Performance Evaluation and Improvement of an Ad Hoc Wireless Network

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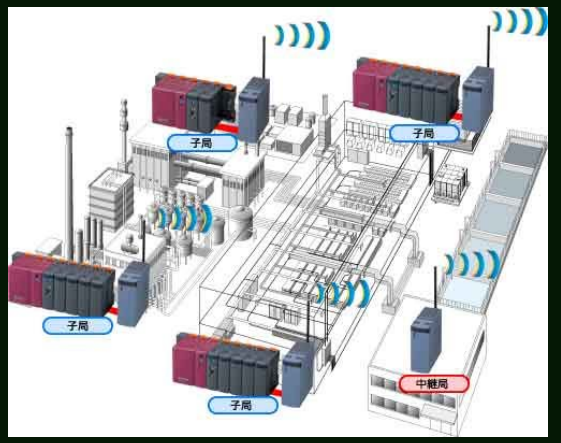
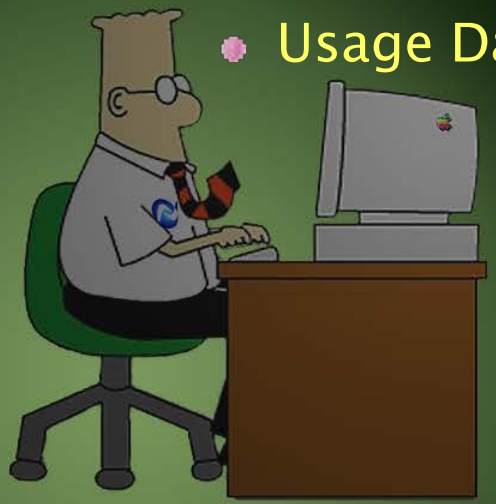
- Introduction of Target System
  - the Flexible Radio Network -
- Basic Network Performance for
  Some Different System Parameter Values
- Suggestions for Performance Improvement
- Conclusion

Flexible Radio Network

- Wireless Ad Hoc Network System developed by Fuji Electric Co. Ltd.
- Multi-hop Network organized by Stationary Terminals
- Application Examples
  - Power Consumption Collection in Manufacturing Plants
  - Sales Account Collection from Vending Machines
  - Usage Data Collection from Ski Lift Gates

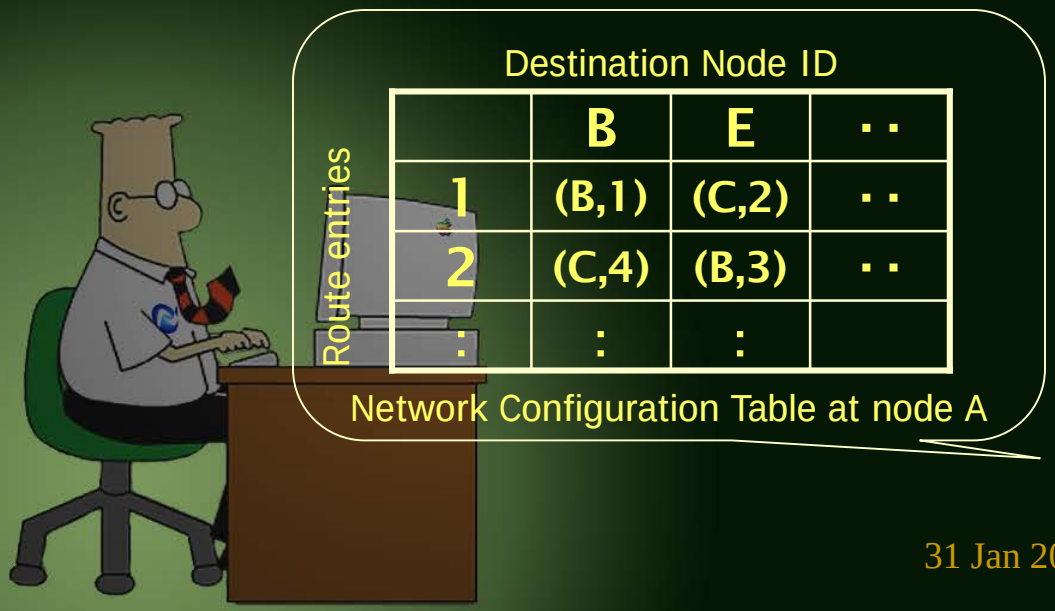


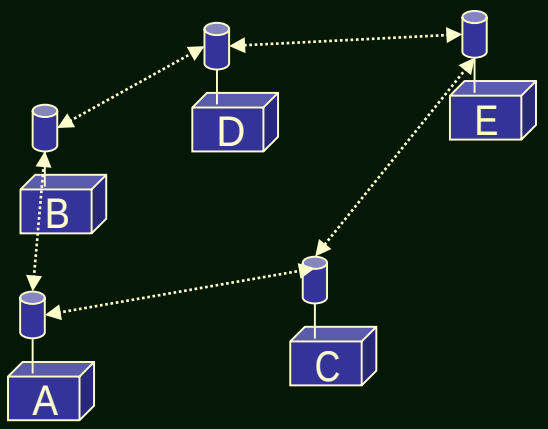


http://www.fujielectric.co.jp/eng/index.html

System Description

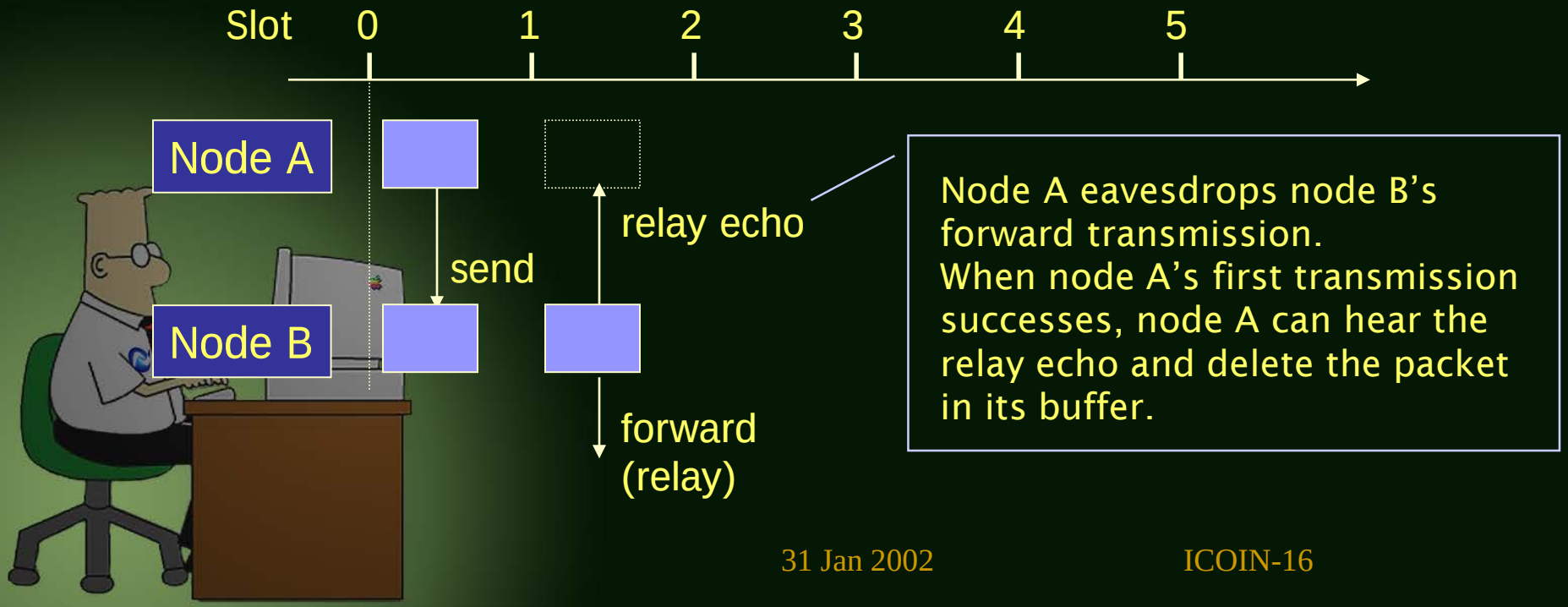
- Network Configuration Table
  - updated by Periodic Table Exchange
  - Each Node maintains Multiple Routes to All Nodes in the Same Network
  - Route Entry = (Neighbor ID, Hop Count)





