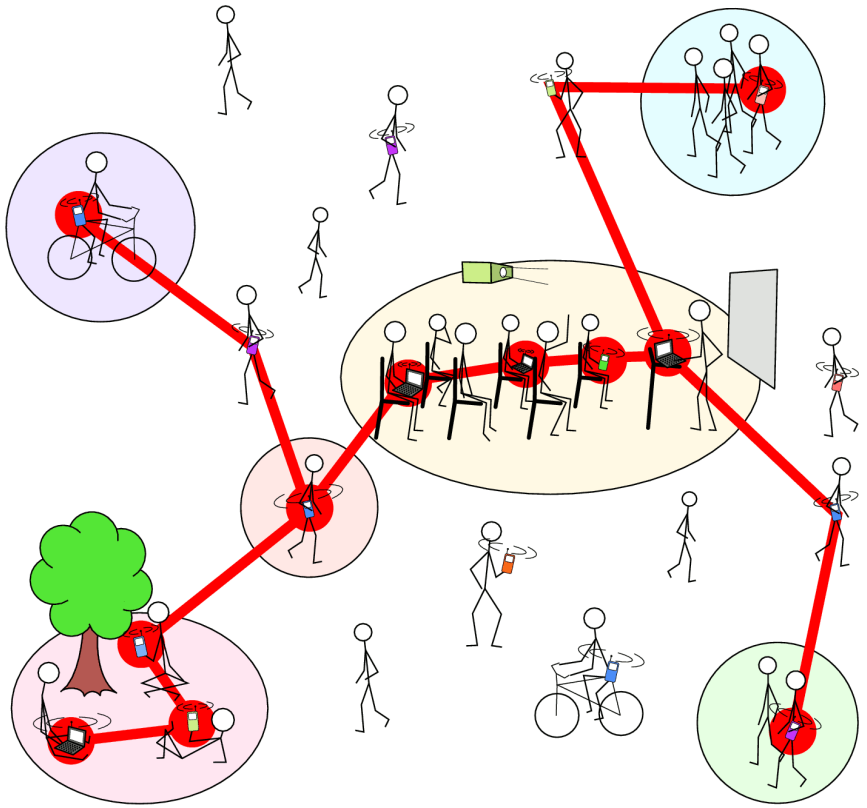
Campus-Wide Wireless Multicast-Services

Requirements:

- Support mobile groups
- No fixed infrastructure
- Low latencies
- High delivery ratios

Use application-layer approach:

- Only group members involved
- Reuse protocols from Internet



3. Multicast Mechanisms

“Cross-layer” mechanism:

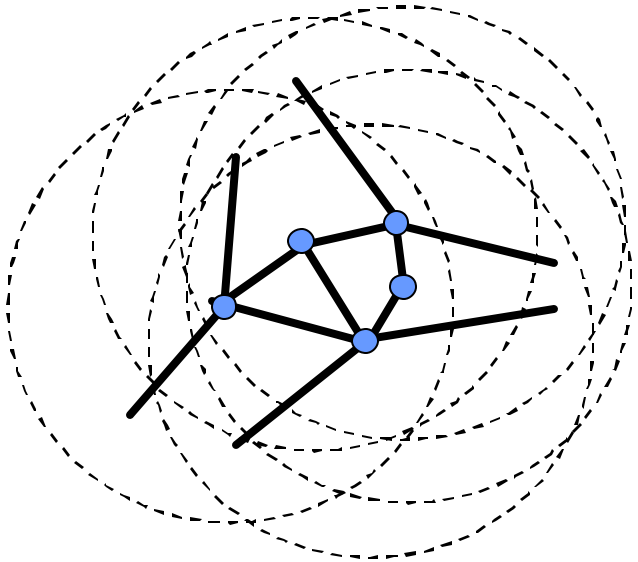
1. Local Broadcast Clusters (LBCs)
   - New to application-layer multicast

“Classic” mechanism:

2. Retransmission requests
3. Buffer management
4. Congestion Control

Cross-Layer Information

Problem: Data forwarding through overlays can be ***highly inefficient!***



Why…?

