Network coding in wireless and ad hoc networks

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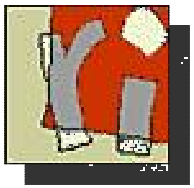
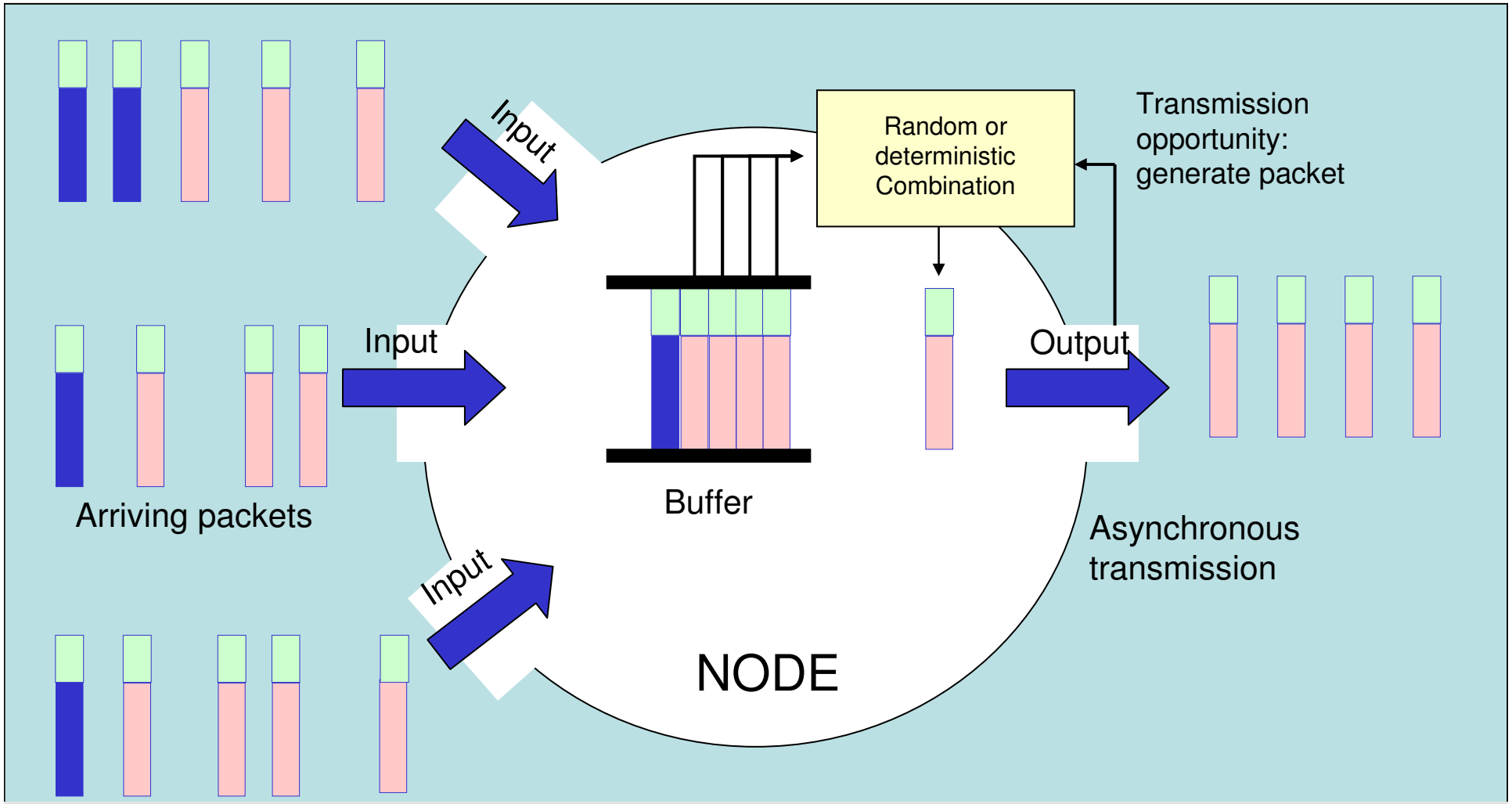


