RTMC: Reliable Transport with Memory Consideration in Wireless Sensor Networks

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Outline

- **Background**
- **Reliable Transport with Memory Consideration**
- **Experiments**
- **Simulation and Comparison**

Wireless sensor networks

- Wireless sensor networks (WSN) consist of many resource constrained sensor nodes with limited computational capability, communication radius and memory space.
- The availability of low-cost hardware such as CMOS cameras and microphones enables sensor nodes to capture images or audio from environment, and increases the requirement of reliable file transport.
  - Image
  - Audio
  - Video

Problems and Challenges

- Requirement: the files to be transmitted generally divided into multiple segments to avoid high packet error rate.
- Problem: How to send all the multiple segments from a source to the sink via multiple unreliable hops?
- Challenges
  - unreliable links in WSN and conflict in transmissions from different nodes may cause packet loss
  - limited memory of relay sensor nodes with possible overflow may also cause packets loss.

Existing Methods

① Node-by-node: One relay node receives all the segments and then re-transmit all the segments to the next hop.
- Possible large delivery latency
- Significant memory requirement

② TCP is widely used to provide end-to-end reliability and congestion control in Internet.
- End-to-end retransmission is not appropriate in wireless systems with high packet-loss rate.
- End-to-end congestion control may have a tardy response and cannot adapt to the rapid change of channel capacity in WSN.
- Control Messages may lost.

A reliable transport protocol:

- A reliable transport protocol in WSN should
  - hop-by-hop retransmission
  - hop-by-hop congestion control
  - 100% reliability (some segments may very important)
  - make good use of bandwidth

- Reliable Transport with Memory Consideration (RTMC)

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RTMC

- Basic Ideas:
  - If the local node knows that its next hop can store m extra segments, then it can send m segments without any negotiations.
  - If the local node does not know whether one segment is received by the next hop, it can not remove this segment.

- Variable Definition
  - segment_length : the number of segments to transport
  - BL▲ :maximal number of segments (small integer)
  - local_free :extra segments can be stored in the local node
  - next_free :extra segments can be stored in the next hop
  - rec_segments : the IDs of the received last BL segments

RTMC

- Packets:
  - Initial Packet: **I**

    Ask the next hop to participate into the current transport.

    local_free, rec_segments, segment_length
  - Data Packet: **1** **2** …

    Send a segment to the next hop

    local_free, rec_segments, segment_id, content
  - Requiring Packet: **R**

    Ask the last hop to send a data packet.