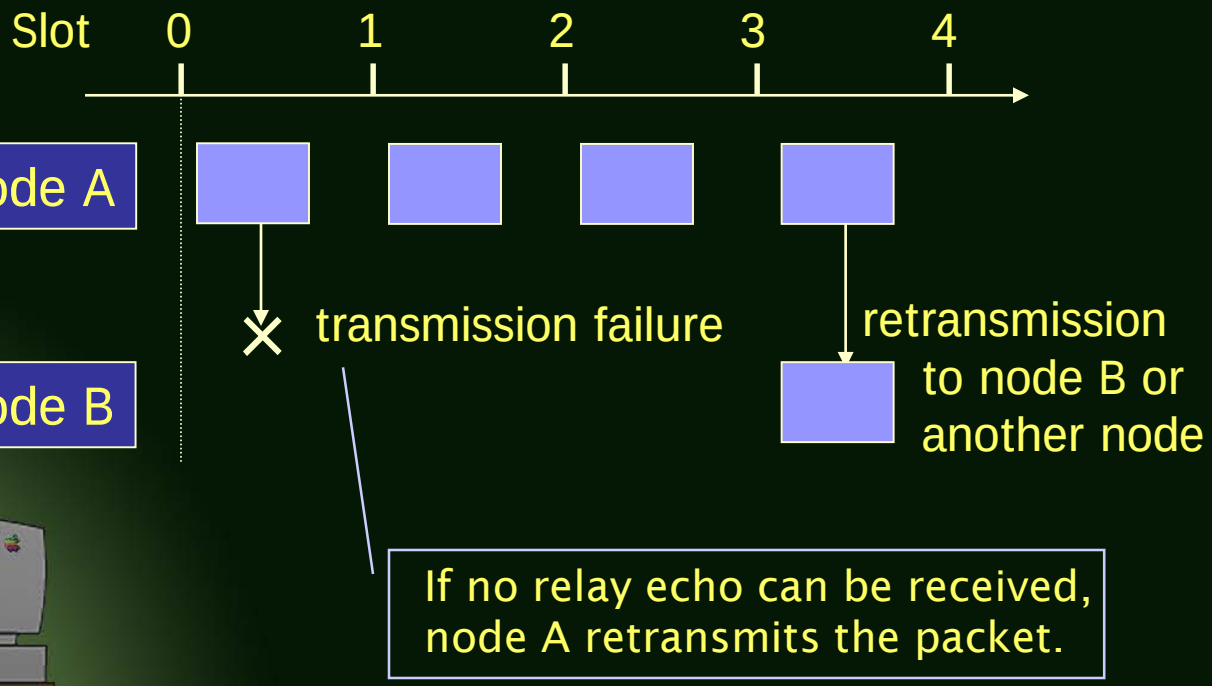
Protocol Description

- Time Division, Slot-based Transmission
  - Packet Maximum Lifetime set in a Source Node
    - decreased by one per slot even when it stays in a buffer
  - Hop-by-Hop Receipt Acknowledgement based on Relay Echo Mechanism