Main idea

Allow ingress node of a network to encode the flows' information

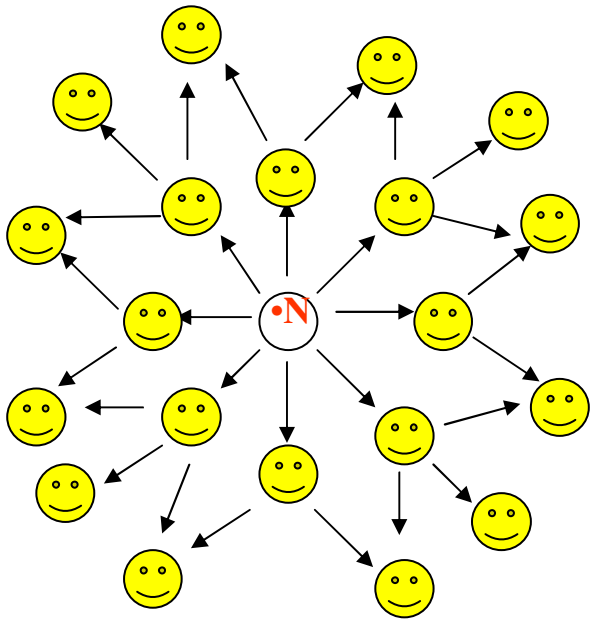
Store and forward = only forwarding

Network Coding

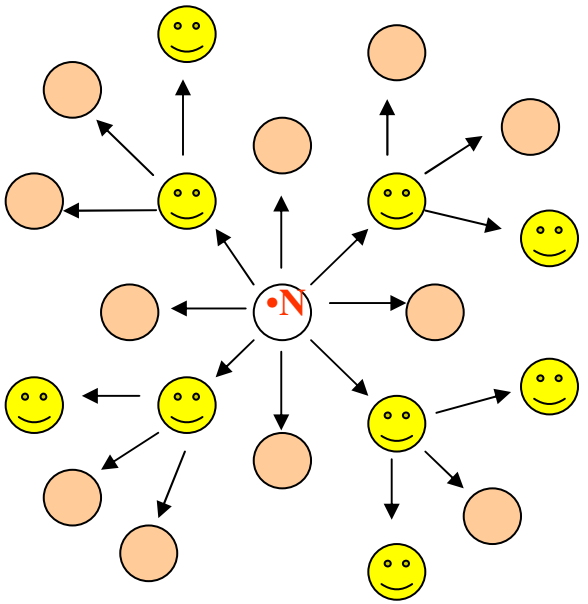


Flooding

- **Flooding** is the most crucial part of any routing protocol in Ad Hoc Networks
- **MultiPoint Relays** are used to minimize flooding cost of broadcast packets in the network



Regular flooding – many redundancy



MPR based flooding

Contribution

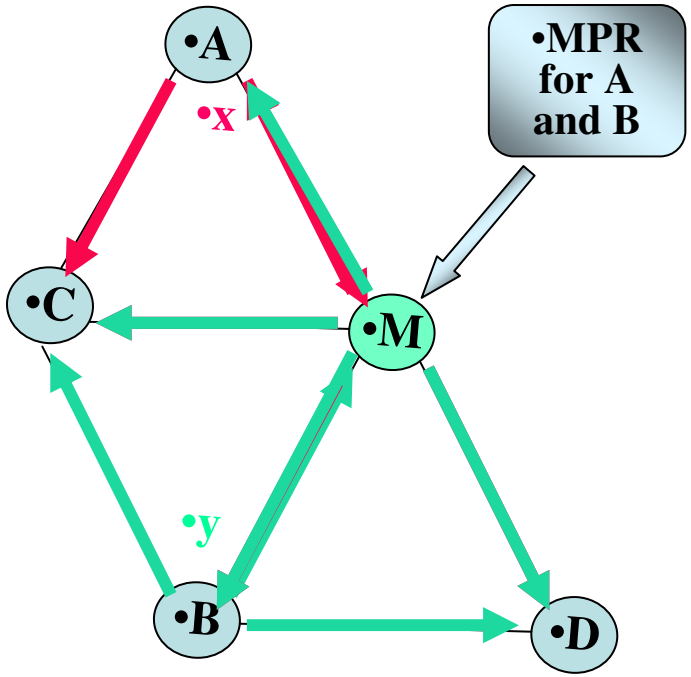
Both MPR and Network Coding could reduce the number of retransmissions.

The idea is to combine both to maximize the optimization:

- Find a distributed algorithm to perform network coding at each MPR node.

