Proposal, Implementation, and Evaluation of a QoS-aware Routing Mechanism for Multi-Channel Multi-Interface Ad-Hoc Networks

Shinsuke Kajioka*, Naoki Wakamiya*, Masayuki Murata*,
Hiroki Satoh†, Kazuya Monden†, Masato Hayashi†, and Susumu Matsui†

*Osaka University, Japan
†Hitachi Ltd., System Development Laboratory

Research background

Wireless ad-hoc network provides temporal communication vehicle

Remote monitoring　VoIP (Voice over IP)

Real-time Multimedia Traffic

QoS requirement → QoS control → Bandwidth reservation, Delay restraint

Cannot satisfy a variety of QoS requirements

Large bandwidth → Capacity expansion → Channel multiplexing, Channel switching

Need routing at all channels and/or modification of MAC

Overview of our proposal

Immobile node with multiple interfaces

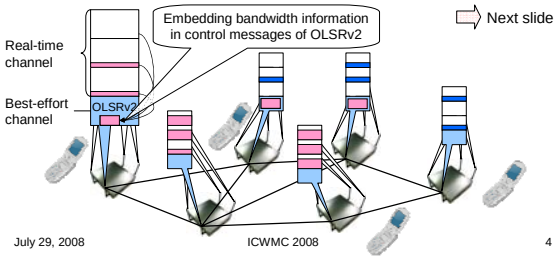
Estimation of available bandwidth
The available bandwidth is used as a routing metric for QoS control

Distribution of bandwidth information on OLSRv2
To distribute and share bandwidth information with low overhead

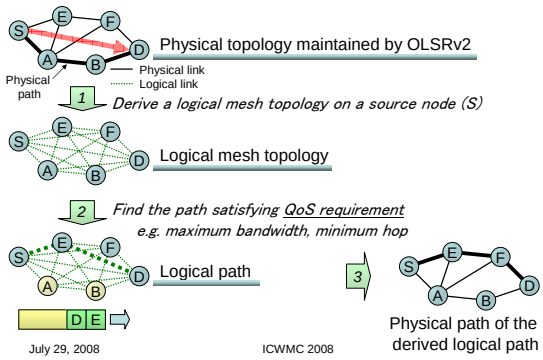
Logical Routing based on topology and bandwidth information
To establish a QoS-aware path without modification of physical routing

Estimation and distribution of BW information

Estimation of available bandwidth
Distribution of bandwidth information on OLSRv2
Logical Routing based on topology and bandwidth information

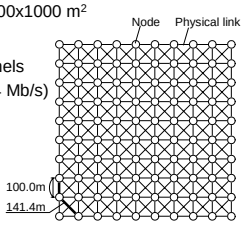


Logical Routing based on topology and BW information



Simulation settings

- Simulator: QualNet 4.0
- Node placement: Grid 10x10 nodes in 1000x1000 m^2
- Wireless: IEEE 802.11g x 4 interfaces
  No interference between channels
  Transmission range: 153 m (54 Mb/s)
  Interference range: 289 m
- Traffic: 64 kb/s per session, VoIP
  (UDP 172 Bytes packets / 20 ms)
  80 sessions
  HELLO interval: 2 s
  TC interval: 5 s
  10 different traffic patterns (random seeds)



Simulation scenarios

Scenario	Channels best-effort	Channels real-time	Logical routing	Channel selection
1	1		N/A	N/A
2	1	1	Off	N/A
3	1	3	Off	At source, at random
4	1	3	Off	Hop-by-hop
5	1	3	On	Hop-by-hop

Separate a real-time channel

Increase real-time channels

Select a real-time channel in a hop-by-hop manner

Conduct logical routing (full proposal)

Simulation results: Packet delivery ratio

Scenario	Channels		Logical routing	Channel selection
1 +	1		N/A	N/A
2 ×	1	1	Off	N/A
3 □	1	3	Off	At source, at random
4 △	1	3	Off	Hop-by-hop
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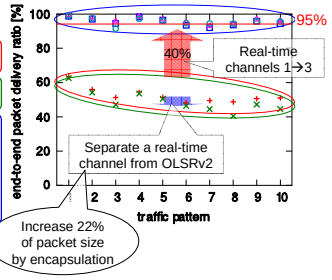

