
Rateless Deluge:
Over-the-Air Programming of
Wireless Sensor Networks using
Random Linear Codes

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Outline

- Introduction
- Related Work
- Proposed approach
 - Rateless Deluge
 - ACKless Deluge
- Experiment and Simulation
- Conclusion

Introduction

- Sensor networks' software often needs to be updated after deployment.
- Over-the-air programming (OAP) protocols play a key role as an enabling technology to numerous sensor network applications.

Introduction

- Performance **degrades** when the network **size** and **density** get **large**, and when **packet loss** is **high**.
- This **lack scalability** can largely be attributed to the **high control overhead**, most specifically with **(NACK)** mechanisms.
 - NACK implosion problem**.

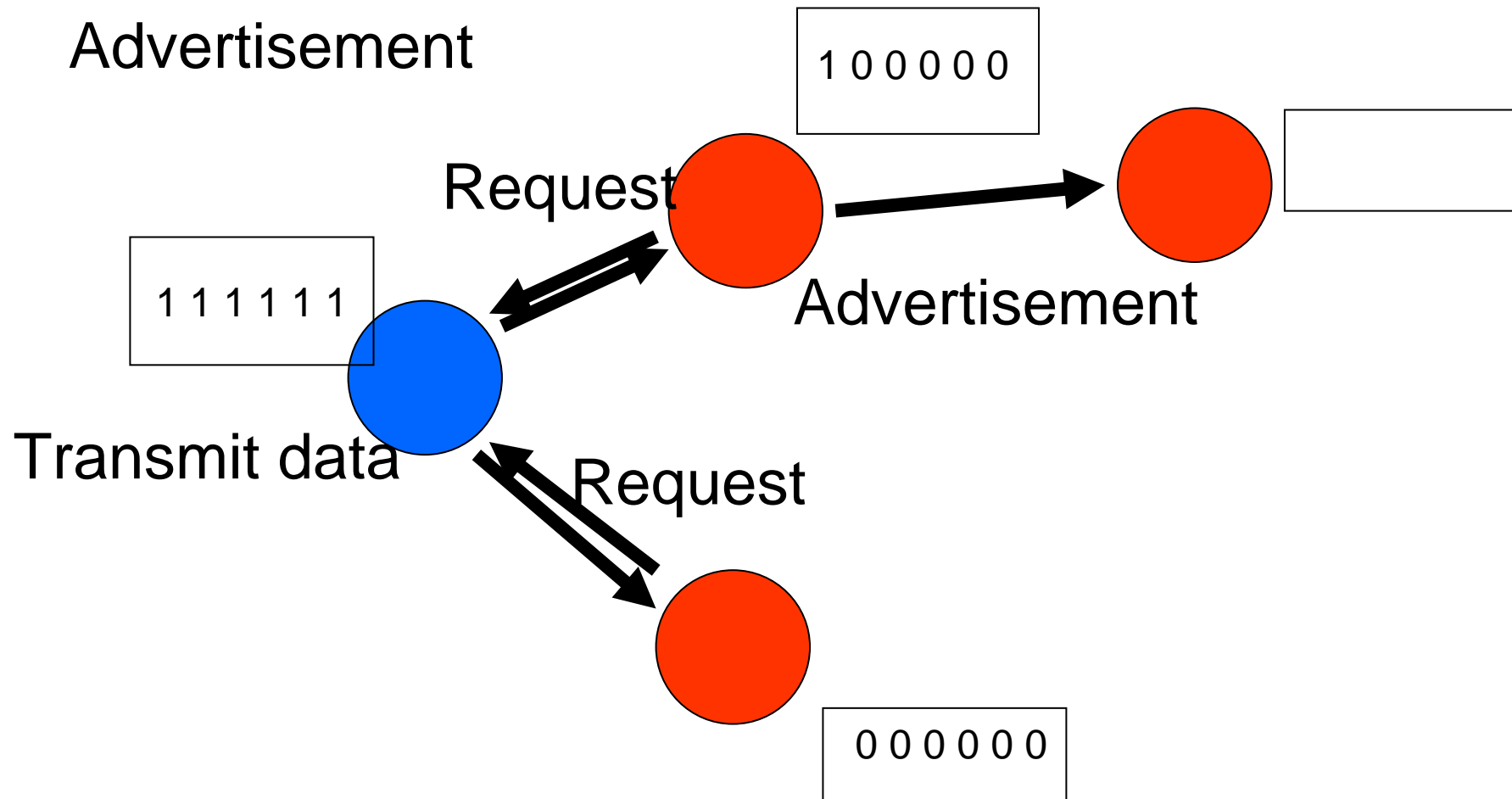
Introduction

- This paper **use rateless coding** to **eliminate** the need to **convey control information** about which packets require retransmission.