Motivation Example

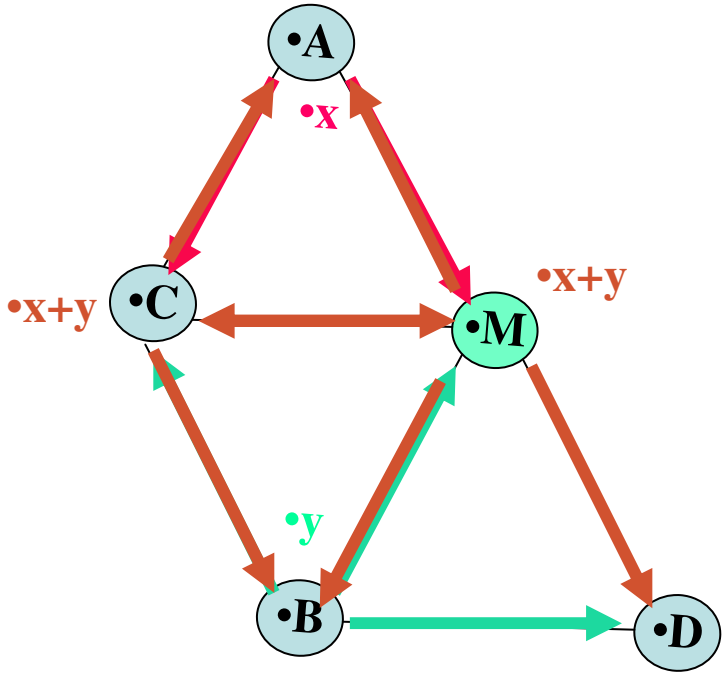
A and B want to broadcast x, y respectively to all nodes



- **Using MPR:**
- **4 transmissions are needed**

Motivation Example (cont.)

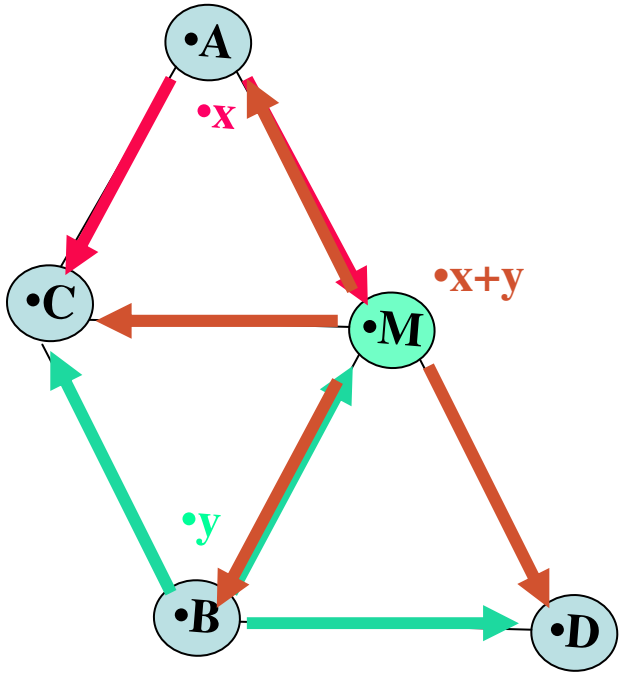
A and B want to broadcast x, y respectively to all nodes



- **Using Network coding:**
- **4 transmissions needed**

Motivation Example (cont.)