- Redundant forwarding of data
- Simultaneous medium accesses

➡ Quickly ***overburdened medium!***

Frequent collisions + IEEE 802.11

= Exponentially increased back-off time + Retransmission

= Growing MAC-Queue length

= ***Increased latencies!***

Cross-Layer Information

Solution: Use ***broadcast capability!***

Overlay nodes…

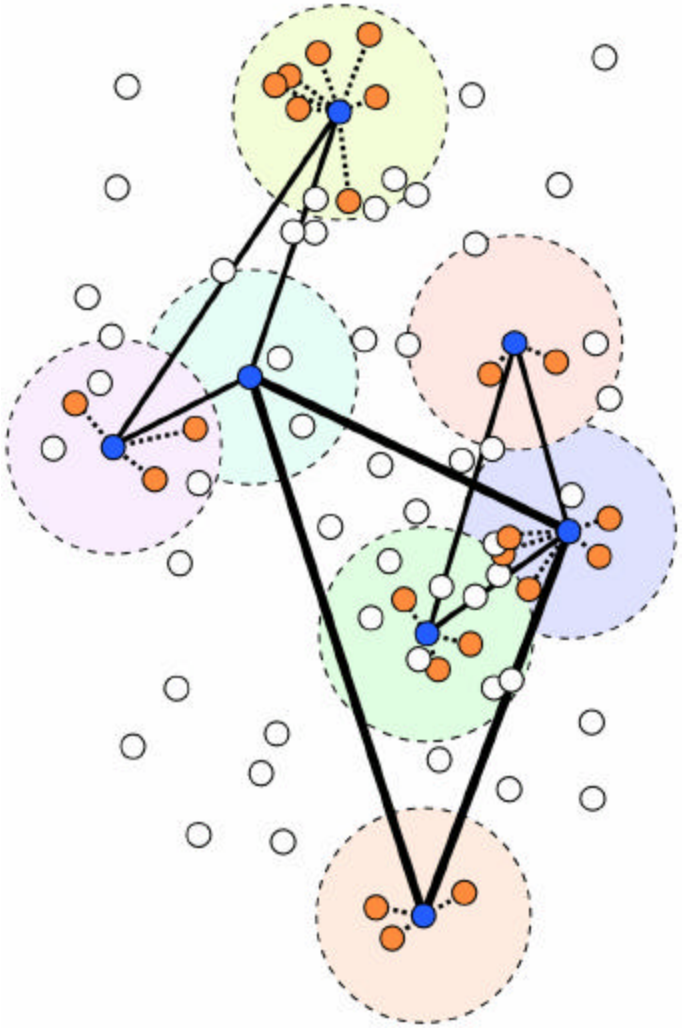
- Broadcast heartbeats
- Broadcast multicast data