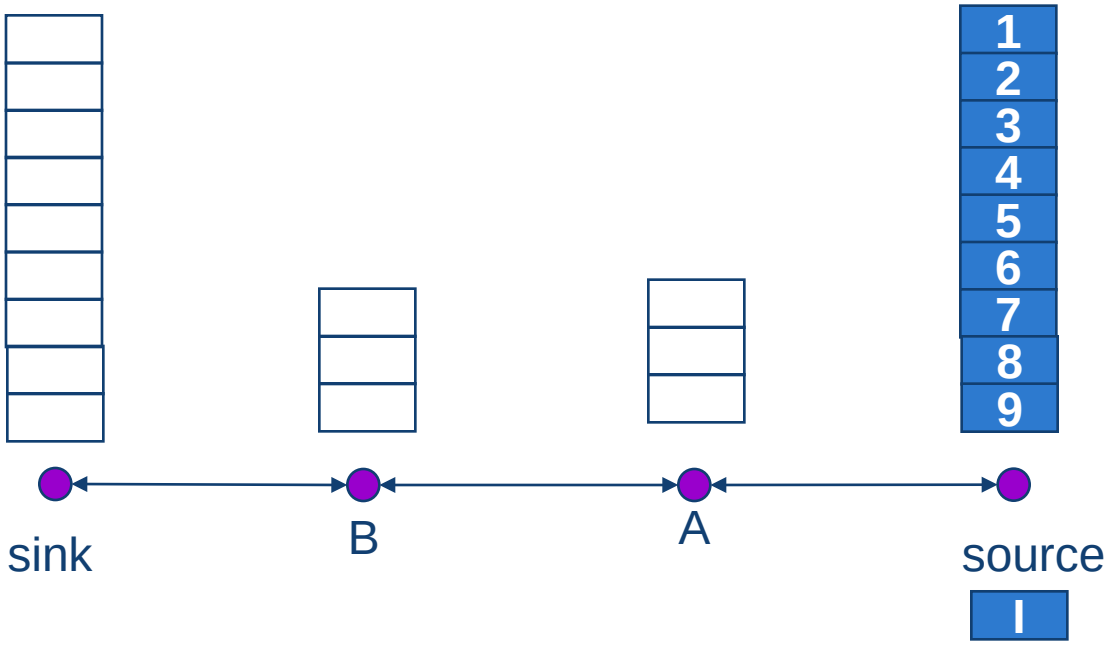
    local_free, rec_segments

RTMC

- An instance to demonstrate that how RTMC works.
  - BL=3
  - segment_length=9
  - hops =3