A and B want to broadcast x, y respectively to all nodes



- **Using Network coding + MPR:**
- **3 transmissions needed**

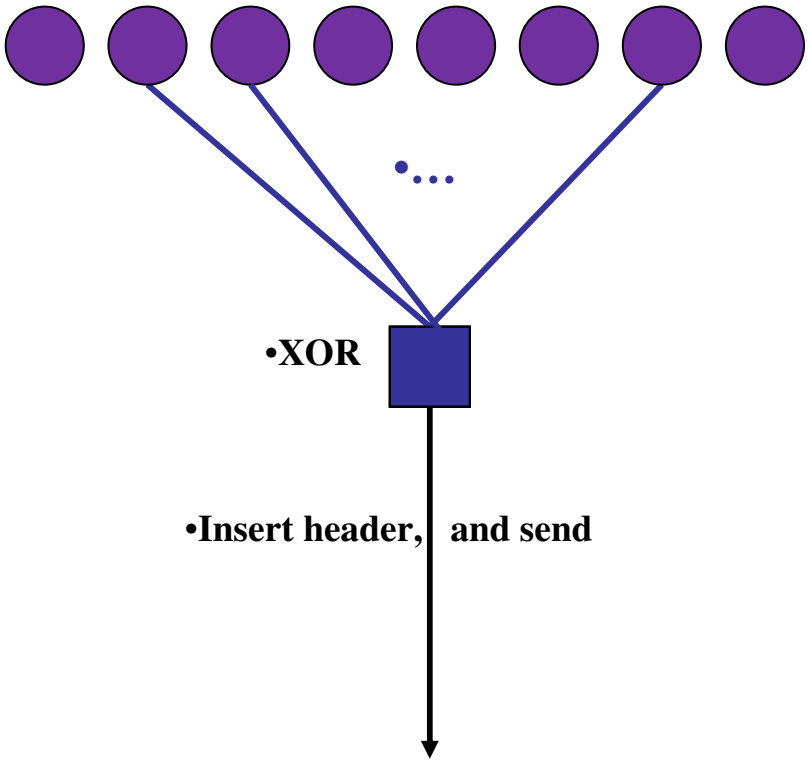
MPR-LT scheme

- **MPR election according to neighbor discovery**
- **Each MPR uses LT code (Fountain code) to mix native packets arriving from MPR-Selectors**
- **MPR uses locally background decoding**
- **Transmits when MAC opportunity occurs**

FEC: Fountain Code

- Proposed for reliable communication in lossy networks
- Has low complexity for encoding and decoding functions
- End-to-end approaches
- Example: LT code