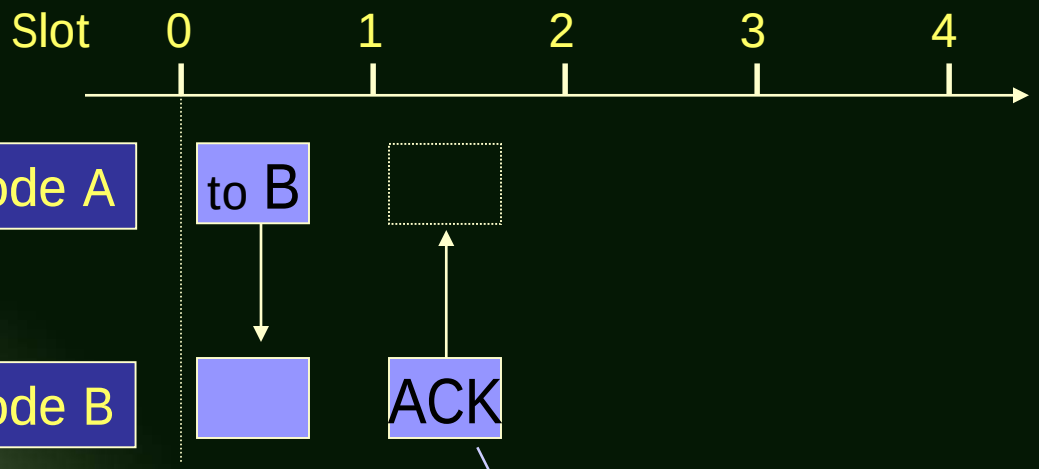
Protocol Description

- Retransmission Control



Protocol Description

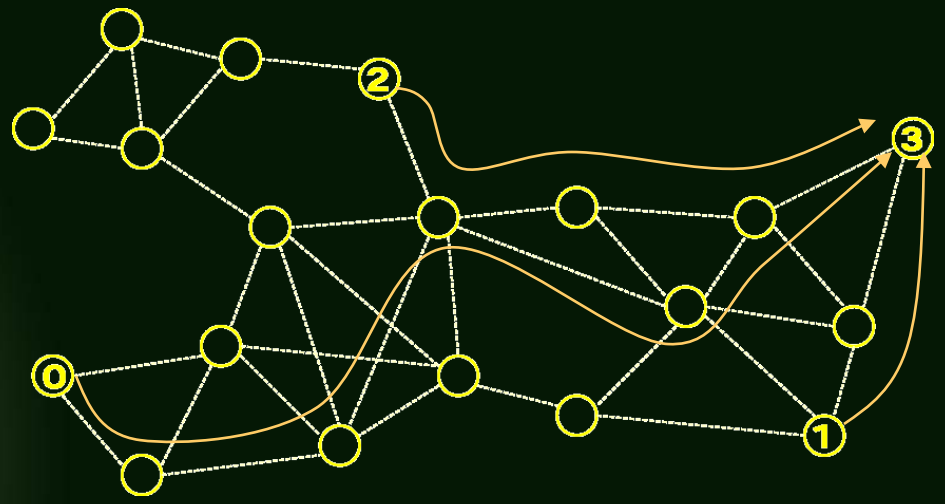
- ACK from Destination



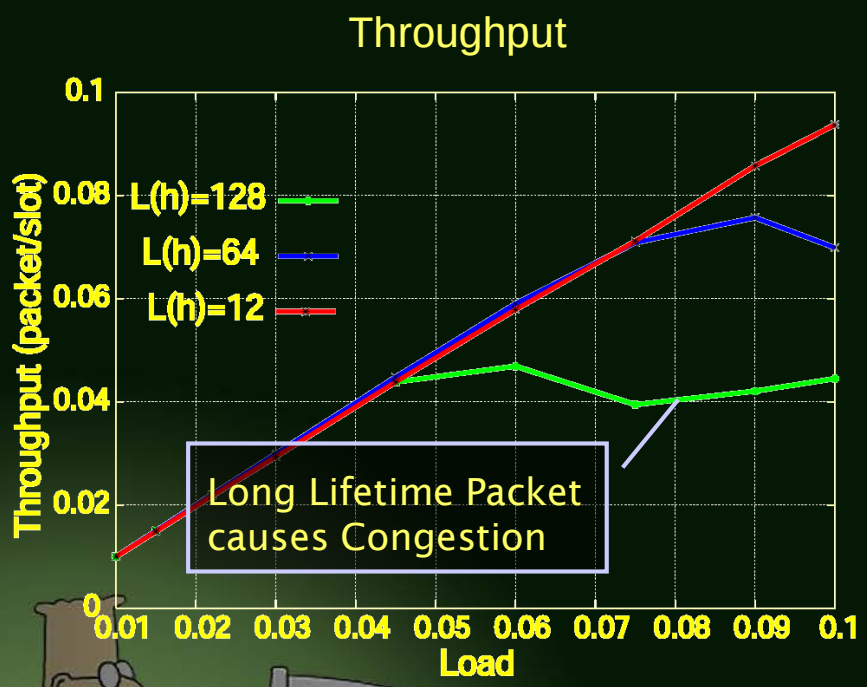
Destination Node returns an ACK packet by way of relay echo

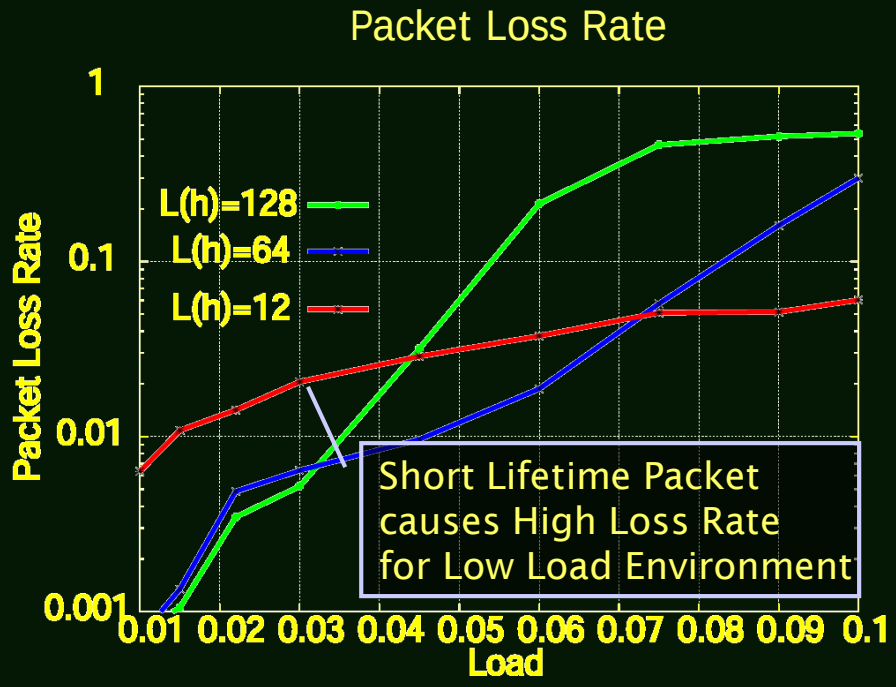
Simulation Description for Original System Evaluation

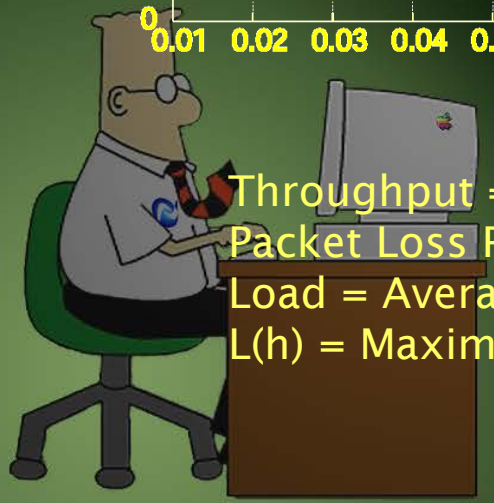
- Network Simulator - ns-2
  with our implementation of FRN
- Maximum Lifetime = 12, 64 and 128 (slots)
- Data Collection Network Model



Original System Evaluation







Throughput = Number of Packets received by the Destination per slot
Packet Loss Rate = Ratio of unreached Packets to the Destination
Load = Average Number of Packets produced per slot
L(h) = Maximum Lifetime (h is described later)