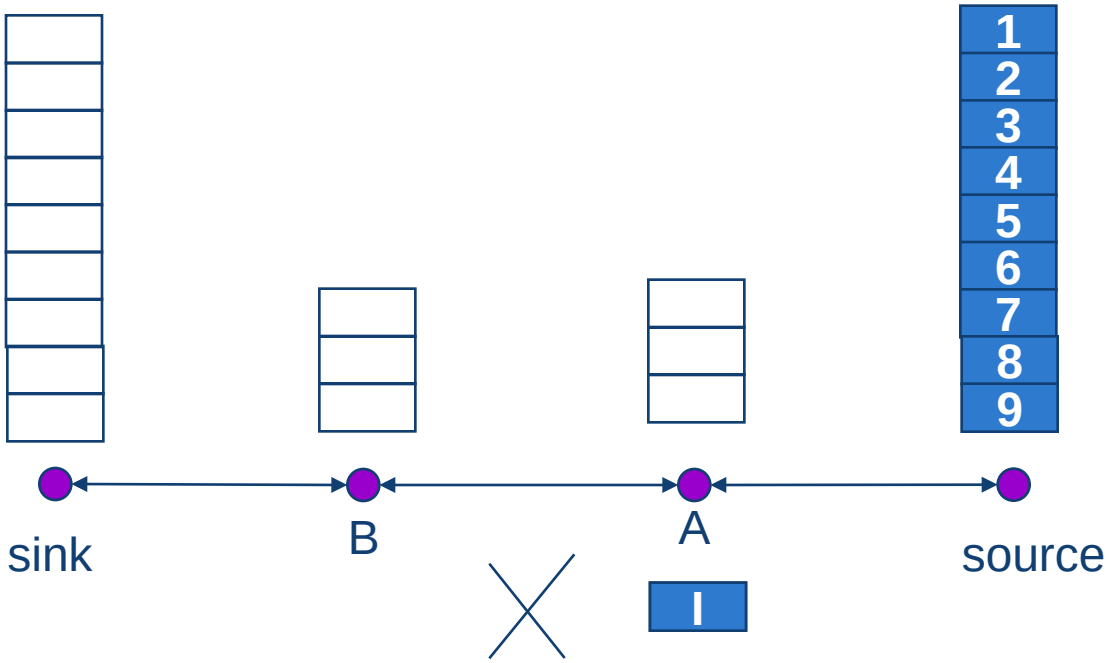
Example by RTMC

- Beginning
  - Send initial packets



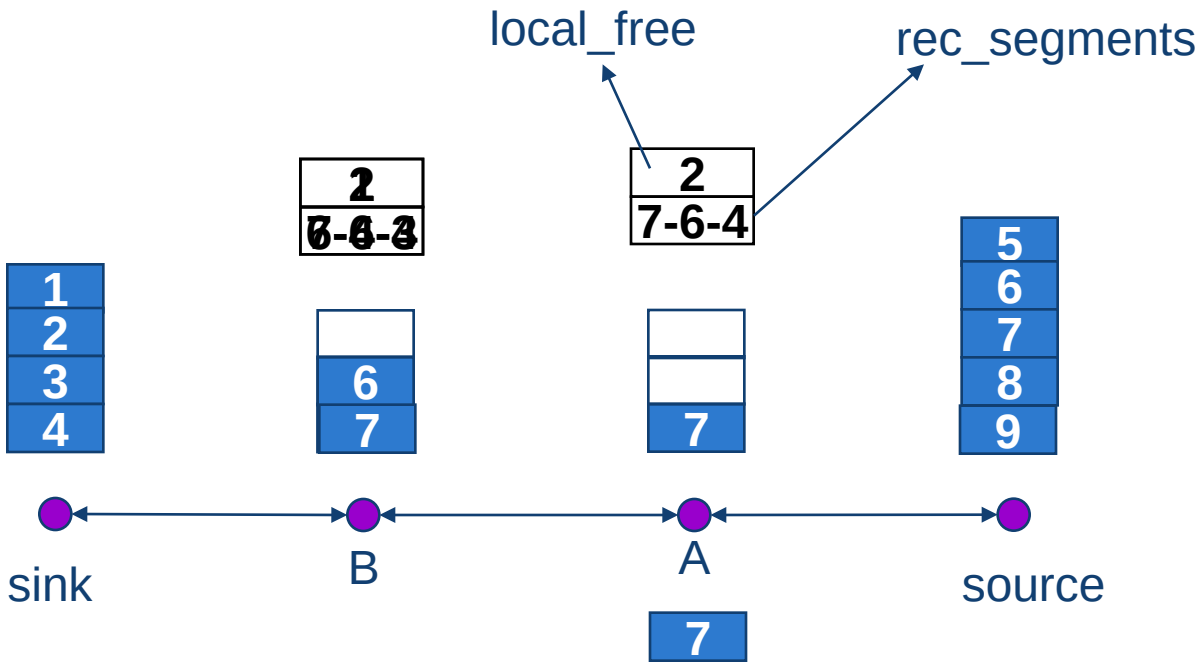
RTMC instance

- Beginning
  - If A does not receive any response from B, an initial message should be retransmitted.



