Performance Improvement in Ad hoc Wireless Networks with Consideration to Packet Duplication

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  - Flexible Radio Network
- Packet Duplication Problem
  - Process of the duplication
  - Methods to improve the performance
- Performance evaluation through simulations
- Conclusion and Future Work

Flexible Radio Network

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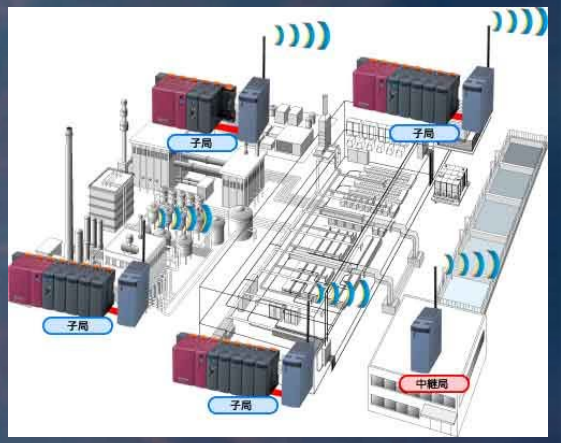
- Wireless data collection system developed by Fuji Electric Co., Ltd.
- Multi-hop network organized by stationary terminals
- Application examples
  - Power consumption collection in manufacturing plants
  - Sales account of vending machines
  - Usage data collection from ski lift gates



http://www.fujielectric.co.jp/eng/index.html

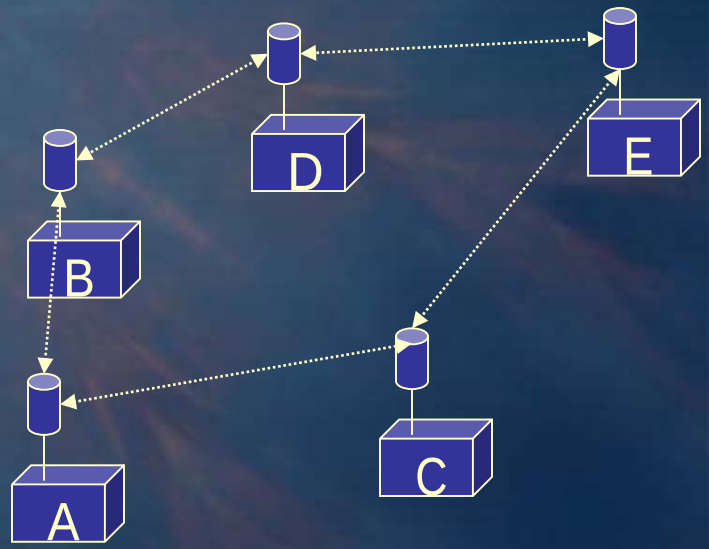
System Description

- Network configuration table
  - Periodic route data exchange
  - Each node maintains multiple routes to all nodes in the same network
  - Route data = (Neighbor ID, Hop count to destination)

Destinaton Node ID

routes	B	E	..
1	(B,1)	(C,2)	..
2	(C,4)	(B,3)	..
:	:	:	

Network configuration table at node A



Protocol Description

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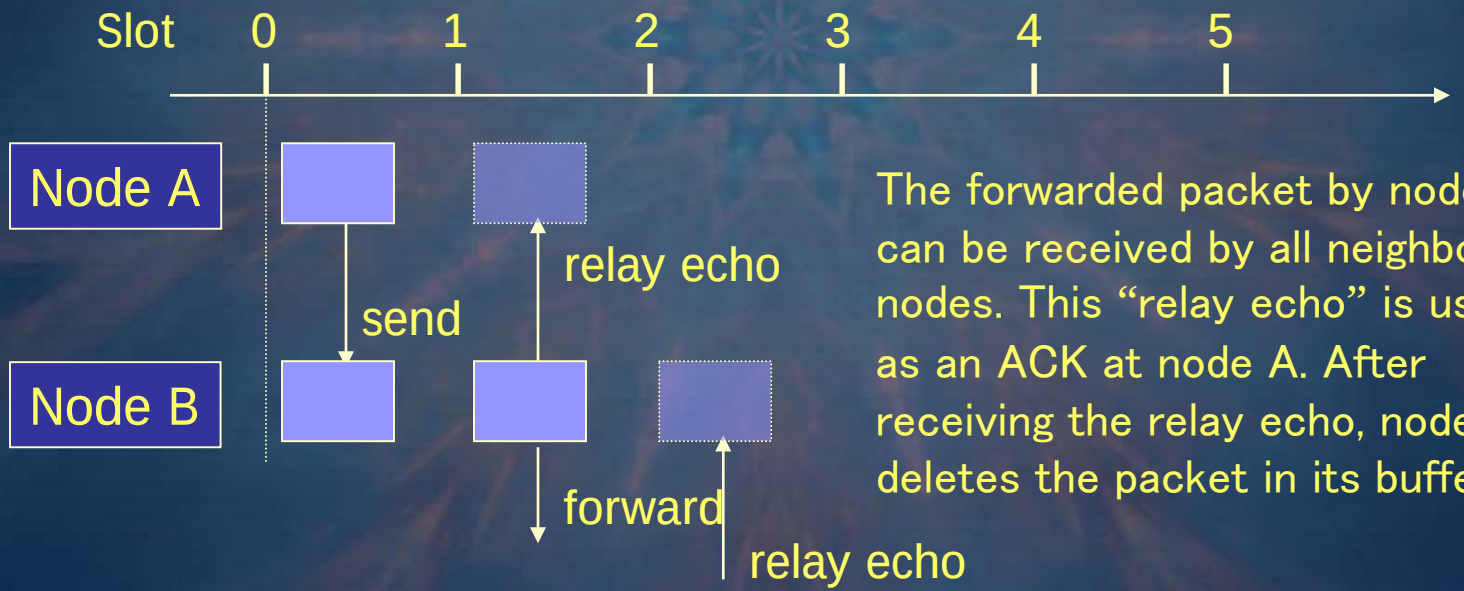
- Fixed time divided slot
  - Slot based maximum lifetime of packets
  - Relay echo acknowledgement