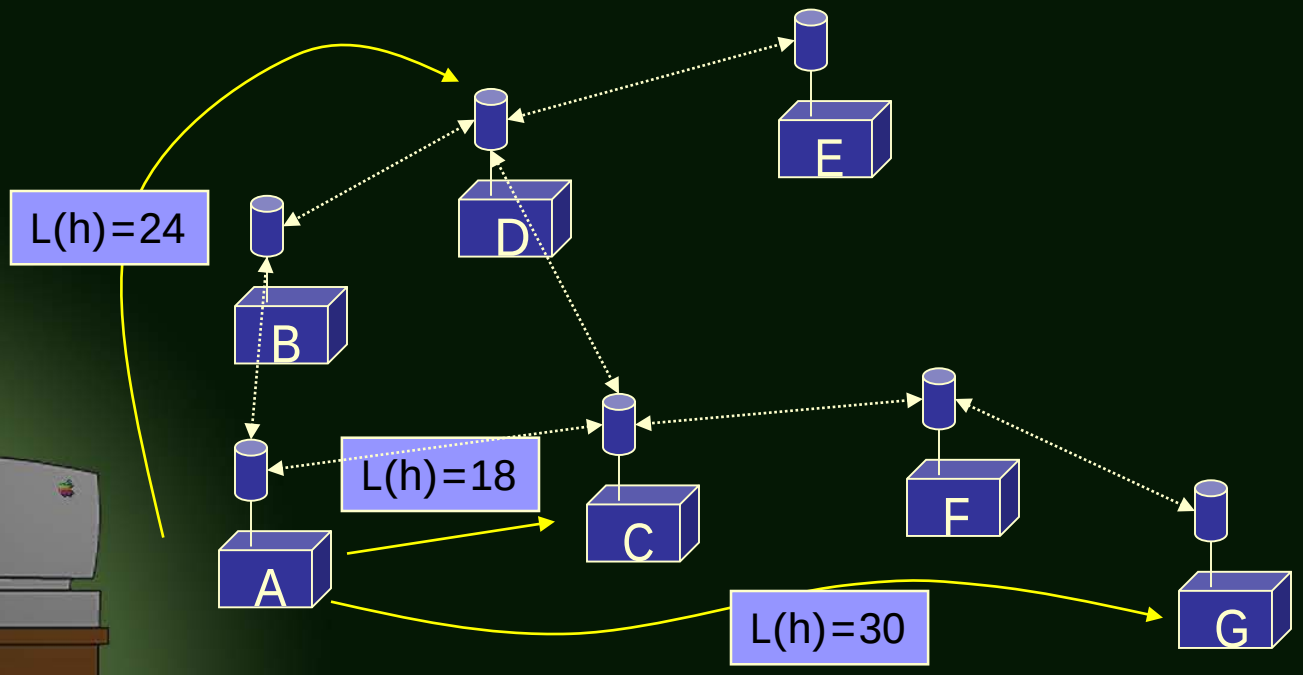
Performance Improvement

- Adaptive Maximum Lifetime
  - Source Node calculates the Maximum Lifetime for Each Packet according to the shortest Hop Count to its Destination
- Methods to Prevent Packet Collision leads to Packet Duplication
  - Random Wait for Retransmission
  - Packet Rejection earlier than its Lifetime expires