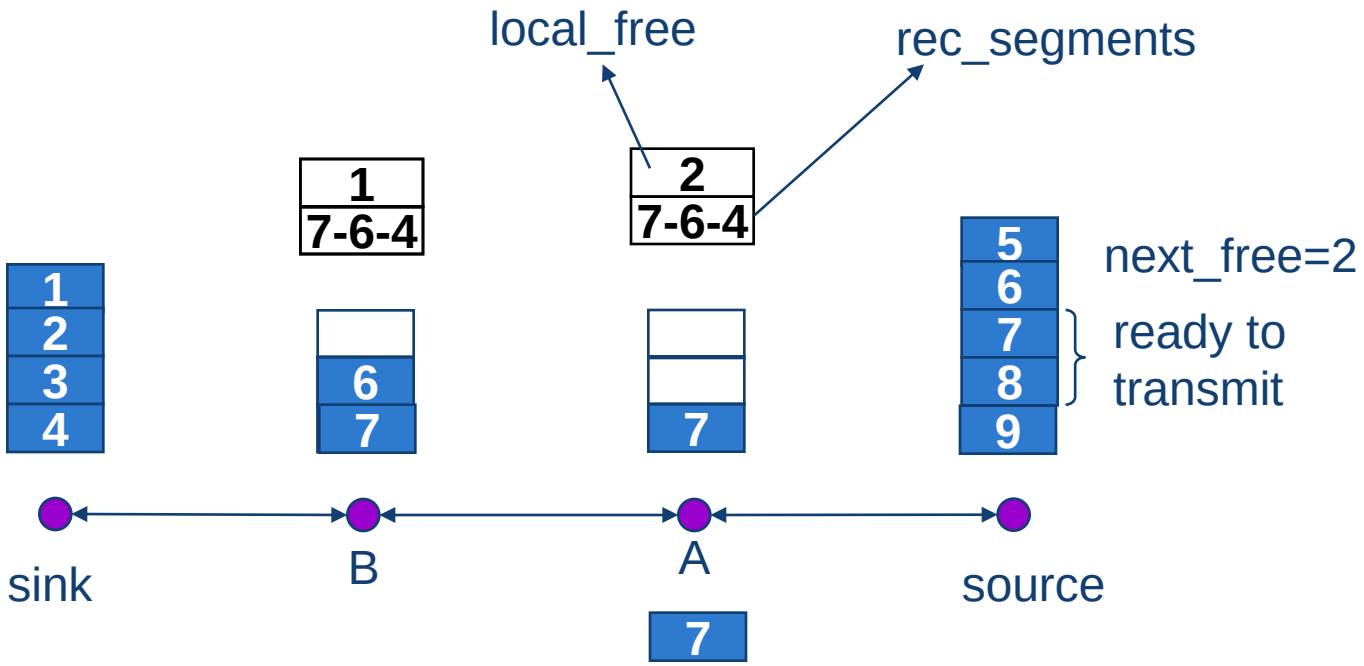
RTMC instance

- Transporting
  - Receive a data packet from the last hop node.



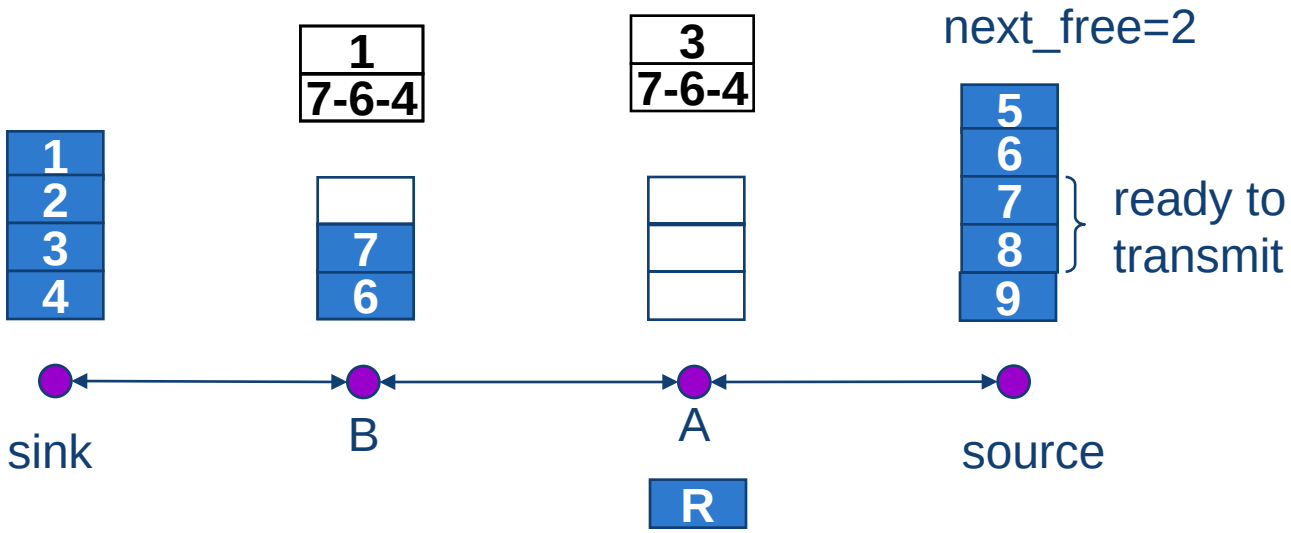
RTMC instance

- Transporting
  - Hear a data packet from the next hop node.



RTMC instance

- Transporting
  - Special case: A is empty but source thinks that A is full, due to packets loss. A should send Requiring packets to source periodically until memory is not empty.



RTMC instance

- Ending
  - For a node, if (1) its memory is empty and (2) it has received all of the segments, then the transport is finished of this node.