The forwarded packet by node B can be received by all neighbor nodes. This “relay echo” is used as an ACK at node A. After receiving the relay echo, node A deletes the packet in its buffer.

Protocol Description

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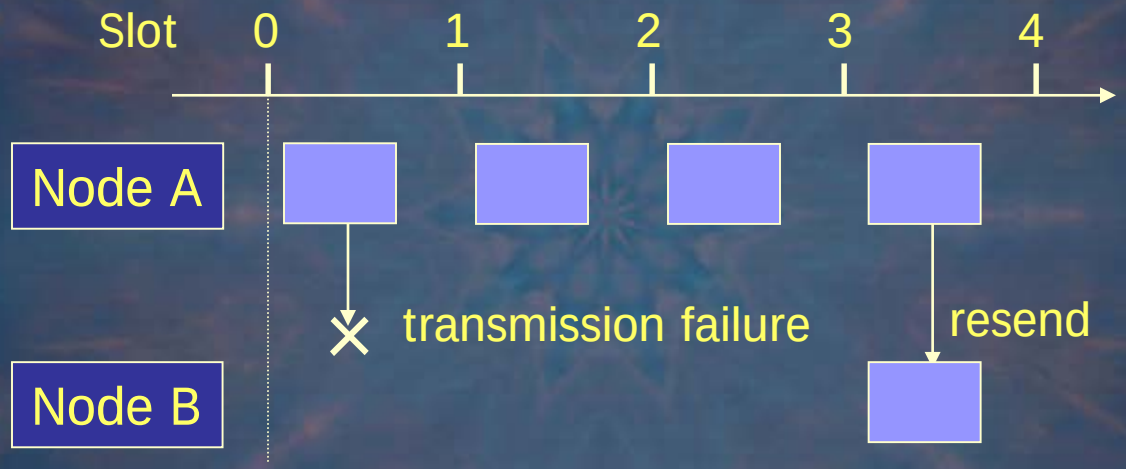
- Restransmission control



Node A retransmits the packet after pre-specified time when it cannot receive a relay echo from node B.

Packet Duplication Problem

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Packet retransmission caused by relay echo receipt failure