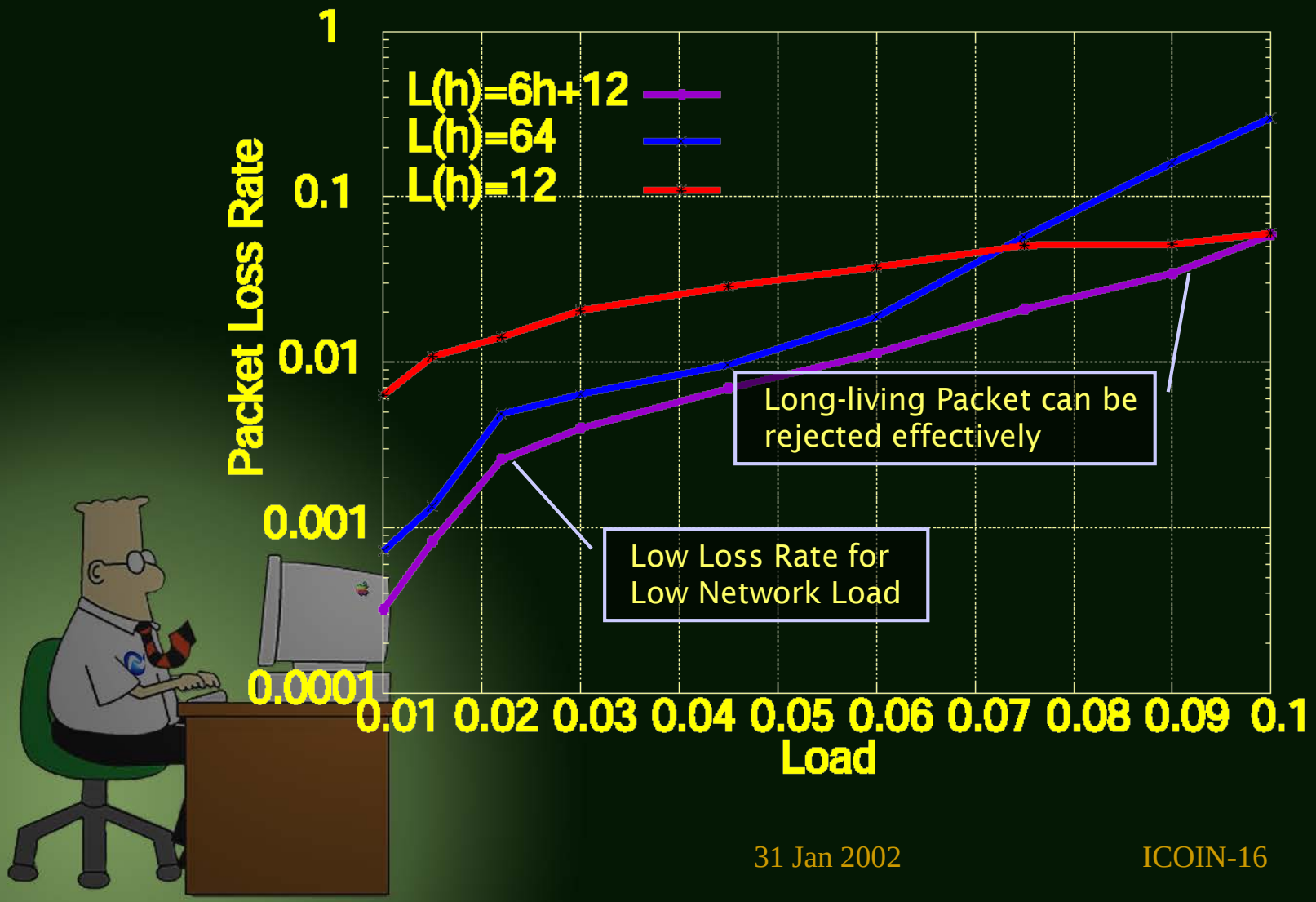
Adaptive Maximum Lifetime

Example Function: L(h) = 6h+12

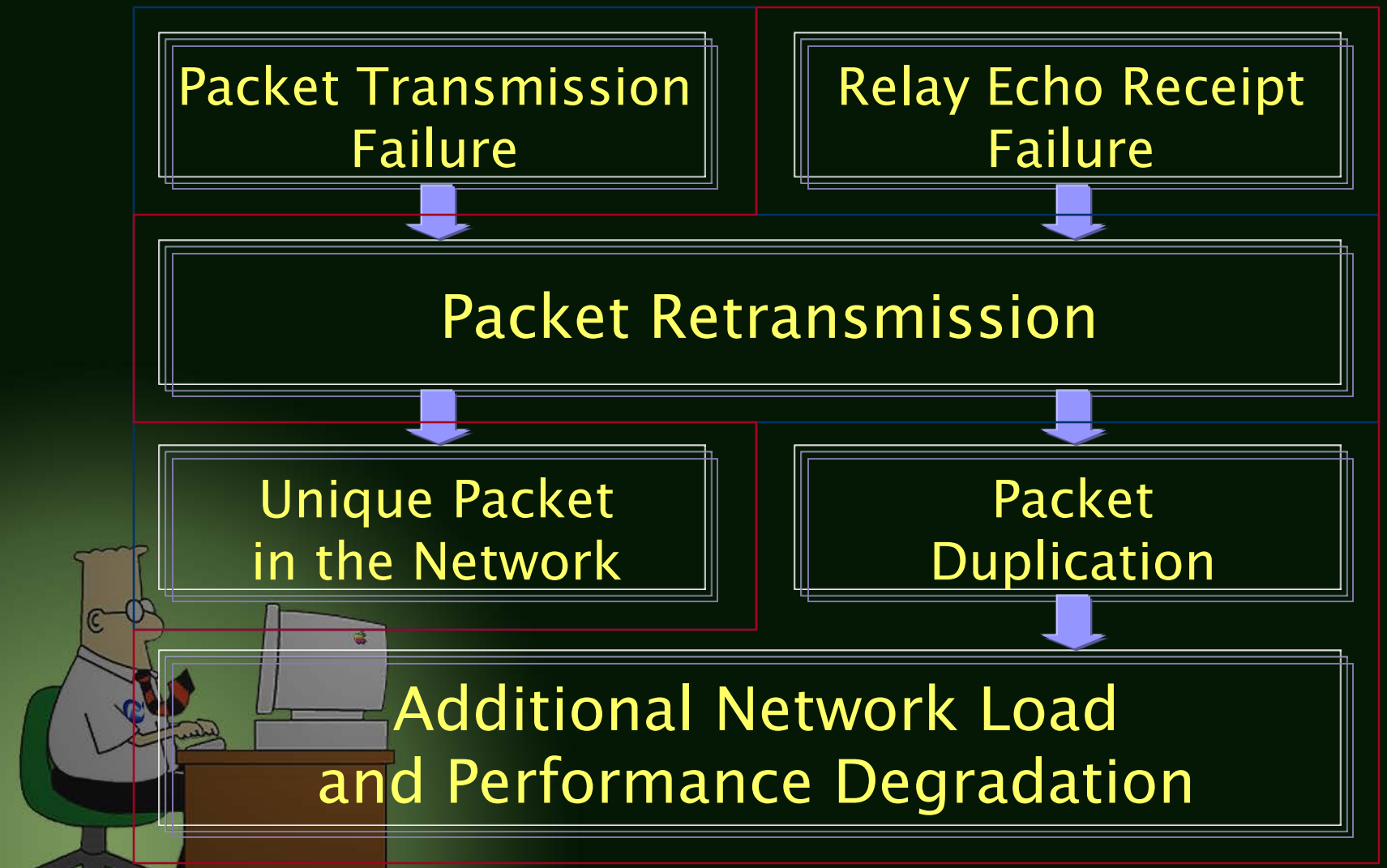
(h is Hop Count of the shortest route)