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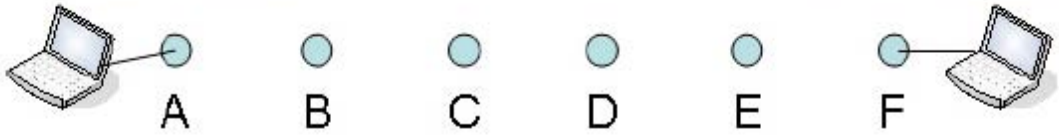
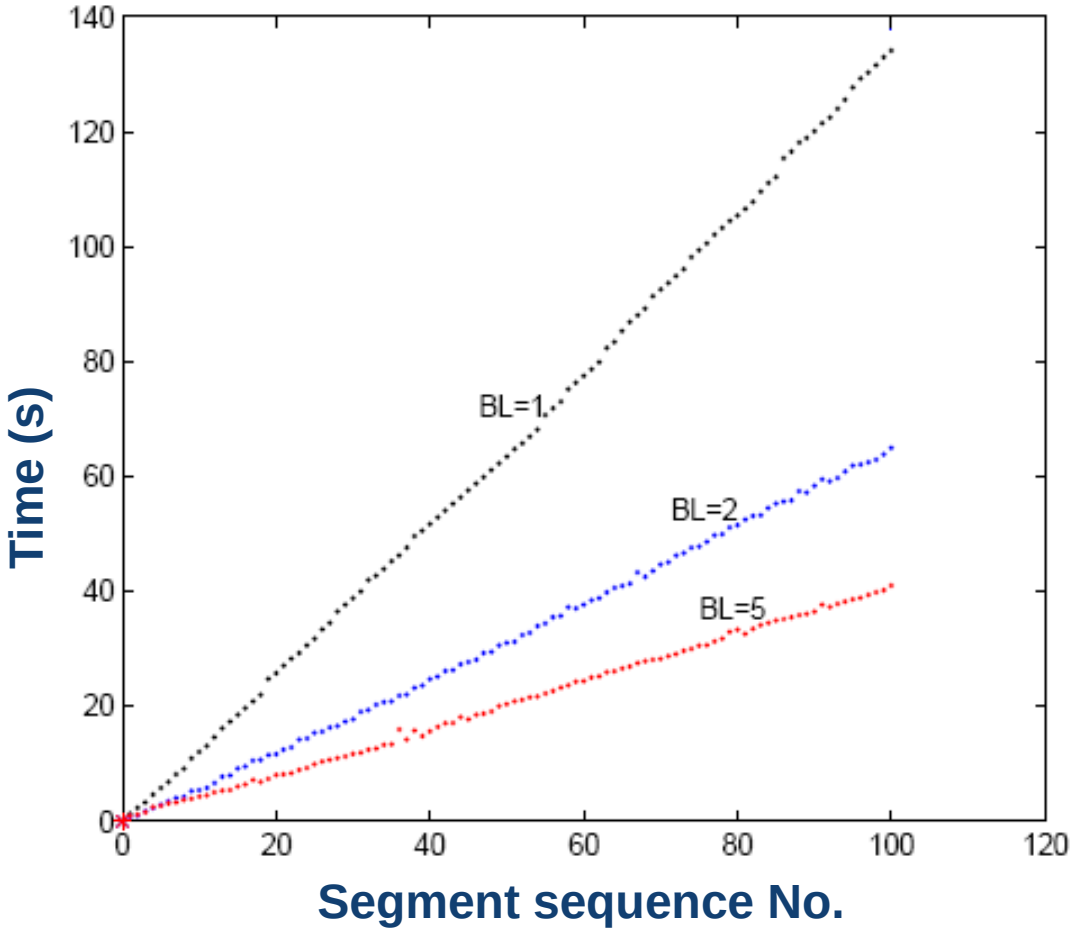
Experiment Scenario