↓

Packet Duplication

↓

Additive network load and performance degradation

Packet Duplication Process

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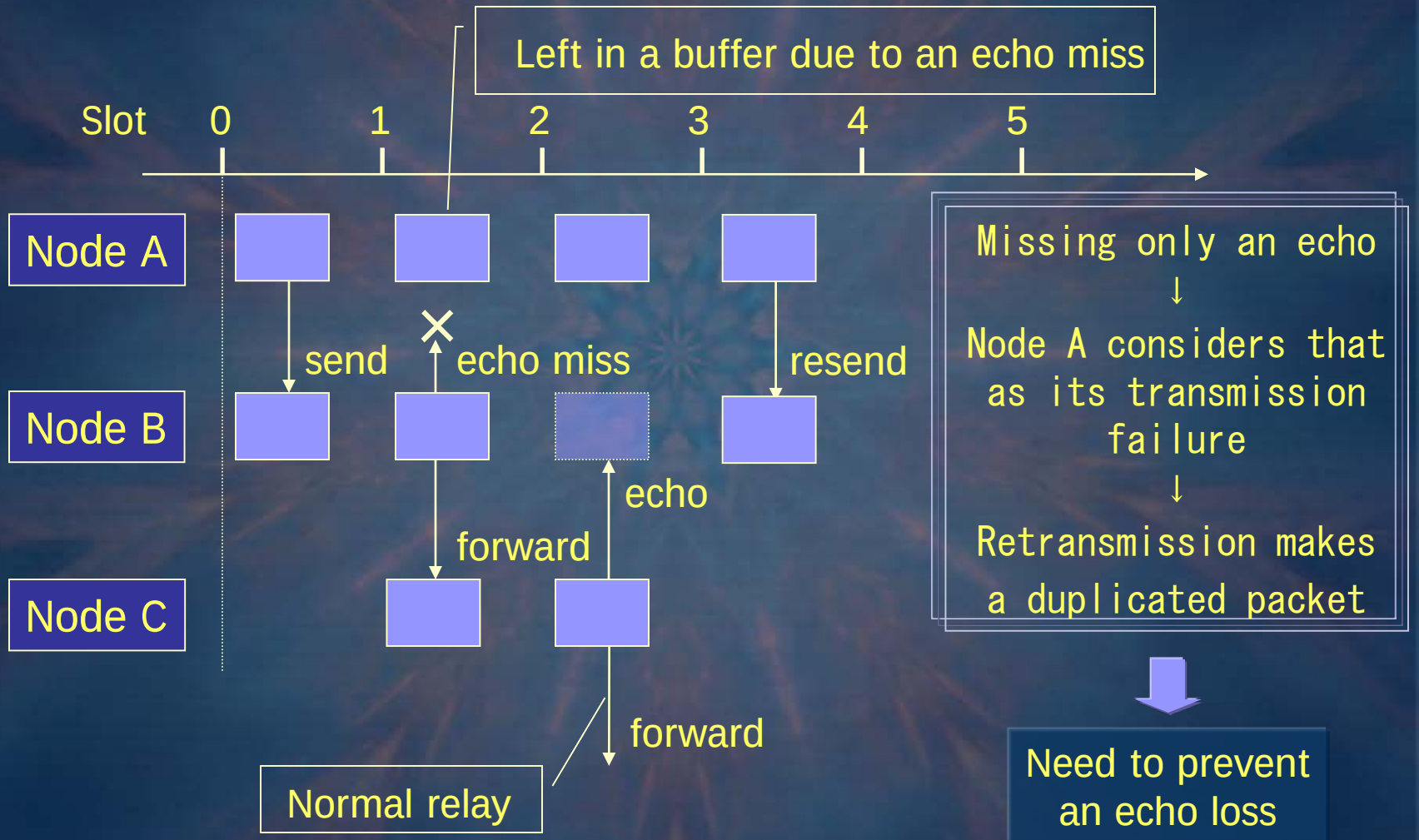

Missing only an echo
↓
Node A considers that as its transmission failure
↓
Retransmission makes a duplicated packet

Need to prevent an echo loss

Policy of Suggestions

- Packet duplication is caused by an echo loss
  - Nodes cannot differentiate a transmission failure and the echo loss
- Focus on the echo loss due to packet collisions
  - Preventing packet collisions leads to decreasing the number of duplicated packets
  - Synergy effect for packet collisions and packet duplications improves the performance

Suggestions

1. Random delay time before packet retransmission

   to reduce the probability of continuous echo loss caused by the retransmission feature