Adaptive Maximum Lifetime

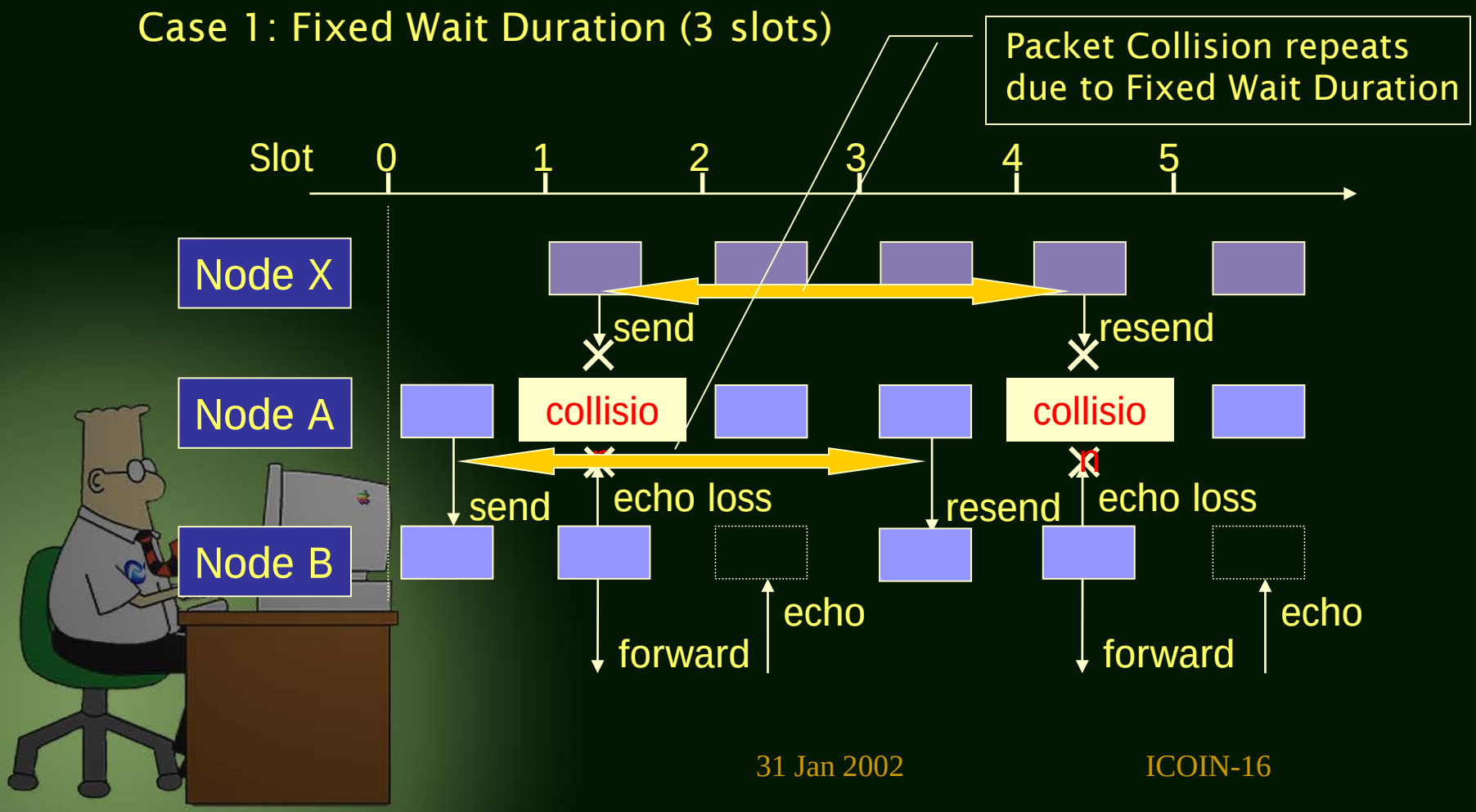


Packet Duplication Problem



Random Wait for Retransmission

- Reduction of Packet Duplication Repeat



Random Wait for Retransmission