LT Encoding



•Native symbols

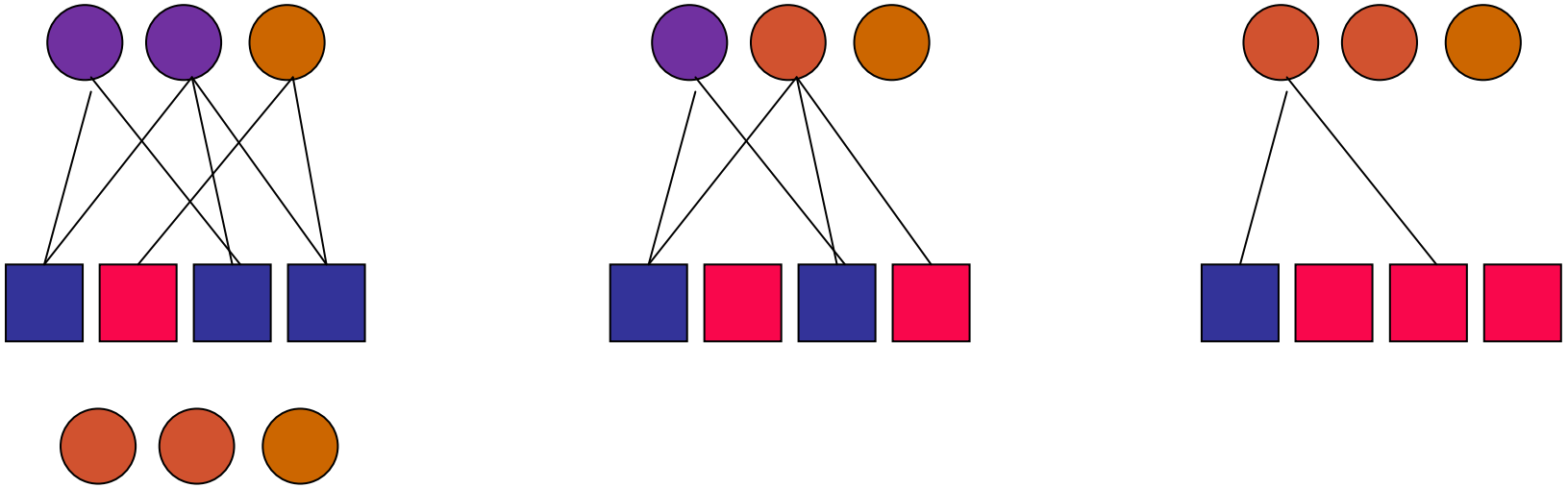
•XOR

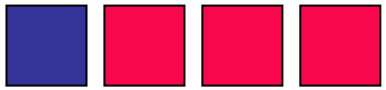
•Insert header, and send

•Choose random d according to a distribution

•Choose d Random native symbols

LT Decoding



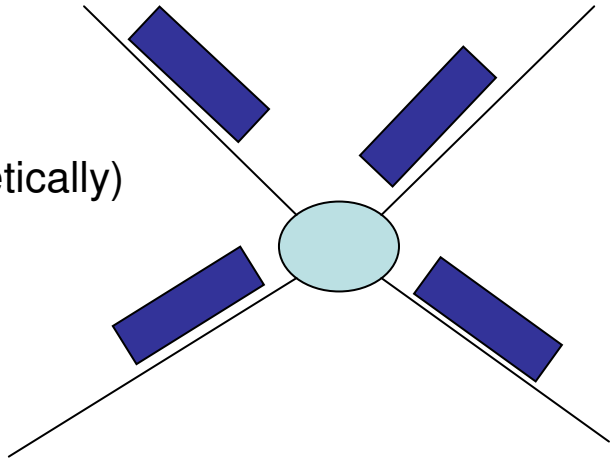


- **Degree distribution is curcial**
- **Average Degree of Distribution should be** $O(\log(k))$
- **Luby Codes are with overhead of** $O(\log^2(k)/\sqrt{k})$