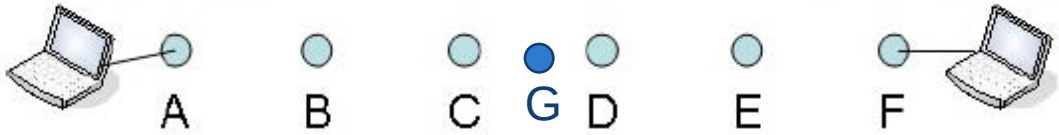


Mica2, 19.2kbps, 10K image file, 100segments

Experiment result without congestion

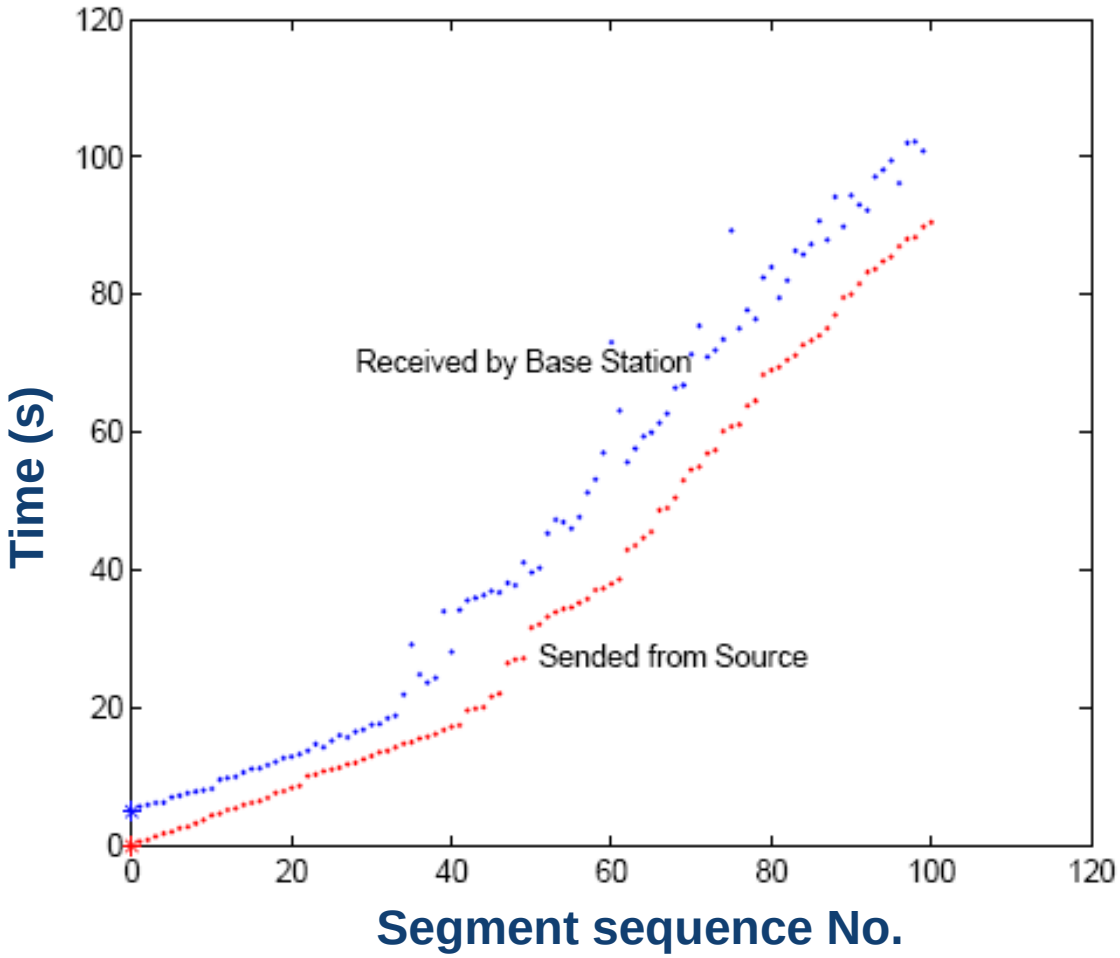


Experiment result with congestion