➡ *Local Broadcast Cluster (LBC)*

Nearby group members…

- Detect overlay nodes via heartbeats
- Receive/send data via overlay nodes

➡ *Locally joined nodes*



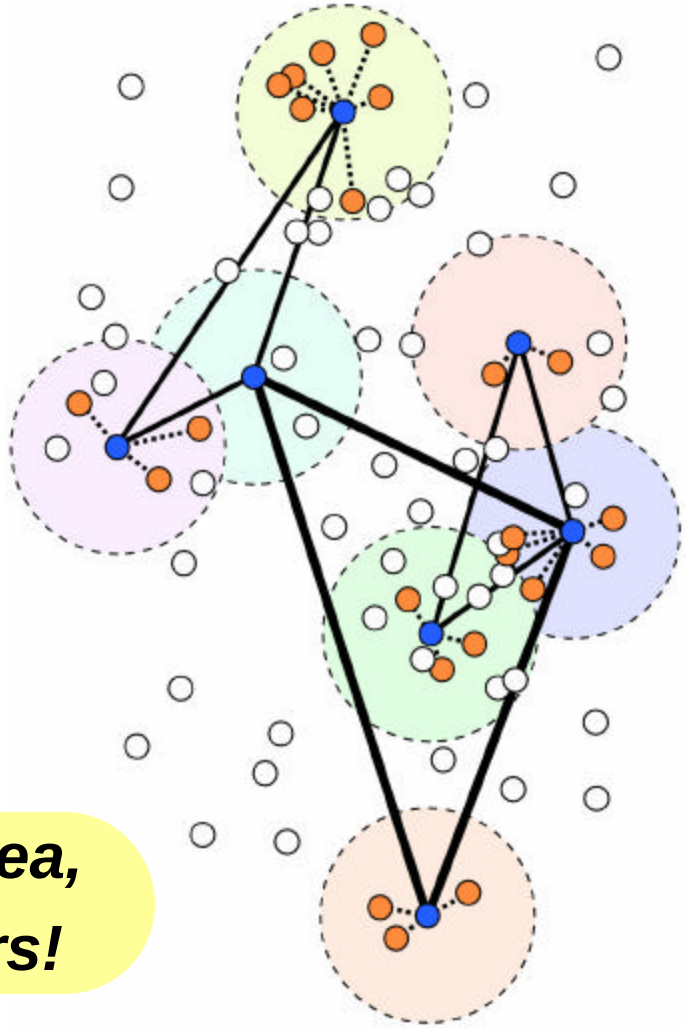
Advantages

Locally joined nodes…

- Do ***not*** join the overlay
- Do ***not*** introduce any control flow
- Are unknown to overlay nodes

Local Broadcast Clusters…

- Reduce overlay maintenance cost
  - ***Very few*** nodes join overlay
- Forward data with ***one*** medium access



Control flow grows with occupied area, not with number of group members!

Retransmission Requests

"Retransmission Request = Send NACK to parent node"

Locally joined nodes…

- Parent node = Nearby overlay node
- Back-off + Broadcast NACK = ***Local NACK Avoidance***
- Overlay nodes broadcast retransmissions

Global NACK avoidance:

- Include seq_{max} in forwarded packets

  seq_{max} ? seq_{no} up to which packets were successfully received

- Suppress NACKs for $seq_{no} > seq_{max}$

Buffer Management

Parent nodes…

- Gather seq_{max} from child (overlay) nodes
- Free buffer up to seq_{min}

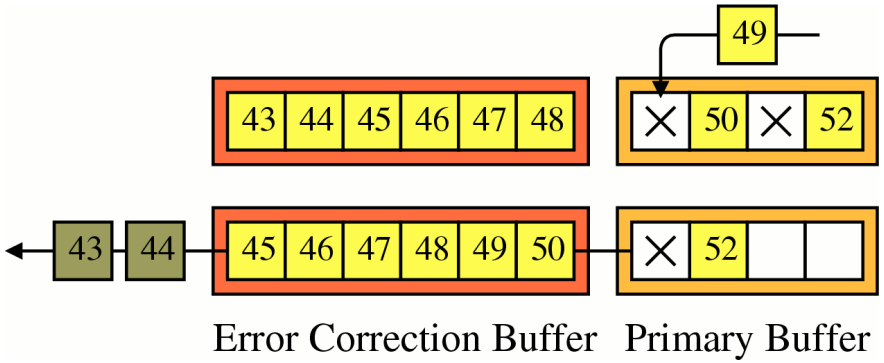
seq_{min} ? min{all gathered seq_{max}, own seq_{max}}

Problem: Leaf nodes…

- Can't gather seq_{max} (no child nodes)
- Free buffers up to $seq_{min} = seq_{max}$
- Complicates error recovery in LBCs

Maintain additional buffer:

- "Error Correction Buffer"
- Keeps packets discarded from primary buffer



Congestion Control

Send seq_{min} instead of seq_{max} to parent node!