2. Drop a packet that lacks lifetime to reach its destination

   to prevent network congestion and packet collisions

Detail of Suggestion 1

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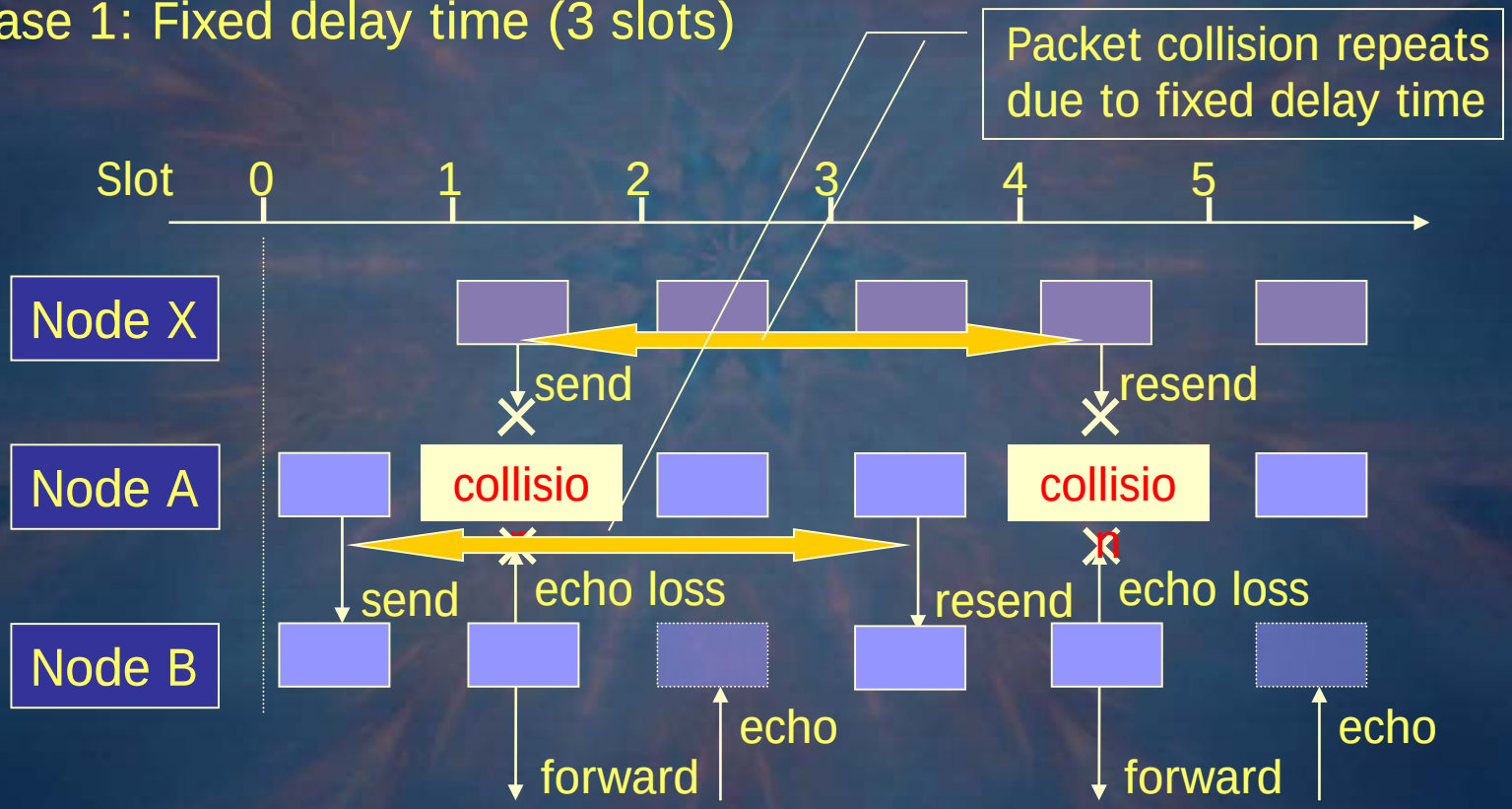
1. Random delay time before packet retransmission

Case 1: Fixed delay time (3 slots)



Detail of Suggestion 1

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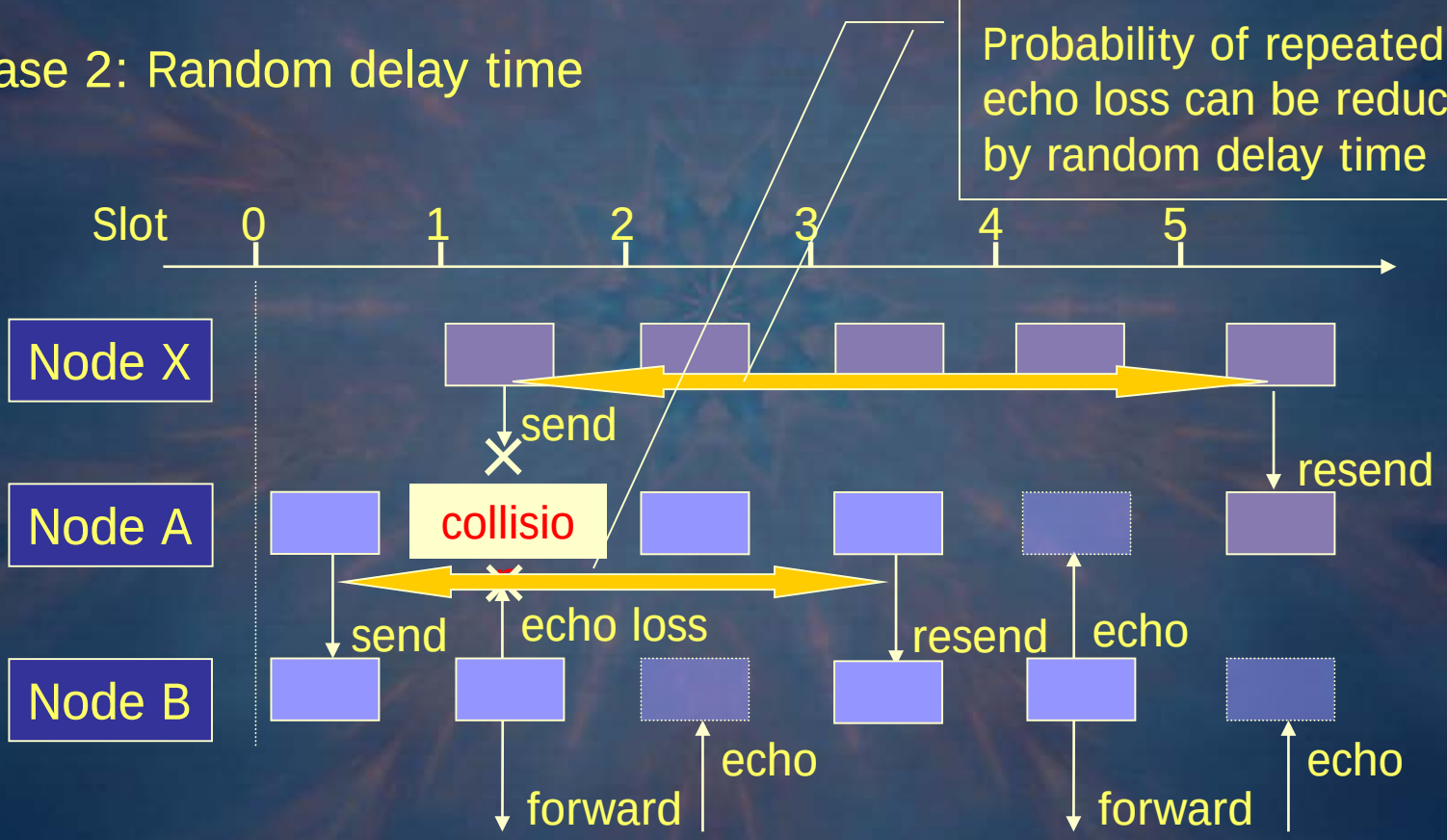
1. Random delay time before packet retransmission