G was turned on 20seconds later

Experiment result with congestion



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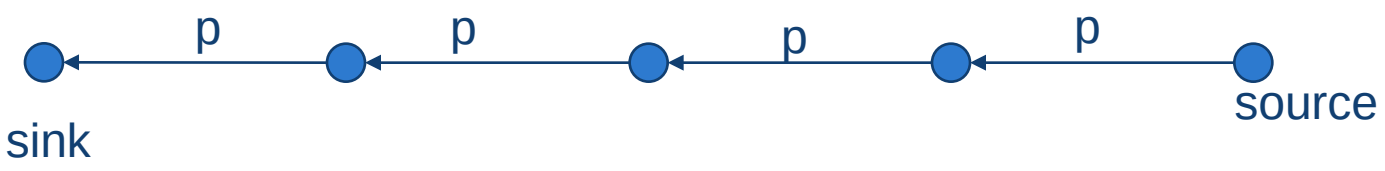
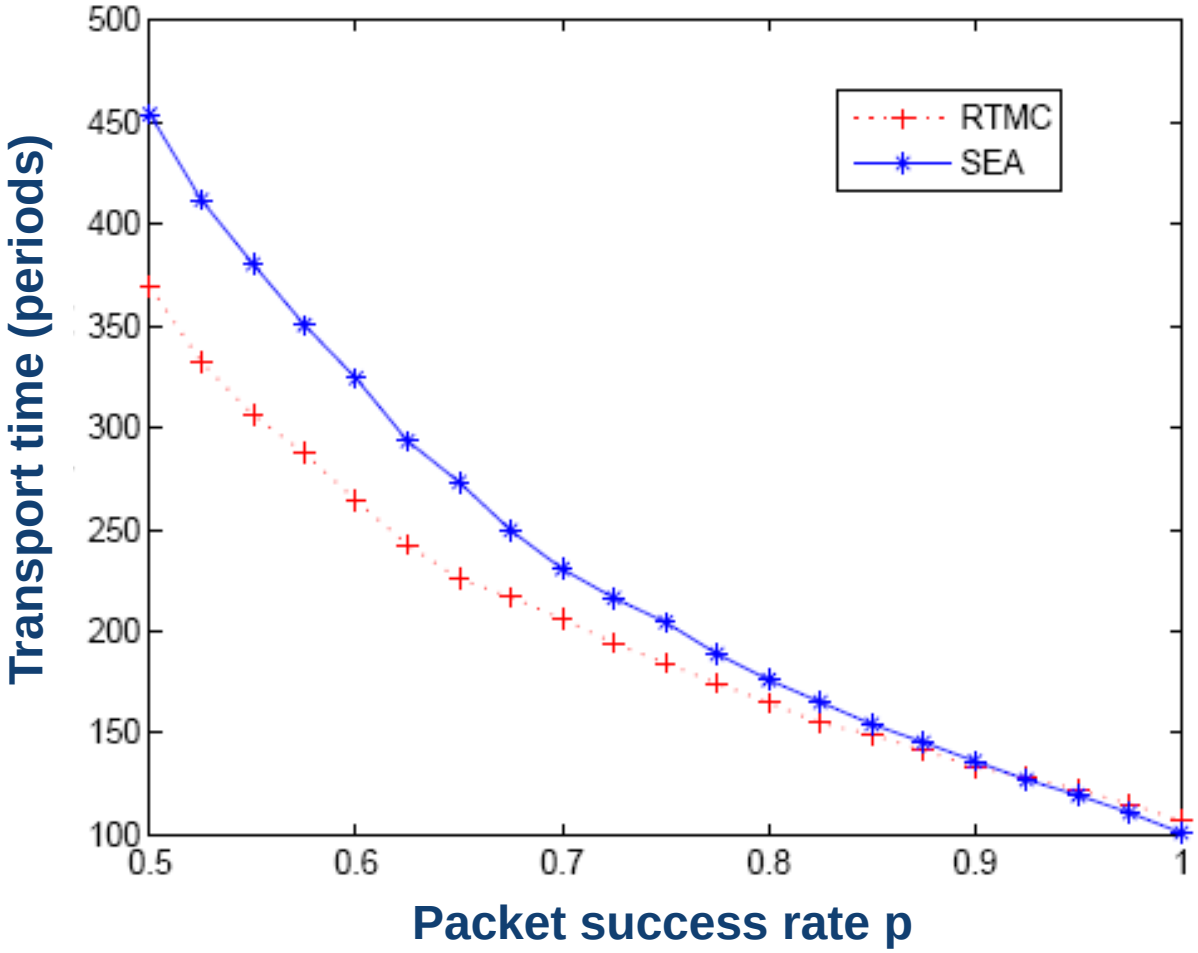
Comparison