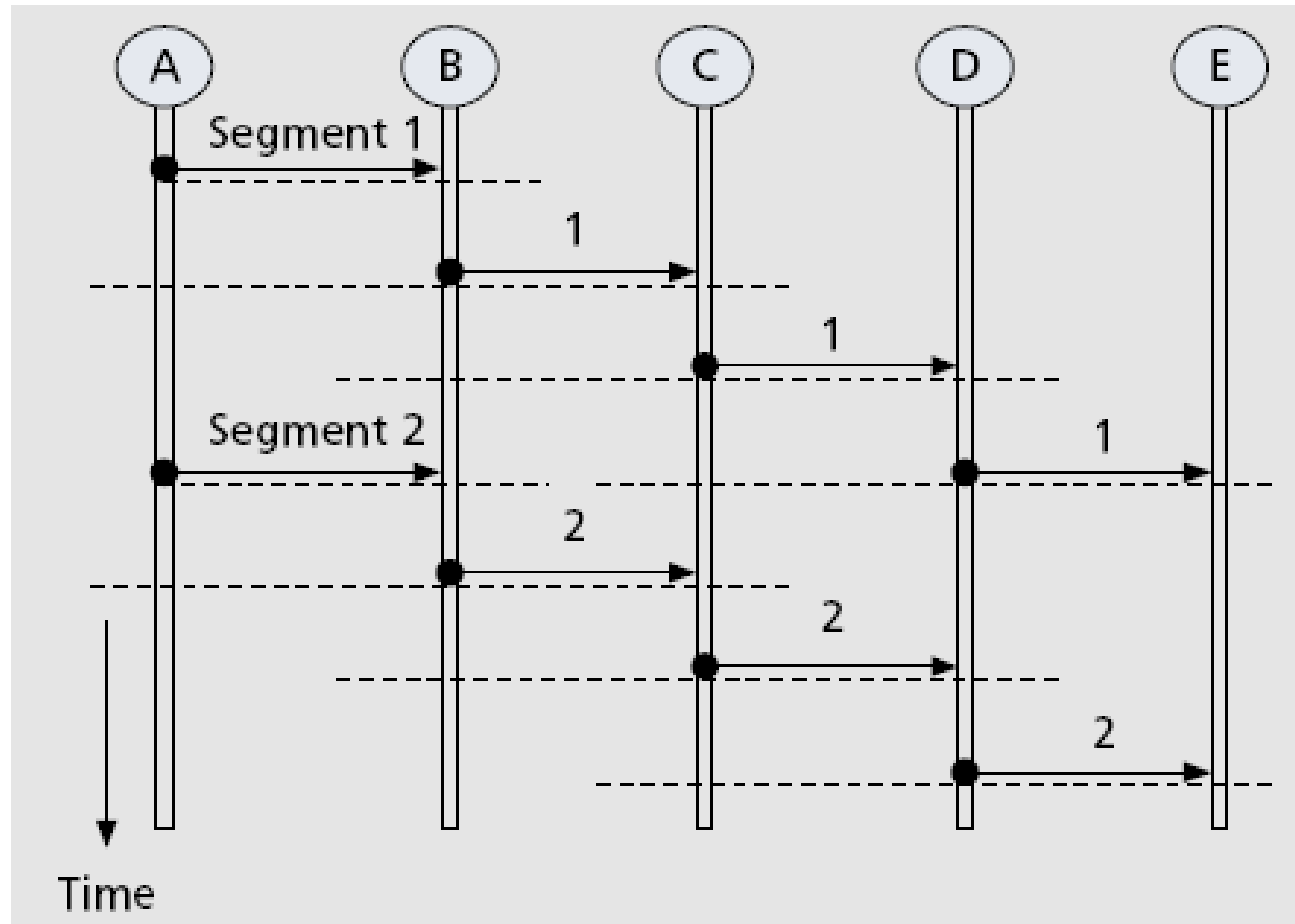
Deluge

- Divides data image into **pages** , each **page** consisting of fix number of packets.
- Piplining.
- NACK-based protocol.