Case 2: Random delay time

Probability of repeated echo loss can be reduced by random delay time



Detail of Suggestion 2

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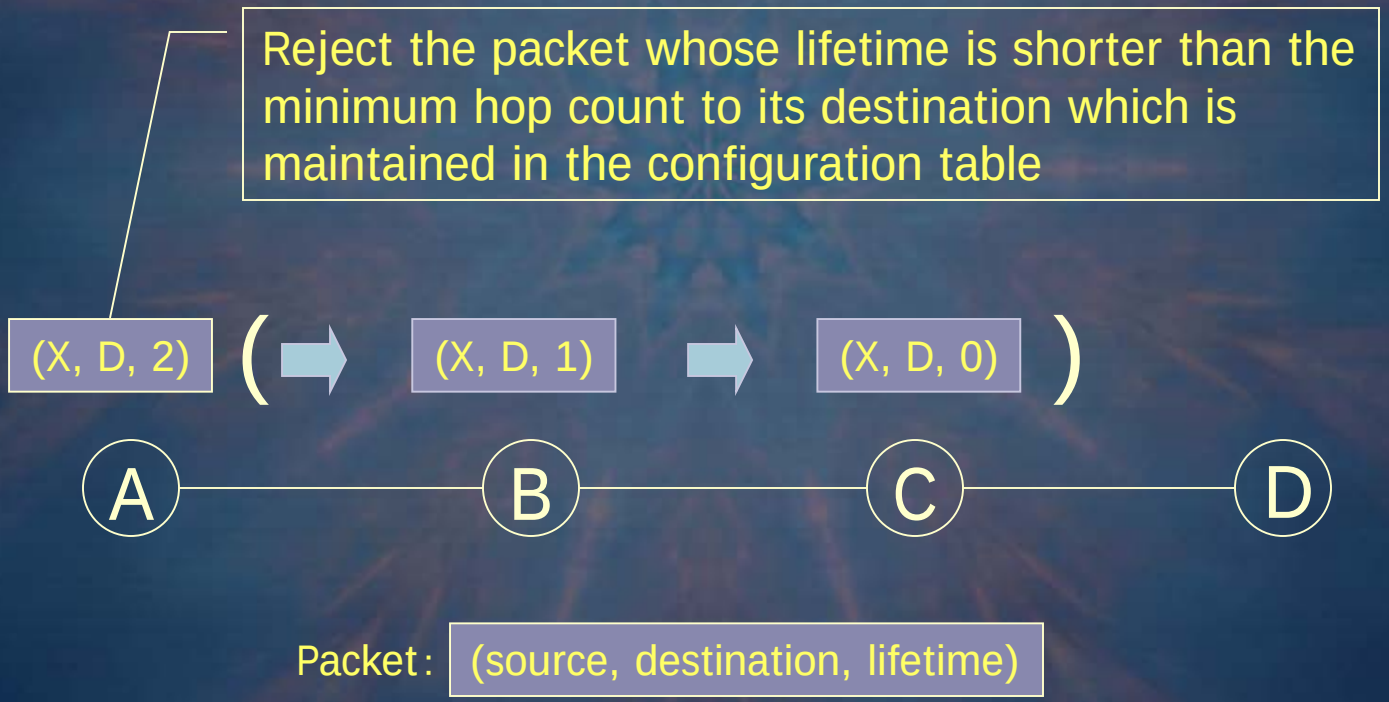
2. Drop a packet that lacks lifetime to reach its destination