Lowest seq_{max} is transmitted to source

- Source learns about packet losses

Congested networks = Many packet drops

- Visible through slowly raising seq_{min}

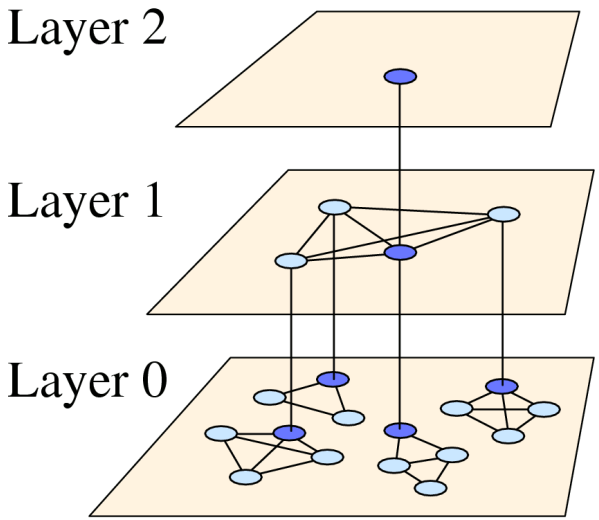
Don't send new data if seq_{min} raises too slow!

- Use medium for error recovery!
- Applicable in distribution of static media

4. Complete Package: NICE-MAN Protocol

Protocol features:

- ***Hierarchically clustered*** receivers
  - No extra routing algorithm needed
- Periodically ***adapted overlay topology***
  - Group members may change clusters
- ***Broadcast medium*** considered (LBCs)
  - Significantly fewer nodes join the overlay
- Selective ***retransmission requests***
  - Local and global NACK avoidance
- Buffer management
- ***Congestion Control***



Will be improved

- Node mobility ✓
- Shared medium ✓
- Packet losses ✓
- Load sensitivity ✓

5. Simulation Experiments

Parameters:

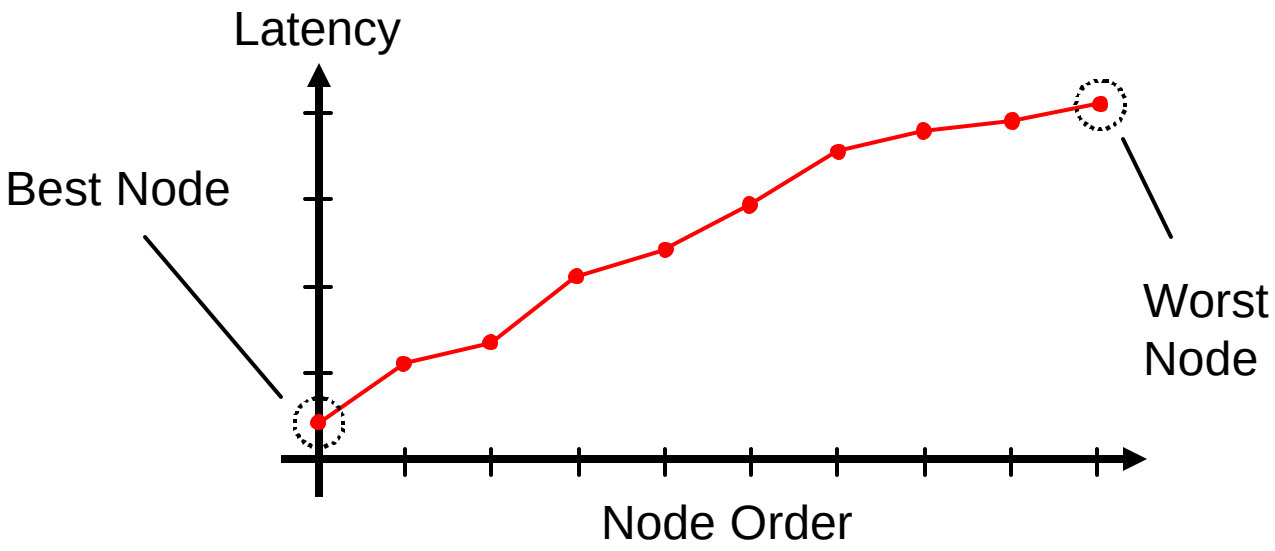
- Area 1000m x 1000m
- IEEE 802.11
  - Transmission range: 150m
  - Bandwidth: 2 $^{Mbit}/_{s}$
- 10 to 50 group members
  - RPGM, v_{max} = 1 $^{m}/_{s}$
  - Cluster size: 1 up to 5 nodes
  - Cluster diameter: 80m
- 50 non members
  - Random Waypoint, v_{max} = 2 $^{m}/_{s}$
- Unicast routing: AODV
- 20 mobility scenarios averaged