Deluge



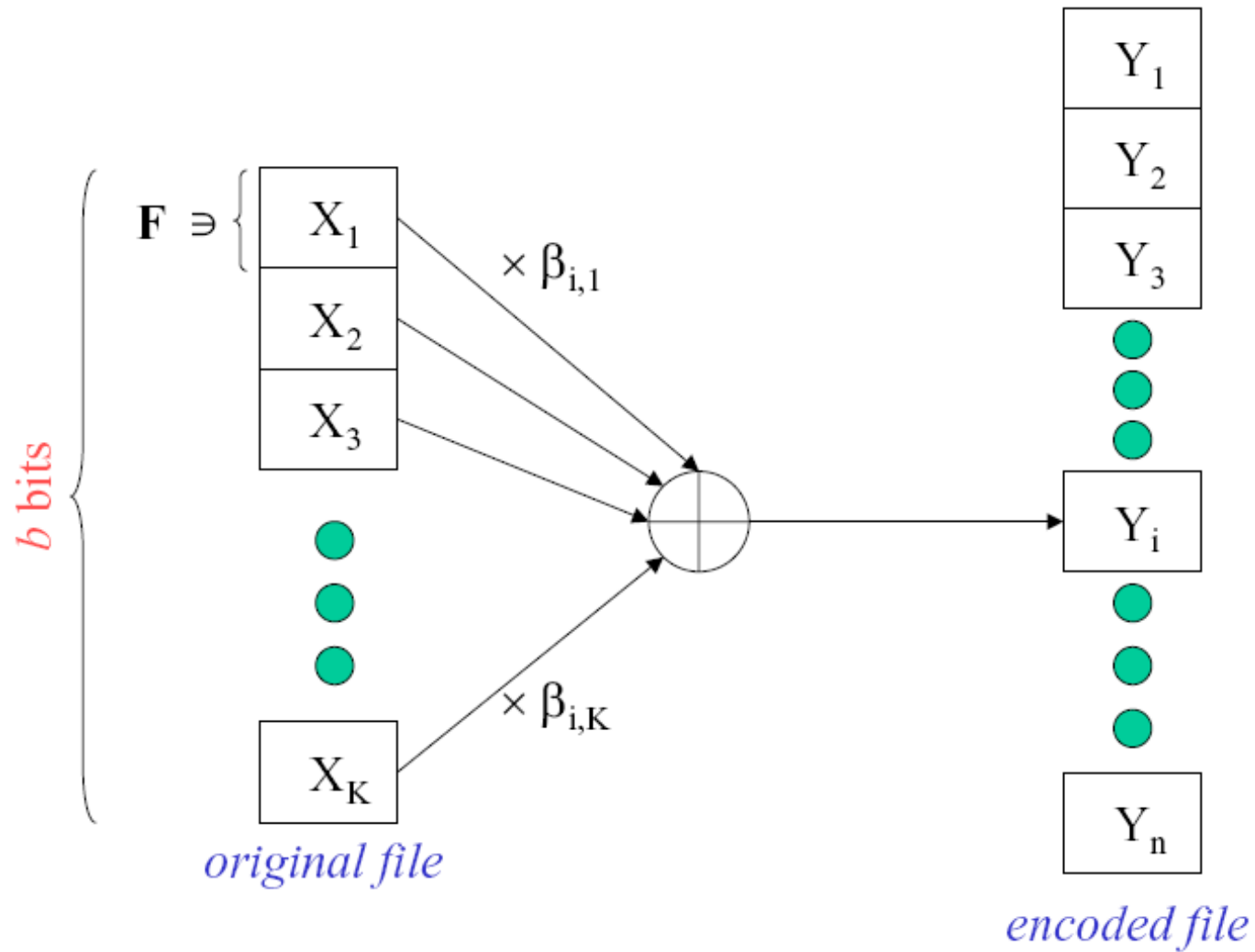
Pipelining



Rateless and Random Linear Codes

- Do not need to indicate which packets require retransmission; just have to receive a sufficient number of packets can be used to decode.
- Communication and energy savings.
- Lower control overhead.

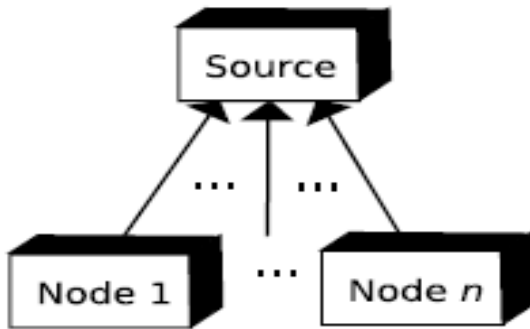
Rateless and Random Linear Codes



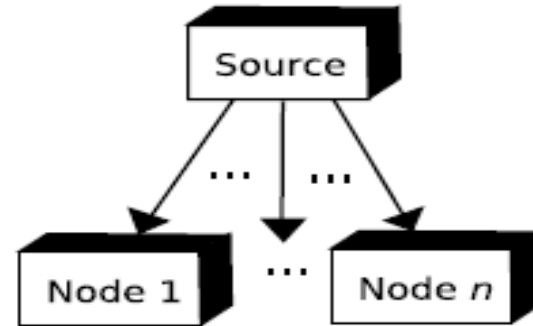
Rateless and Random Linear Codes

Traditional:

Request Lost Packets:

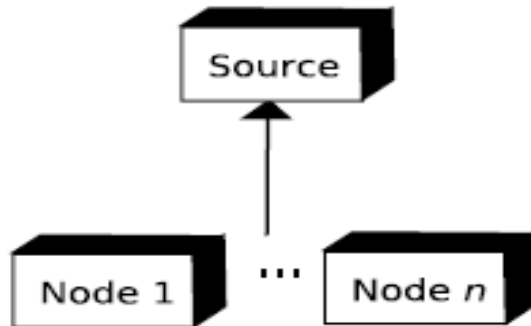


Transmit Lost Data:

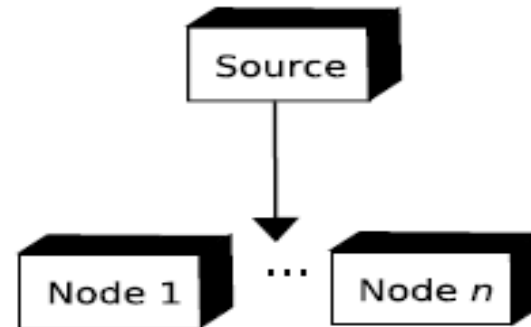


Rateless Codes:

Request Lost Packets:



Transmit Lost Data:



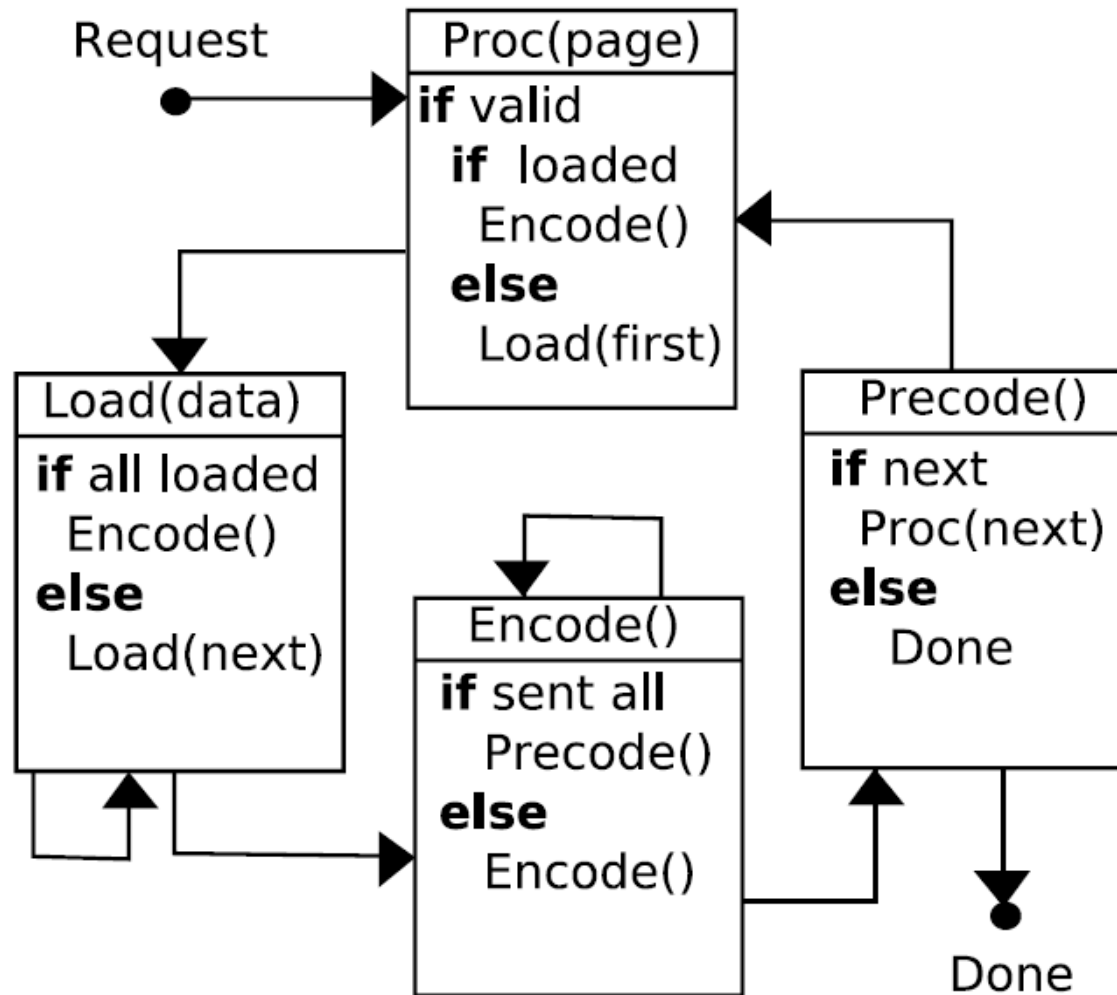
Rateless Deluge

- Modify the original Deluge protocol in that it uses rateless codes to transmit data.
- This change causes the communication in the control and data planes are reduced.

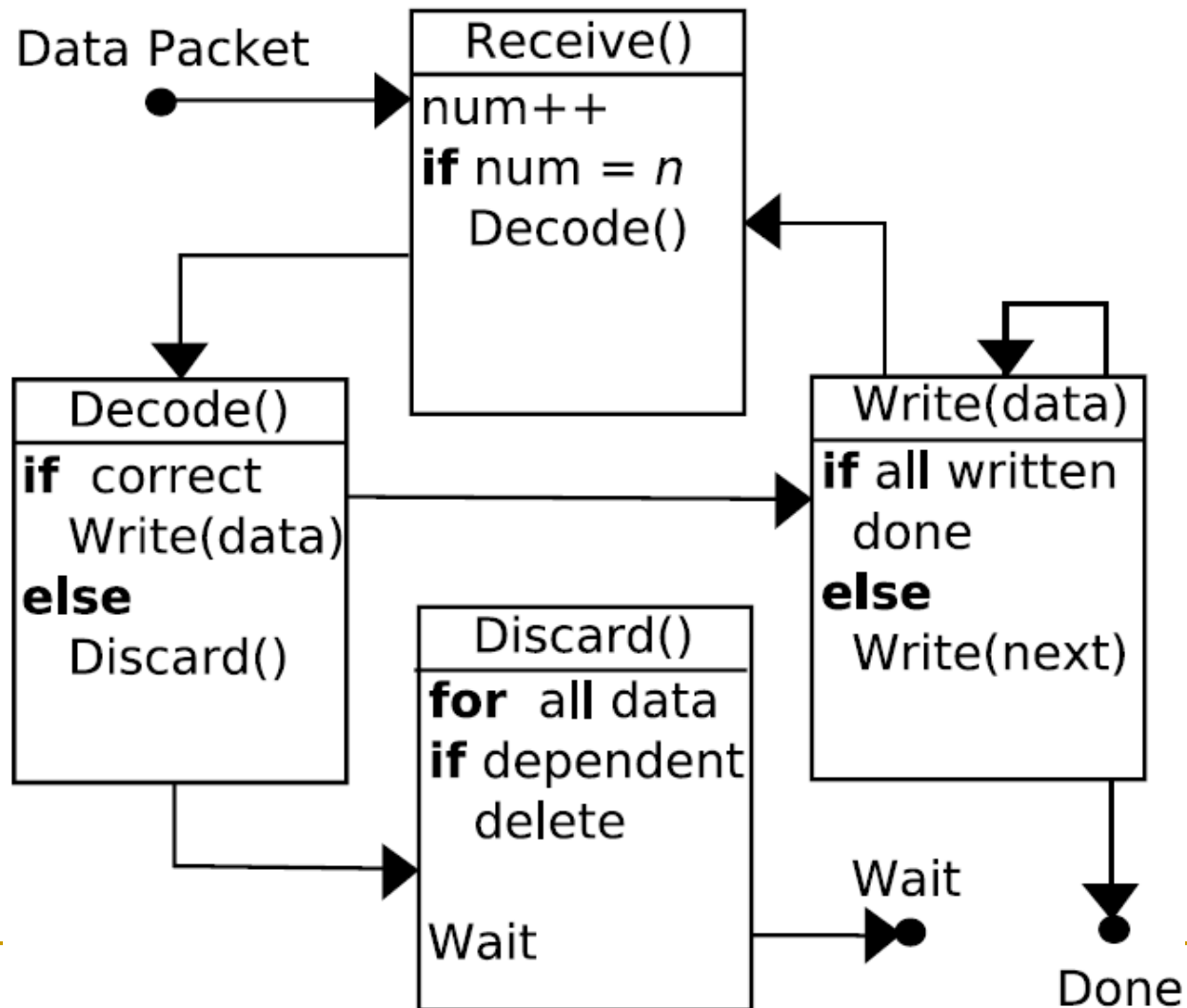
Rateless Deluge

- Change for request mechanism:
 - Only need the **number of missing packet** instead of **bit vector**.
- Change for sender:
 - Encoding before send (cost time).
 - >**Precoding**.
- Change for receiver:
 - Decoding after receive.