Packet: (source, destination, lifetime)

Simulation Environment

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- The Network Simulator - ns-2
- Random node allocation with three packet generating nodes shown in the below figure
- Performance measures are
  - throughput
  - packet loss rate (PLR)
  - duplication rate

Simulation Environment

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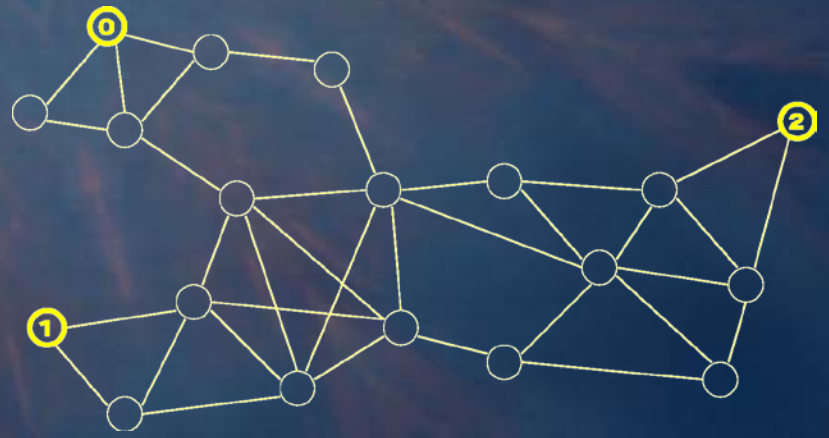
- Two kinds of the maximum lifetime, 8 and 128
  - See the relationship between the maximum lifetime and each suggestion
- Compared systems under these lifetimes are
  - the original system
  - the systems with each improvement
  - the system with both improvements



Throughput

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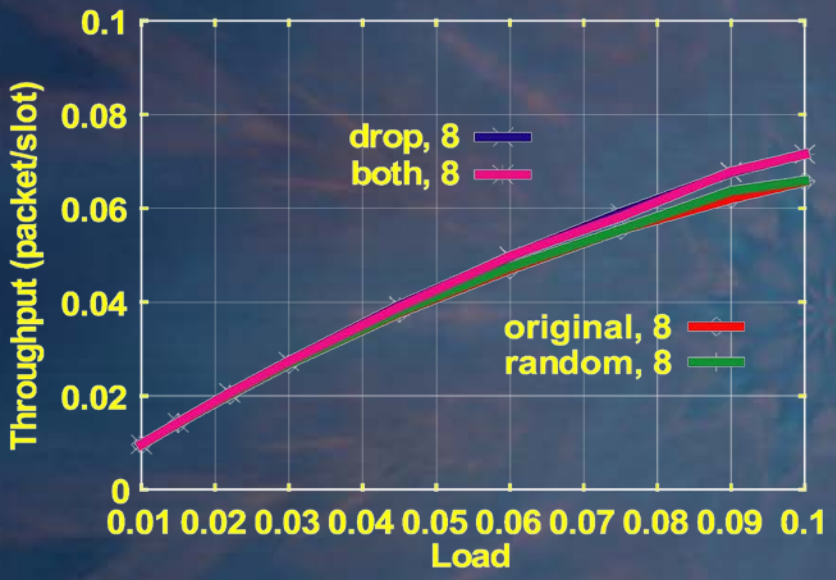
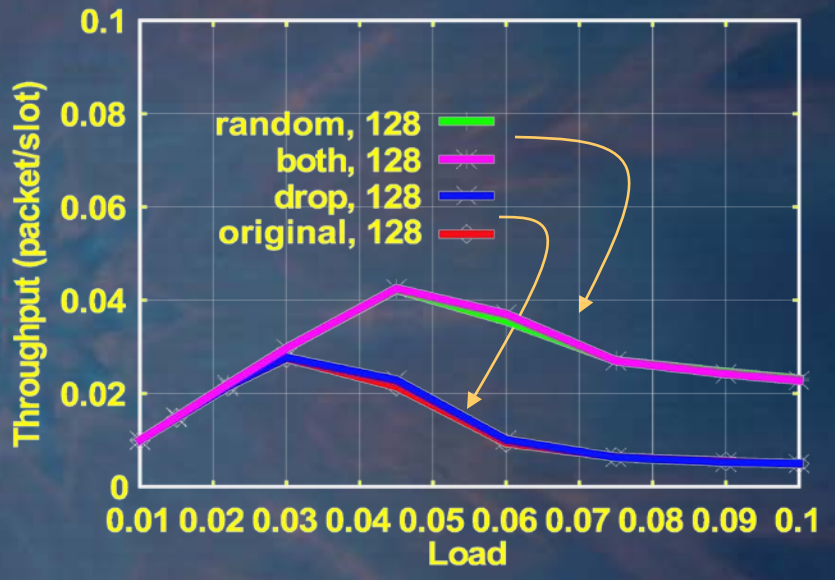
Maximum lifetime is 8