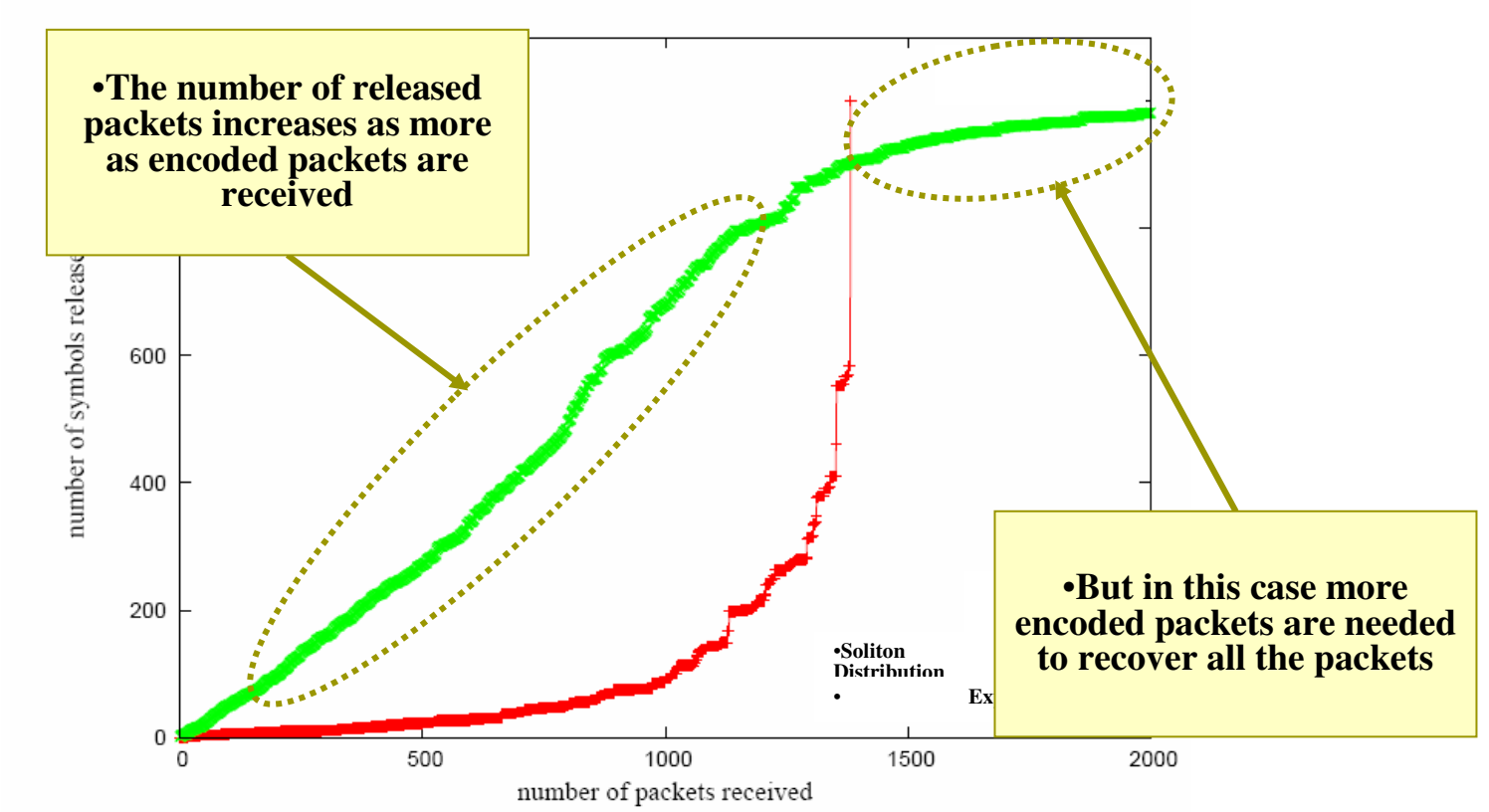
MPR-LT Flooding

- MPR receives packets and try to decode
- If successful decoding, packets are moved to broadcast buffer
- When transmission opportunity => transmits according to LT codes
  - Probability = 1/(number of neighbors + 1)
- Needs to decode with small encoded packets
- Robust Soliton Distribution is not suitable in this case
- Use Switched Distribution
  - Start with a binary exponential
  - Then switch to Robust Soliton
  - Switching threshold is equal to 0.7*k* (calculated theoretically)
  - Overhead to decode with probability $1 - \delta$

$$K' = 1.4k + O(\sqrt{0.4k}\, ln^2(\frac{0.4k}{\delta})$$

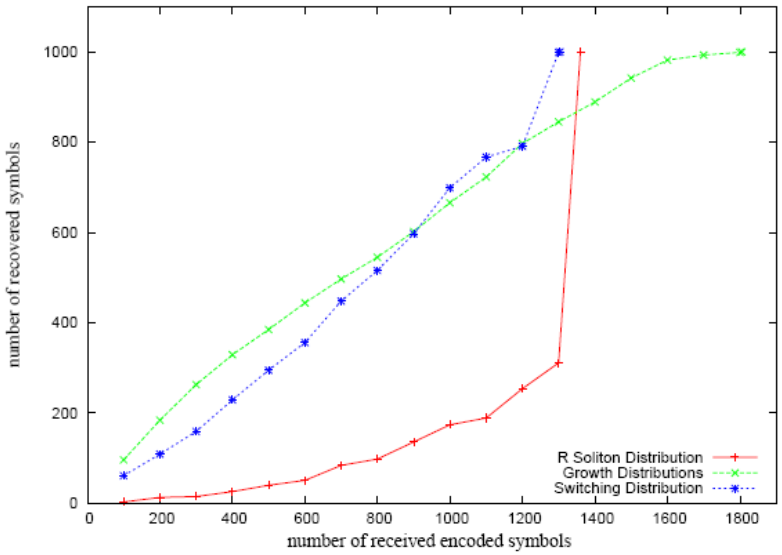


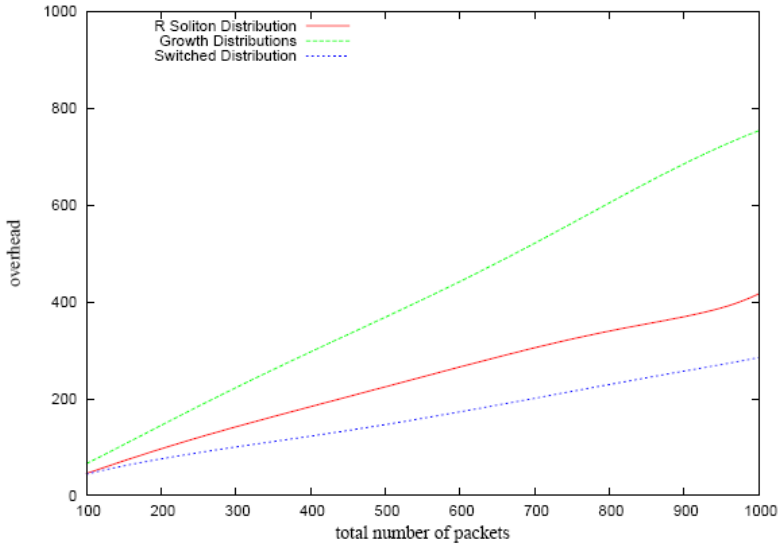
Degree Distribution



•Different Distributions for N=1000.

Switched Distribution





Idea for ANR-JST call

- Identified partners: Paris XI University, Kyoto University, INRIA, NTT, Orange
- Ideas:
  - Femto2femto cell routing using network coding for 4G mobile networks
  - Conception of distributed algorithms
  - Performance analysis
- Previous collaboration
  - Paris XI University and Kyoto University
    - Performance analysis of MPR-LT flooding