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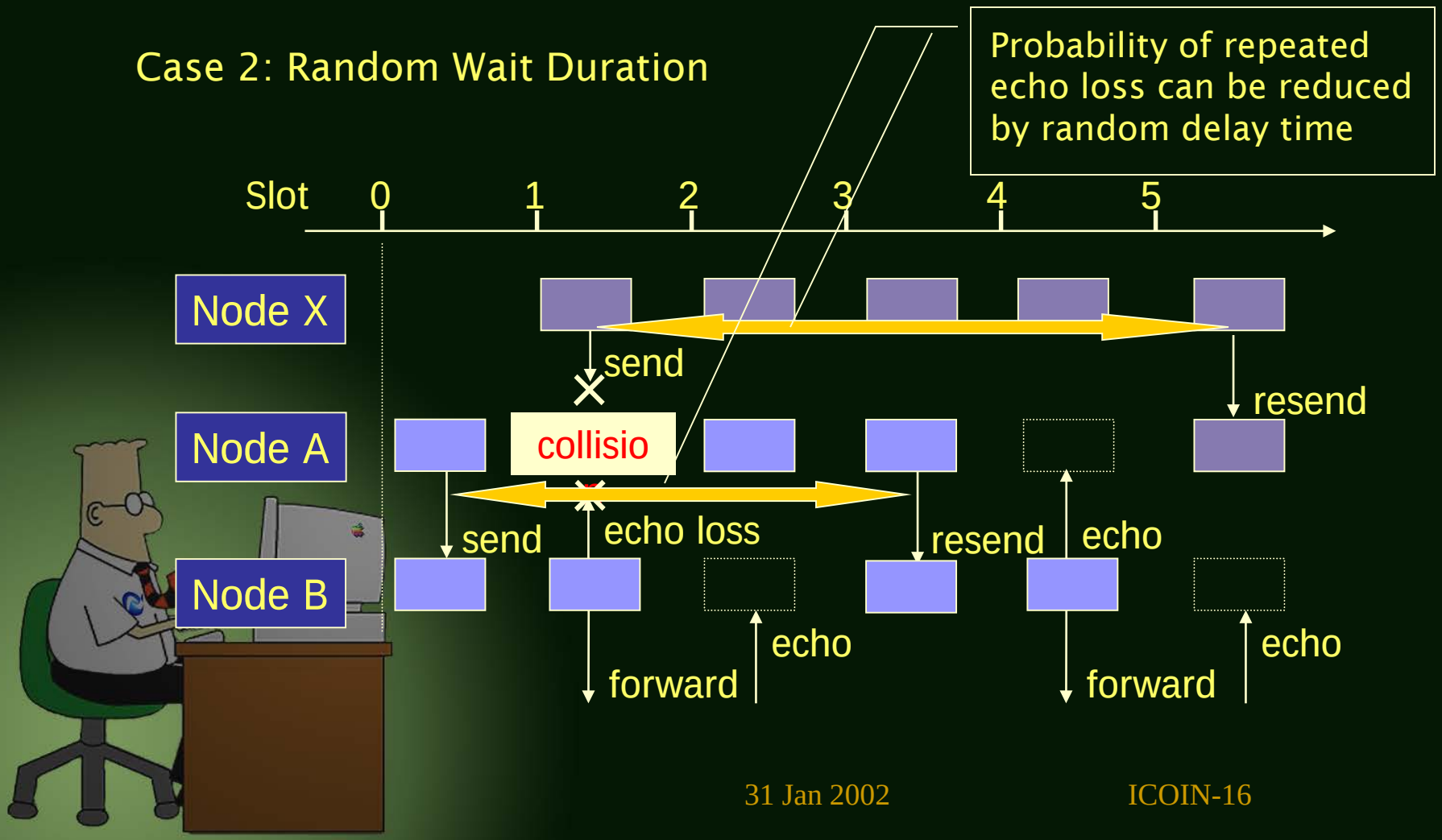
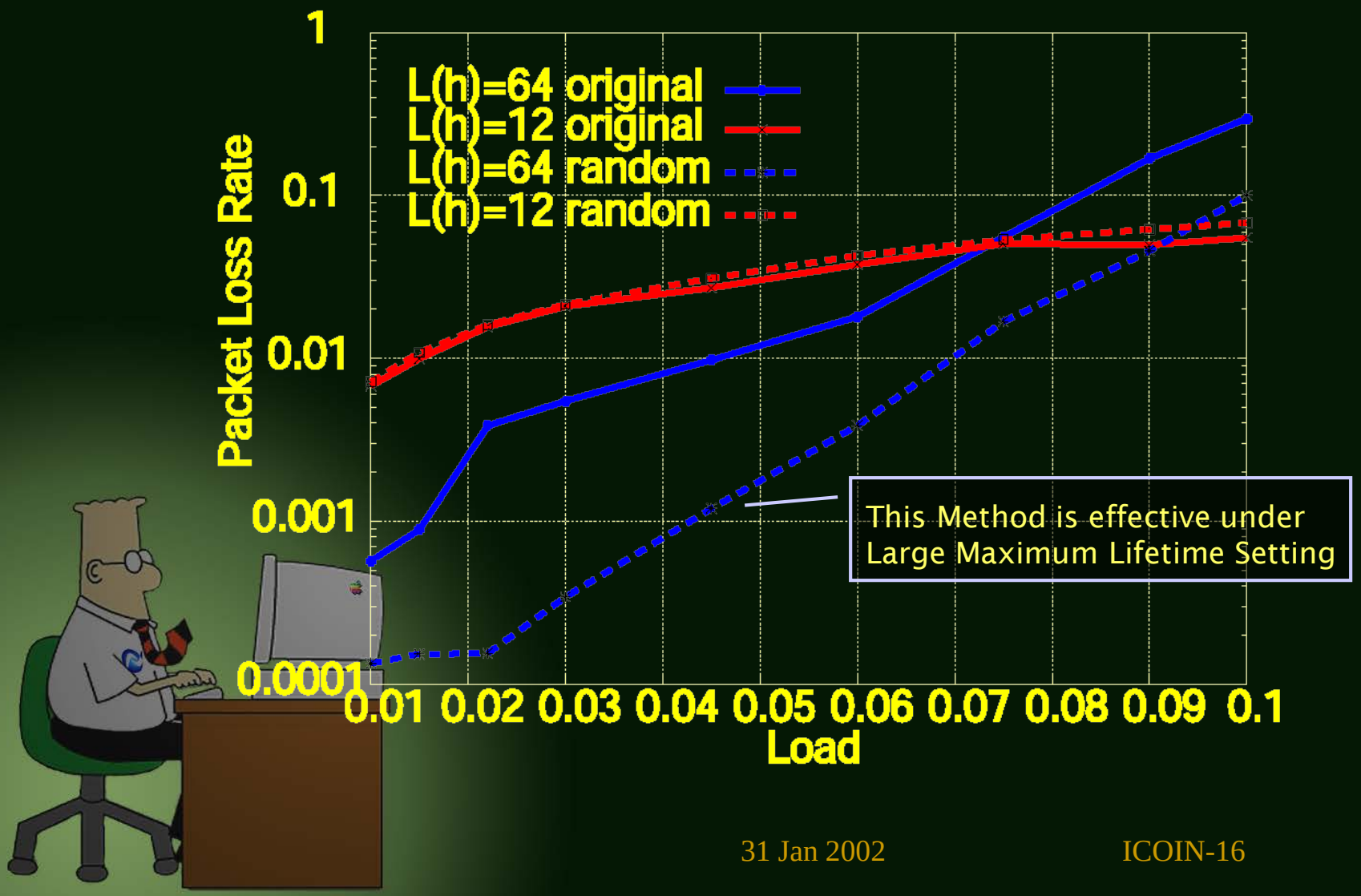
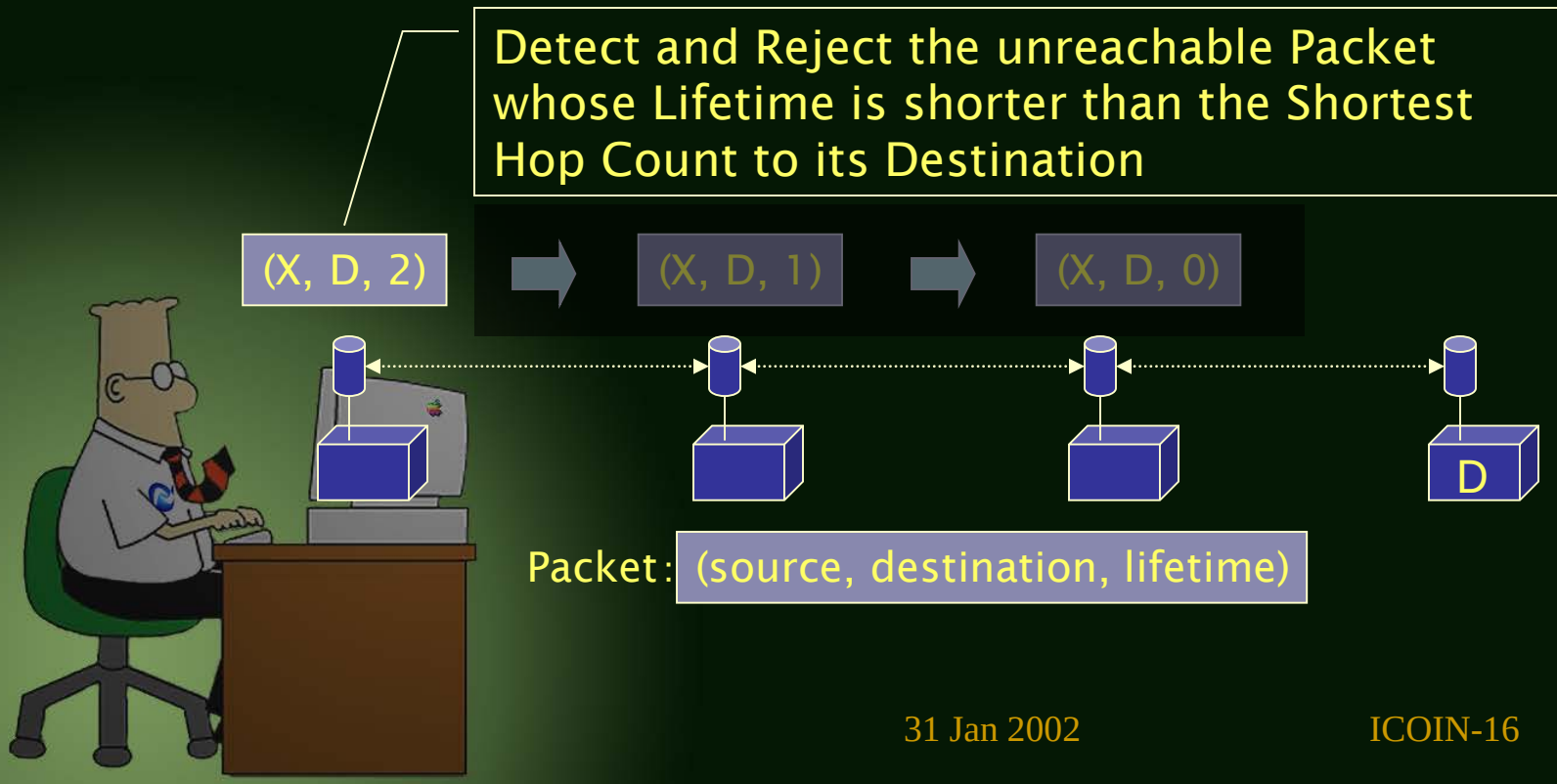