Maximum lifetime is 128



Explanation of labels

original・・・original system
random・・・only suggestion 1
drop・・・only suggestion 2
both・・・both suggestions

Throughput improvements

	lifetime 8	lifetime 128
random	ineffective	much effective
drop	a little effective	ineffective
both	a little effective	much effective

Packet Loss Rate (PLR)

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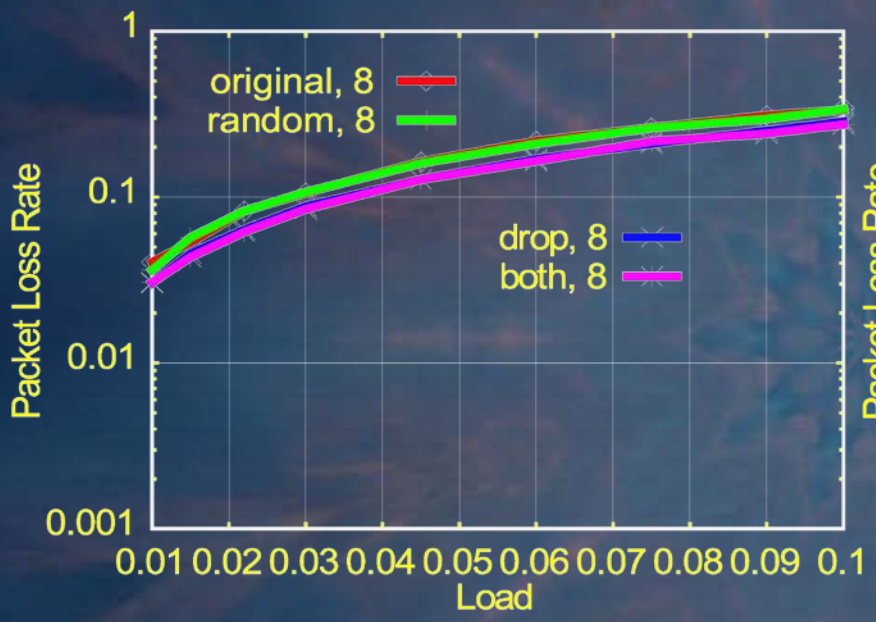
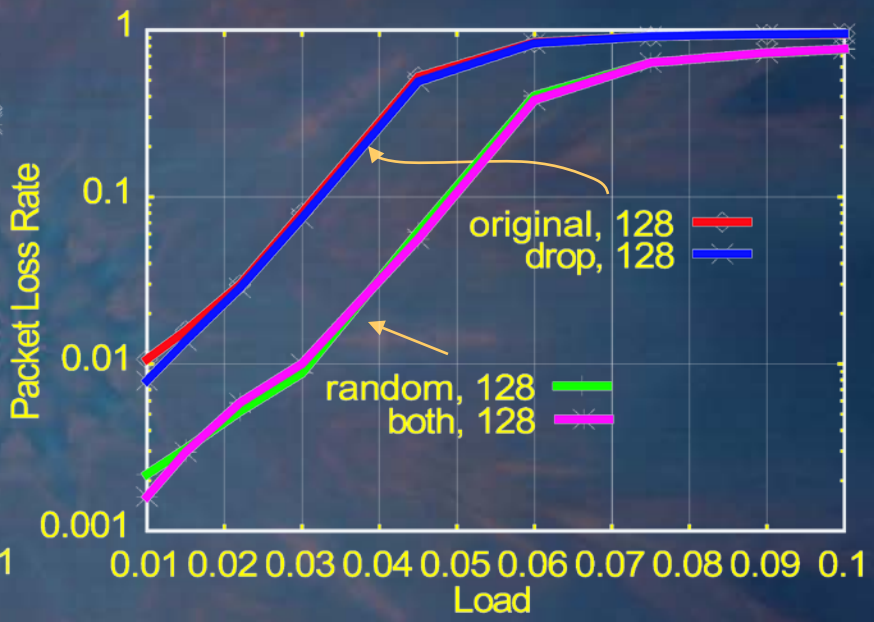
Maximum lifetime is 8