Multiple real-time channels contributes to increment of packet delivery ratio

Simulation results: Delay

Scenario	Channels		Logical routing	Channel selection
1 +	1		N/A	N/A
2 ×	1	1	Off	N/A
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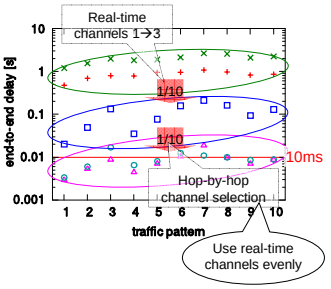

Hop-by-hop channel selection contributes to reduction of end-to-end delay

Simulation results: Traffic distribution

Number of transmitted MAC frames per node

Scenario	Channels		Logical routing	Channel selection
1	1		N/A	N/A
2	1	1	Off	N/A
3	1	3	Off	At source, at random
4	1	3	Off	Hop-by-hop
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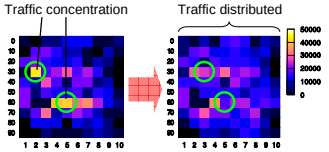


Scenario 4 w/o logical routing

Scenario 5 w/ logical routing

1.02×10^8 variance 0.76×10^8

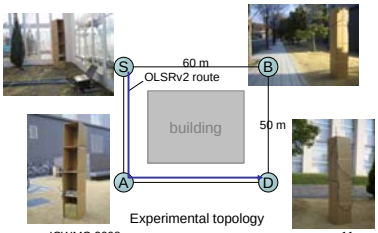
0.53 fairness index 0.66 (similarity)

Logical routing contributes to load distribution

Practical experiments: System and environment

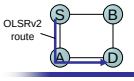
- Wireless: IEEE 802.11b/g x 3 interfaces in ad-hoc mode
  (#0 for best-effort channel, #1 and #2 for real-time channel)
- Traffic: 64 kb/s per session, VoIP, new session appears every 5 s
  (UDP 172 Bytes packets / 20 ms)

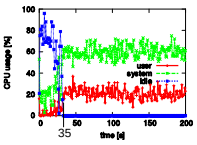
The ad-hoc wireless relay node



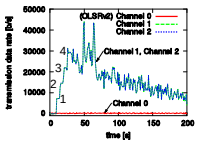
Experimental topology

Practical experiments: Results

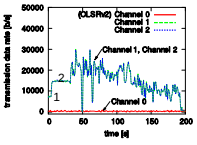




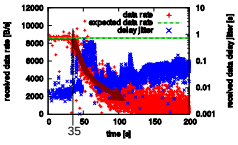
Transition of CPU usage – node S



Transmission data rate – node B



Transmission data rate – node A



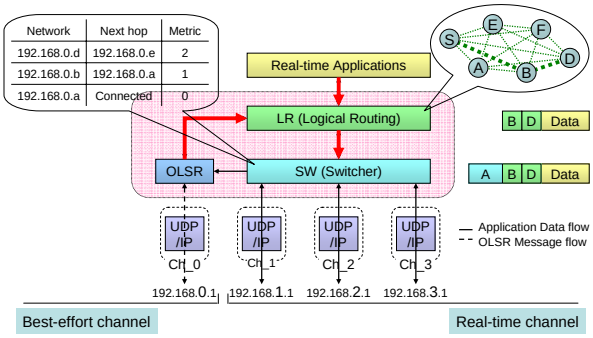
Received data rate – node D

Conclusion and future work

- Conclusion
  - Proposed QoS-aware routing in multi-channel multi-interface ad-hoc networks
    - Estimation of available bandwidth
    - Distribution of BW information on OLSRv2
    - Logical routing over OLSRv2 network
  - Simulation experiments
    → packet delivery ratio: 95%, delay: 10 ms, traffic distribution
  - Practical experiments
- Future work
  - Comparison with other QoS routing protocol, e.g. QOLSR with more general topology and parameter settings
  - Application to dynamic scenarios, e.g. with mobile nodes, changing topology

Thank you.

Node structure



Simulation results: Delay jitter

Scenario	Channels		Logical routing	Channel selection
1 +	1		N/A	N/A
2 ×	1	1	Off	N/A
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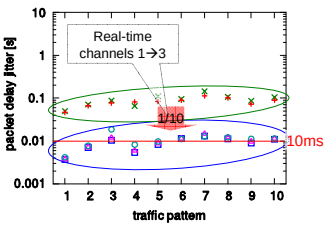

Estimation of available bandwidth

Available bandwidth (of a channel) = Ideal capacity – Total amount of data transmitted and received on the channel

Available bandwidth (of a node) = Σ Available bandwidth (of a channel) / Number of real-time channel