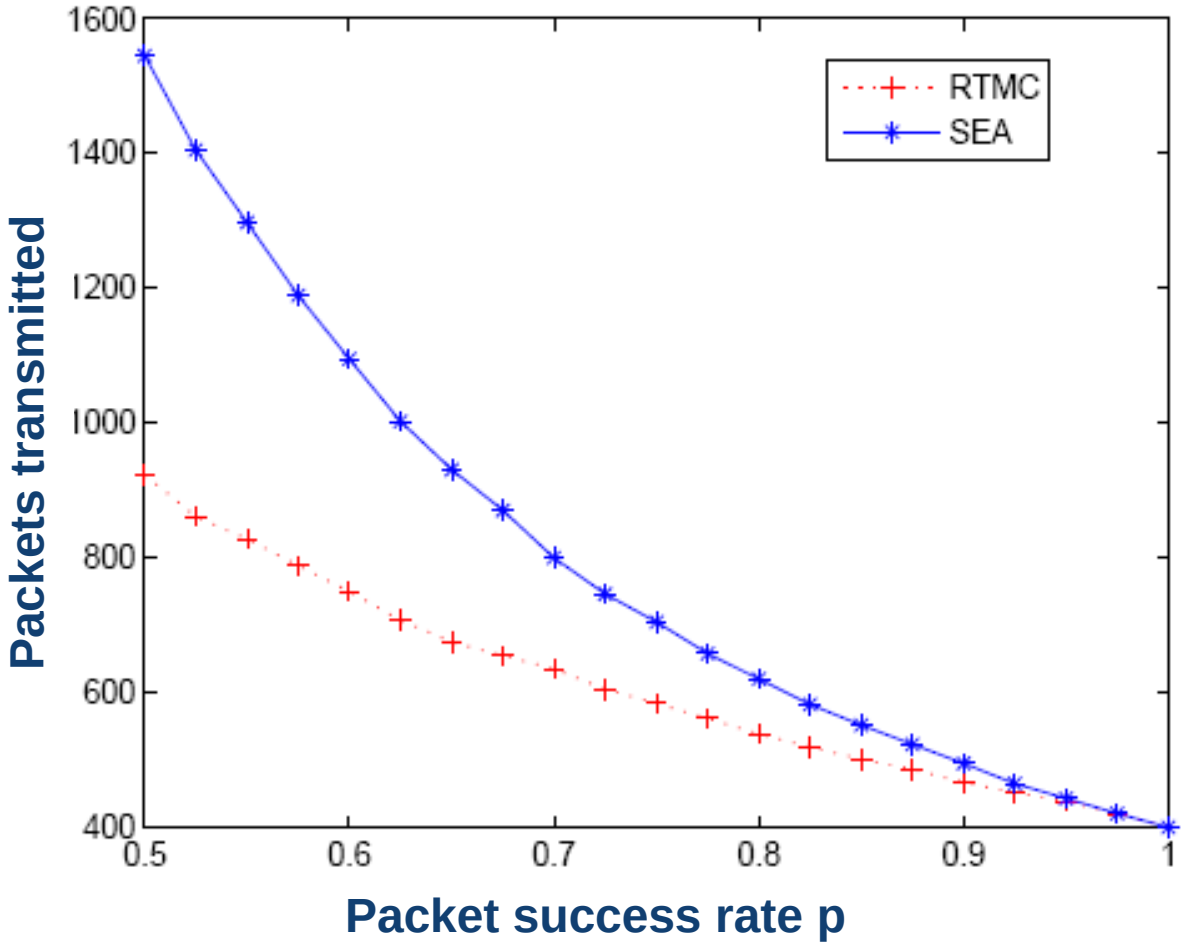
- SEA
  - A receiver sends back an acknowledge after receiving a packet.
  - The sender retransmits the packet if it does not receive the acknowledge.
  - Each node can store no more than 10 segments
- RTMC
  - Each node can store 5 segments
- Simulation
  - 5 nodes, TDMA (one message for RTMC, one message and one acknowledge for SEA).



Simulation Result



Simulation Result



Conclusions

- RTMC can get 100% reliability due to hop-by-hop retransmission and congestion control mechanism.
- RTMC can use channel effectively and has low delivery latency, since the transmission rate can quickly change with the traffic change in the network.
- RTMC costs less energy, since the number of retransmission packets is reduced.
- Both experiment and simulation results support these conclusions

Thank you