Maximum lifetime is 128



Explanation of labels

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random・・・only suggestion 1
drop・・・only suggestion 2
both・・・both suggestions

PLR degradation

	lifetime 8	lifetime 128
random	ineffective	much effective
drop	a little effective	ineffective
both	a little effective	much effective

Duplication Rate

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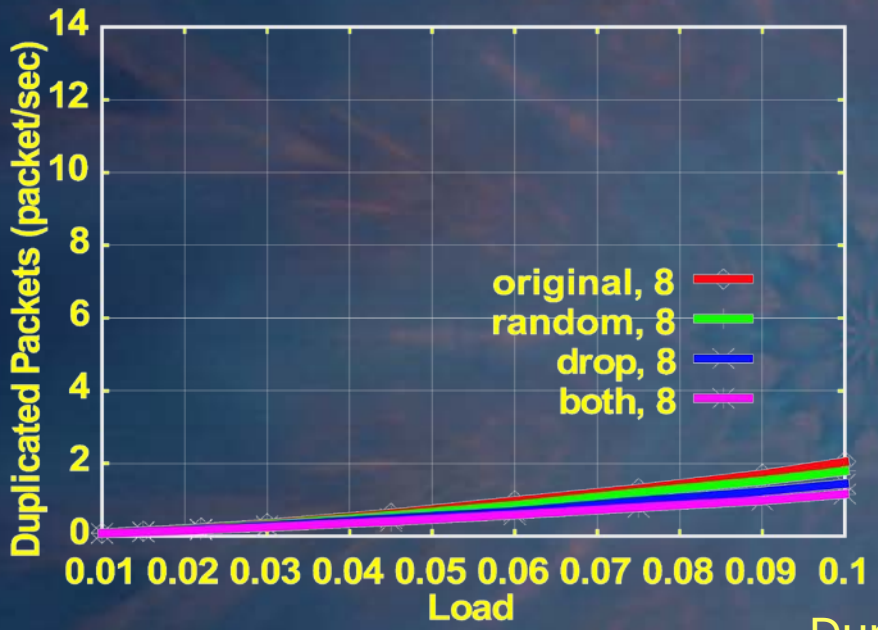
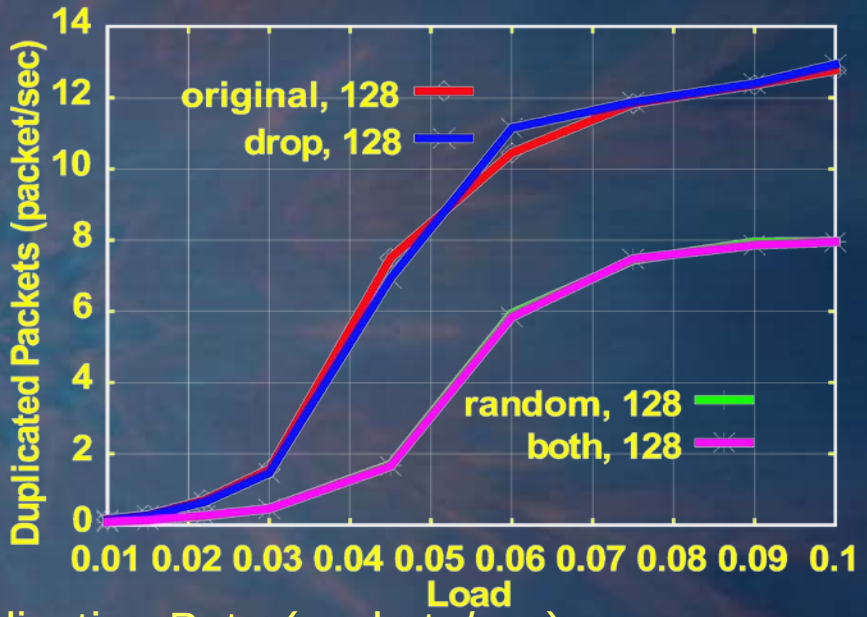
Maximum lifetime is 8



Maximum lifetime is 128



Explanation of labels

original・・・original system
random・・・only suggestion 1
drop・・・only suggestion 2
both・・・both suggestions

Duplication Rate (packets/sec)

	lifetime 8	lifetime 128
random	ineffective	much effective
drop	a little effective	ineffective
both	a little effective	much effective

Conclusion and Future Work

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- Our suggestions are capable to prevent an echo loss and a packet duplication
- The system with both improvements always shows the good performance regardless of the maximum lifetime value

- Future Works
  - Effective method to decide the maximum lifetime based on a route length
  - Another evaluation on a system with end-to-end upper layer protocol such as TCP