State diagram for sender



State diagram for receiver



ACKless Deluge

- Attempts to completely **eliminate** the need for **NACKs**.
->no waiting time for precoding
- Employs a **FEC** mechanism at the **packet level** which sends extra encoded packets in addition to the requested number of packets.
- FEC is dependent on **number of neighbor** and **probability of loss**.

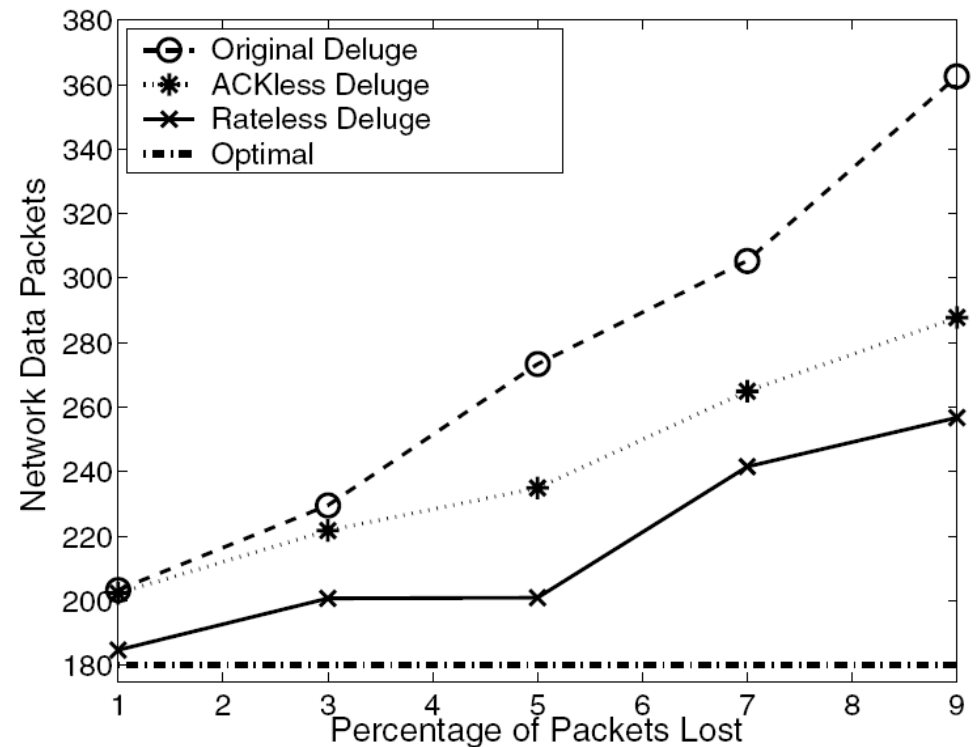
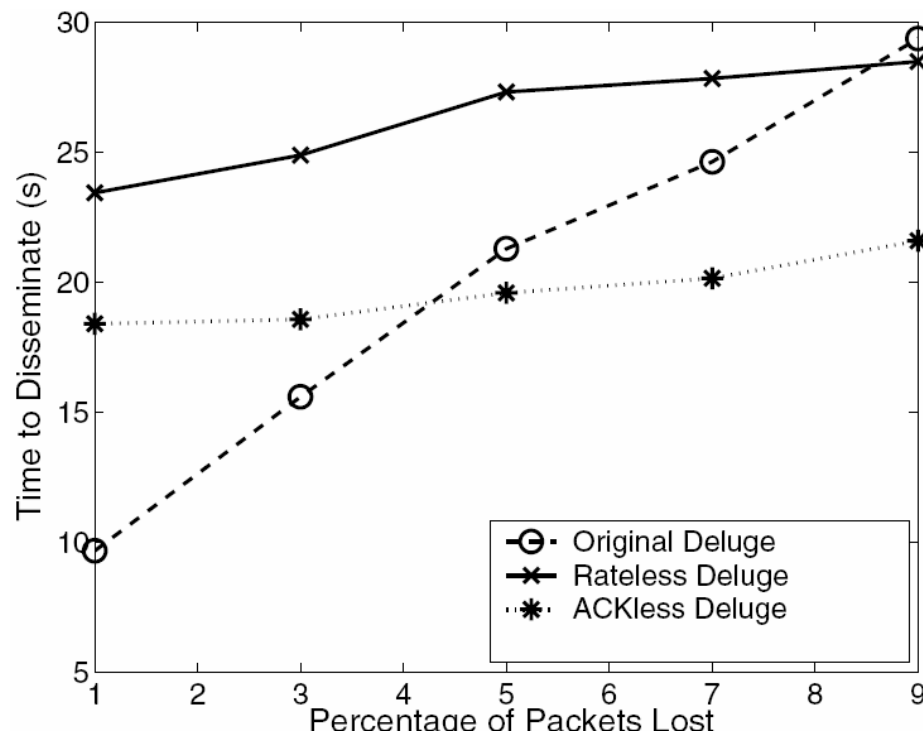
Experiment