Random Wait for Retransmission

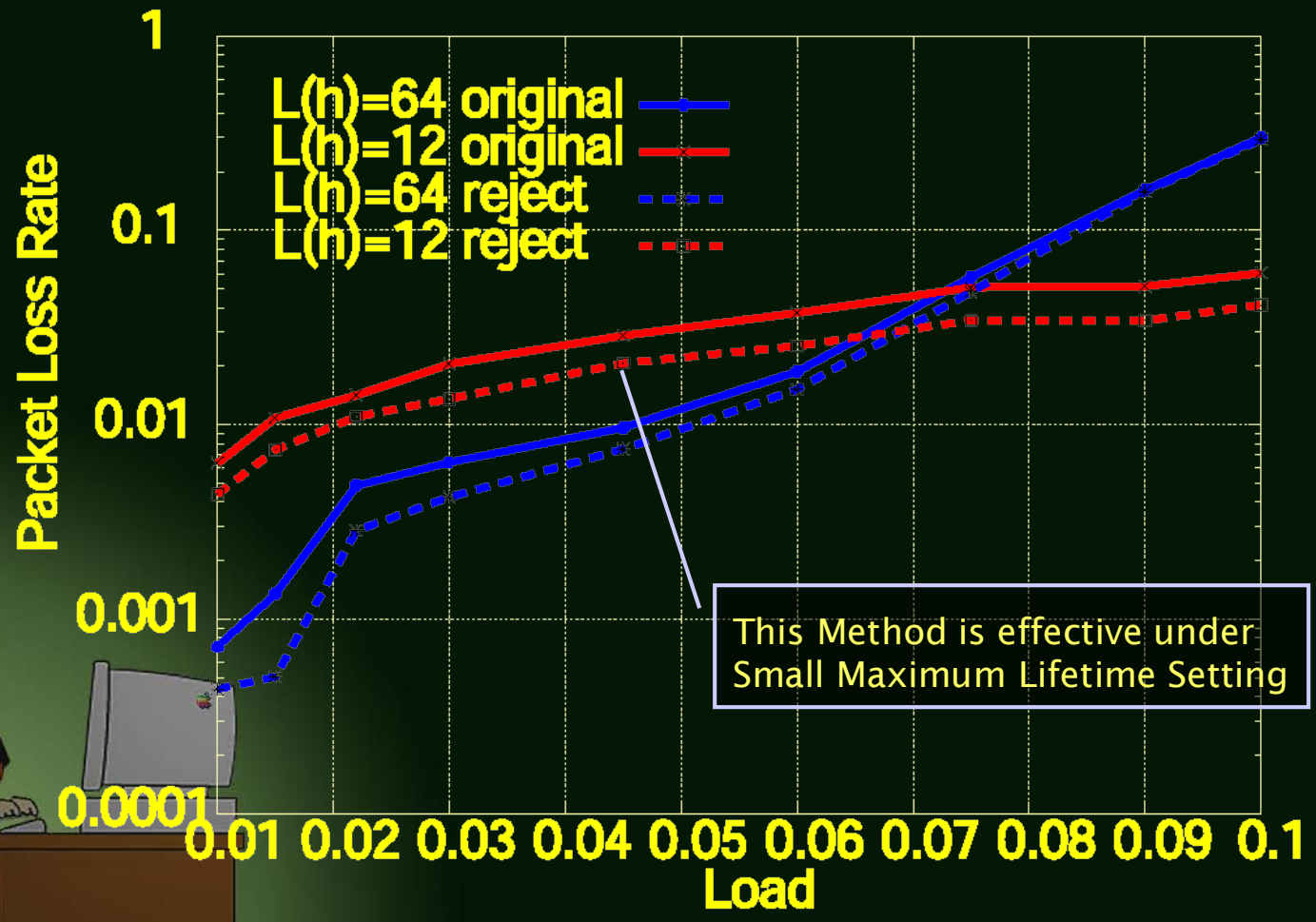


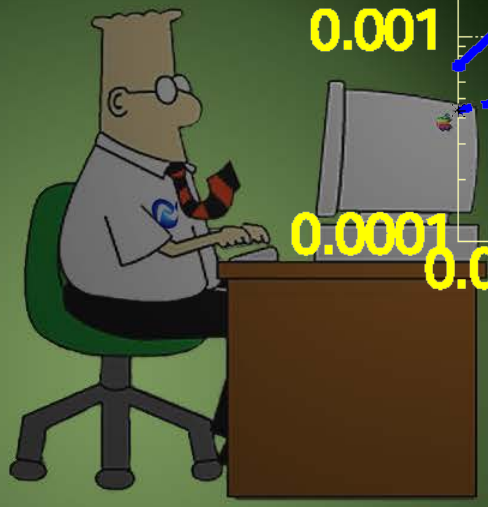
Early Packet Rejection

- Packet Rejection earlier than its Lifetime reaches Zero
  - Unreachable Packets cause Useless Collisions

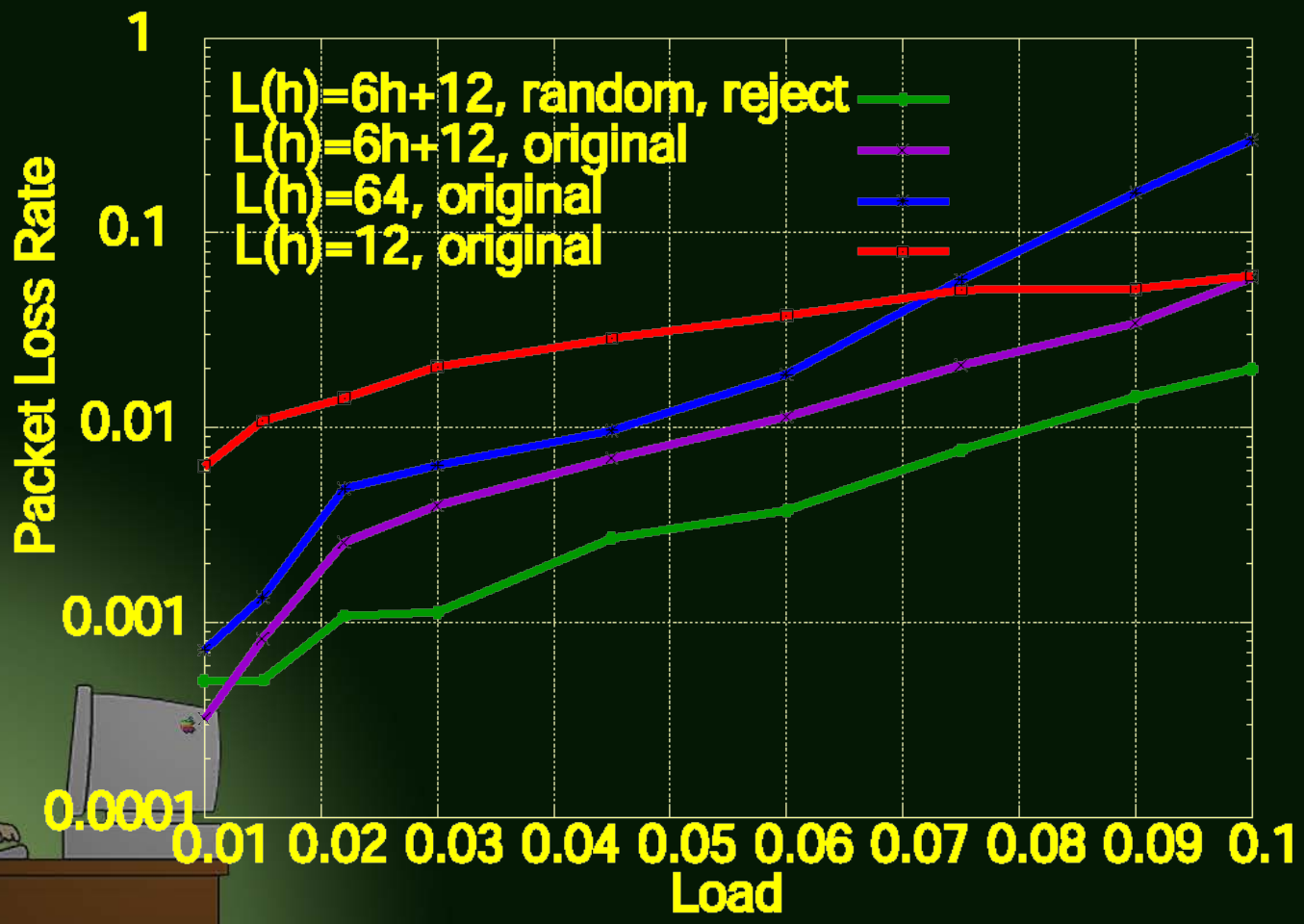


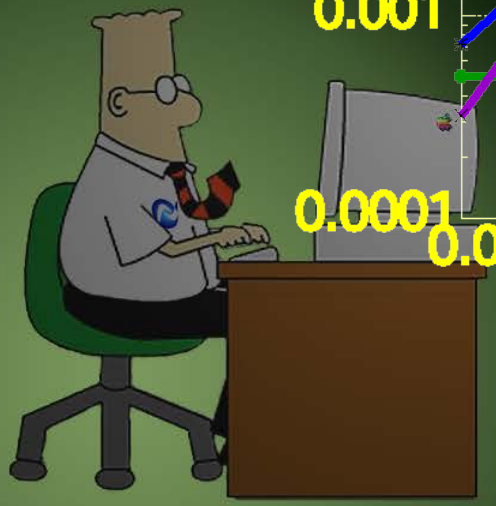
Early Packet Rejection





PLR for All Methods Together





Conclusion and Future Work

- Flexible Radio Network (FRN) system
  - Relay Echo Mechanism, Multiple Route Maintenance for Reliability
    - Maximum Lifetime Calculation with Route Length is capable of increasing Network Reliability
  - Packet Duplication caused by Relay Echo and Retransmission Mechanism
    - Relationship between Maximum Lifetime Setting and Effect of Random Wait Duration, Early Packet Rejection
    - Much Better Performance is achieved by applying All Methods Together
- Future Works
  - Evaluation for End-to-End Protocol on FRN
  - Implementation into actual FRN Terminals