Simulation Experiments

Unreliable data delivery

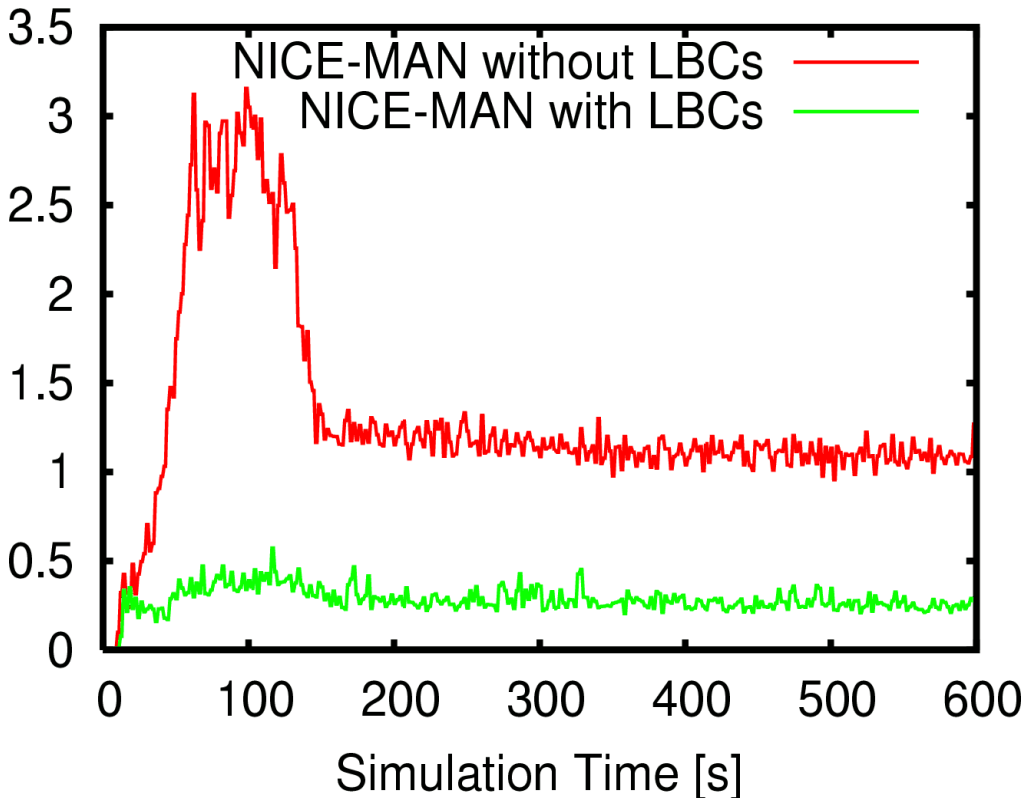
2 x 512 Bytes/sec

30 Receivers



Unreliable Data Delivery

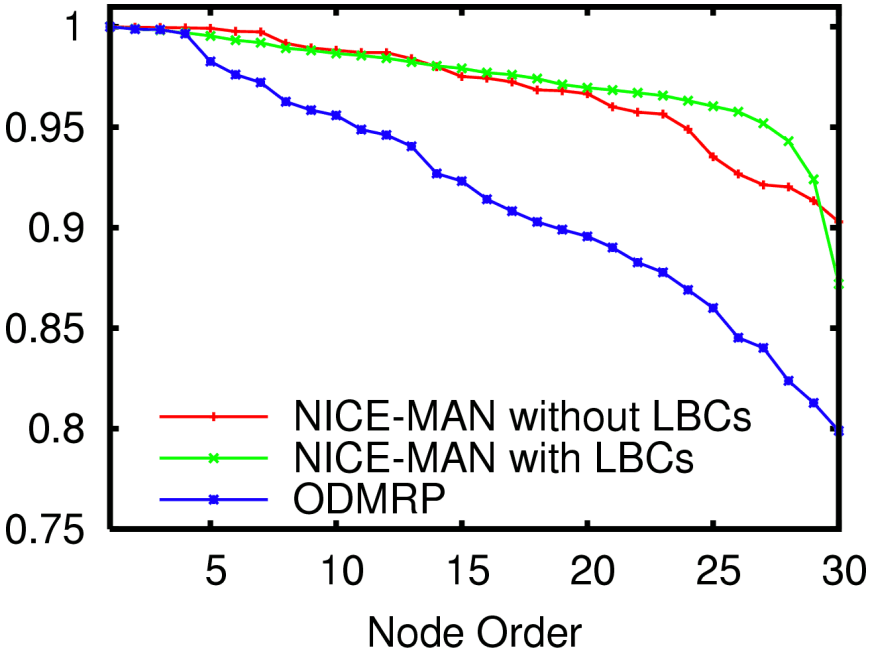