■ 1-Hop

16 motes

■ 9-pages image

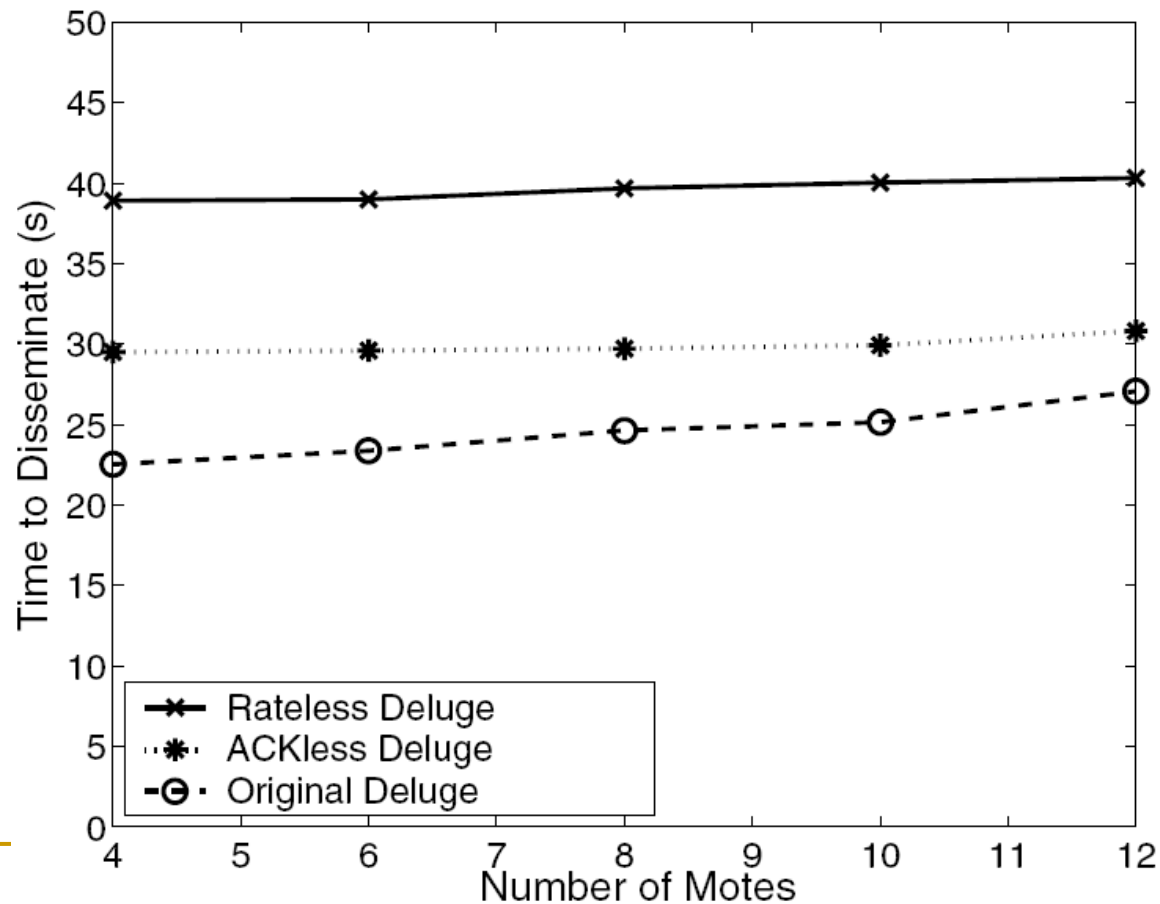
20-packets per page



Experiment

- N/2 1-Hop
- 9-pages image

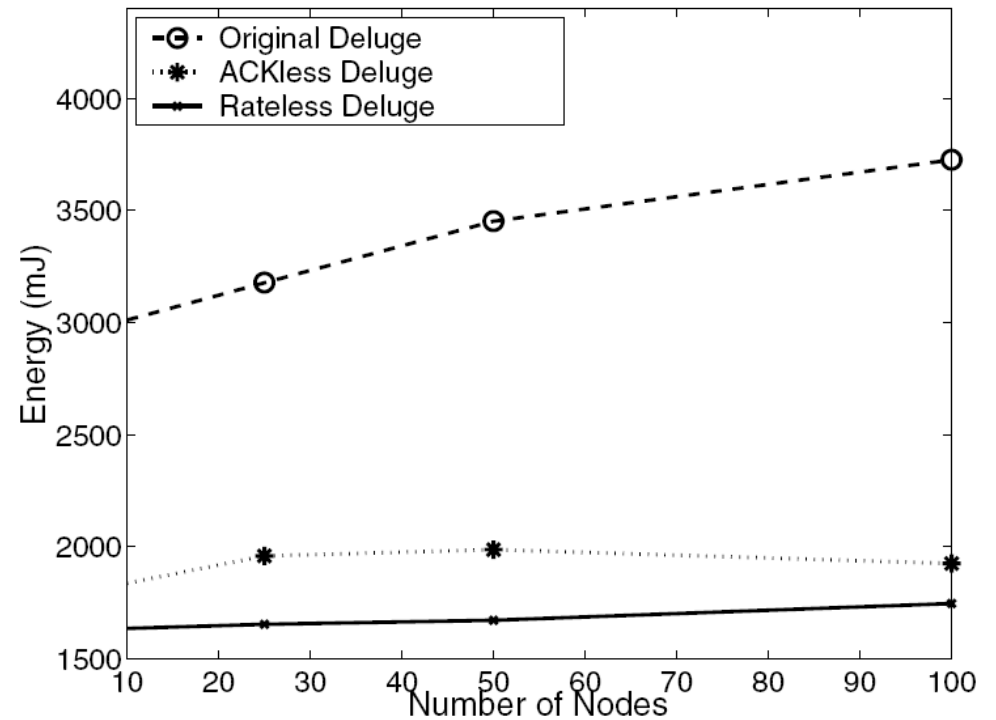
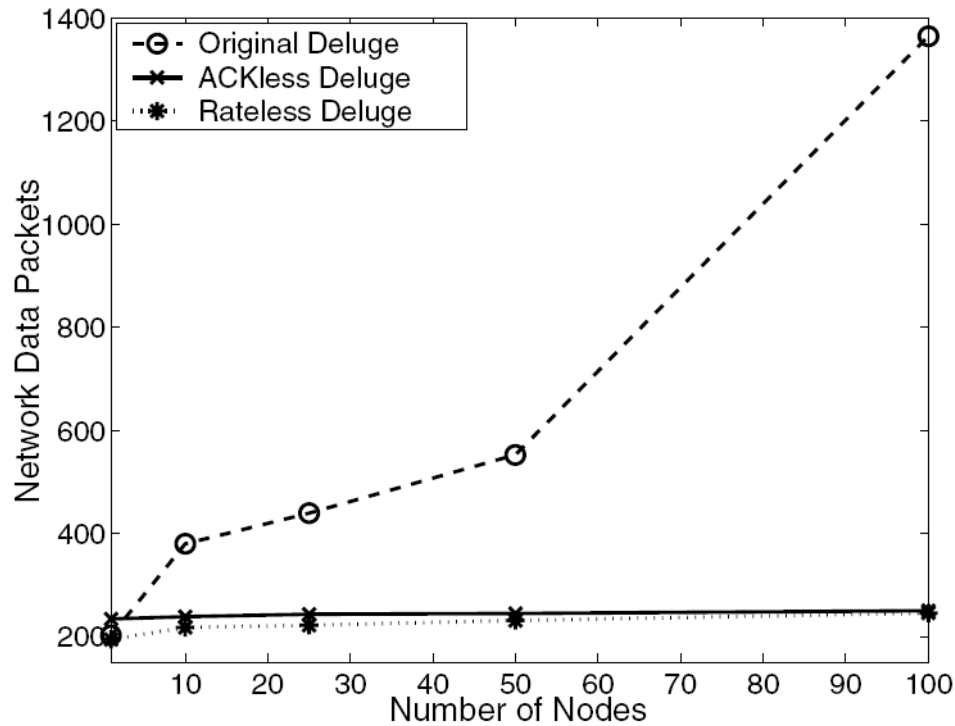
N/2 2-Hop



Simulation

■ 9-pages image

7% Packet loss rate



Conclusion

- This paper shows the benefits of using random linear codes for over-the-air programming of sensor networks.
- We expect that rateless code transfer mechanisms are practical and useful for any communication protocol in wireless sensor networks.