Control Flow (Kbytes/sec) - With/without LBCs



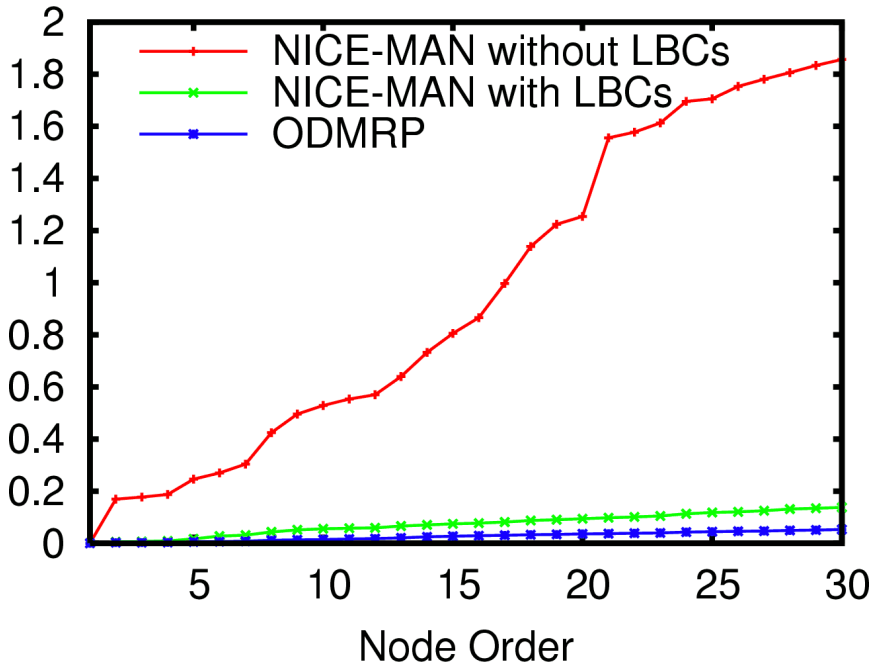
Cross-layer to ***reduce*** control flow!

Unreliable Data Delivery

Delivery Ratios



Latency [s]



High delivery ratios (IEEE 802.11)

10x improvement on latency using ***cross-layer!***

Simulation Experiments

Reliable data delivery

4 x 512 Bytes/sec

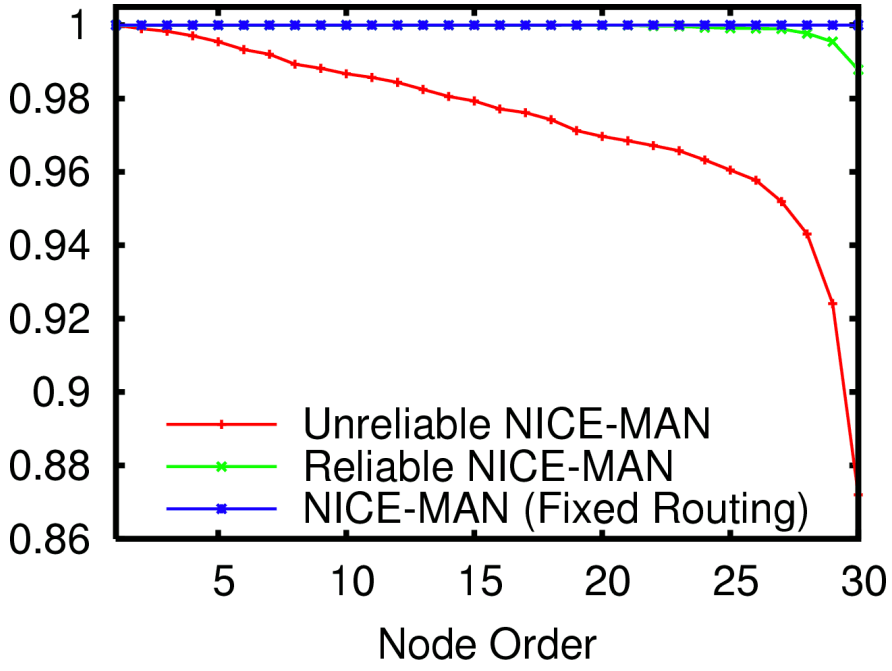
30 Receivers

Retransmission Requests

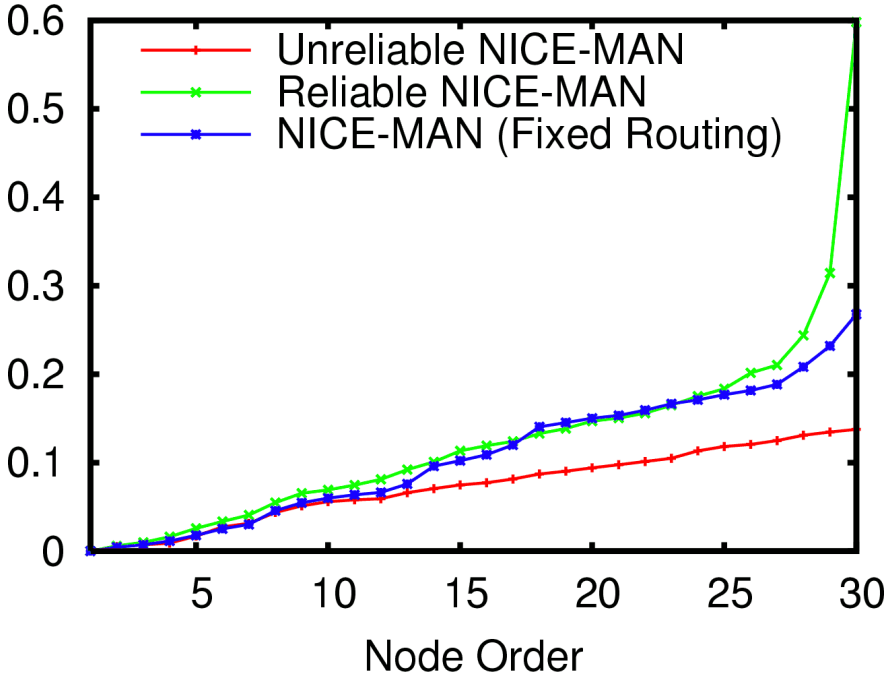
Congestion Control

Reliable Data Delivery

Delivery Ratios



Latency [s]



Reliable data delivery

Slight increase of latencies (x1.5)

6. Summary and Future Work

Summary:

- Use ***cross-layer for efficiency***
- Protocol: NICE-MAN
- Performance: 2 Kbytes/sec to 30 pedestrians

Future topics:

- Performance for multiple multicast sources?
- Improve retransmissions
- True rate adaptive congestion control
- Better performing overlays
- More realistic user behavior