An Efficient Multicast Protocol in Mobile Ad-hoc Networks Using Forward Error Correction Techniques

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Outline

- Introduction
- Recovery Points and FEC based Multicast Schemes
  - RP establishment scheme
  - RP mergence scheme
  - FEC scheme
  - RP maintenance scheme
- Experimental Results
- Conclusions

Introduction (1/2)

- Multicasting is a strategy to effectively use bandwidth for point to multi-point communications
- Mobile Ad-hoc Networks
  - Multi-hop communications
  - Highly dynamic topology
  - Unstable forwarding path
- Reliable multicast becomes a very challenging research problem in mobile ad-hoc networks

Introduction (2/2)

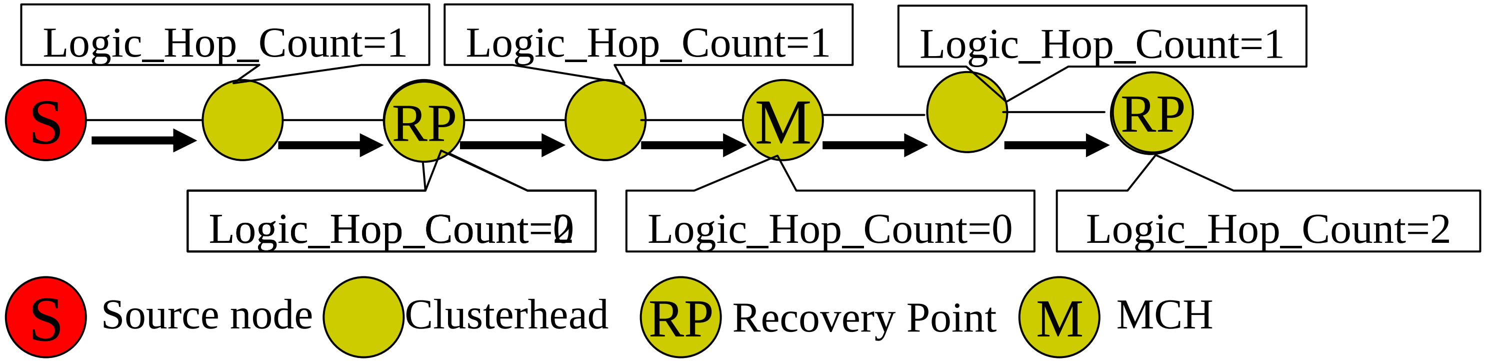
- Many reliable multicast protocols have been proposed for MANETs
  - ARQ (Automatic Repeat reQuest) based protocols
  - Gossip-based protocols
  - Hybrid ARQ and FEC (Forward Error Correction) based protocols
- These reliable multicast protocols may need the recovery schemes
  - A major challenge to these recovery schemes is to reduce feedback implosion problem
  - Especially, when the number of receivers and senders increases

Recovery Points and FEC based Multicast Schemes

- In this work, we propose a recovery points and FEC based multicast scheme
- RP establishment scheme
  - Keep data packets from the source
  - Recover the lost packets for its downstream RPs
- RP mergence scheme
  - To avoid excessive control overhead
- FEC scheme
  - Enhance the reliability of data transmission
- RP maintenance scheme

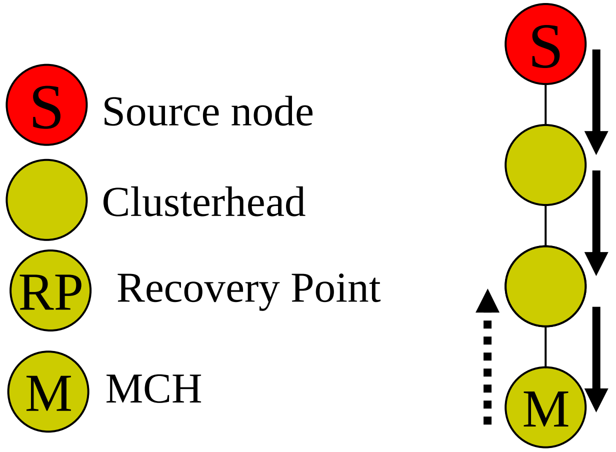
RP Establishment Scheme

- Source nodes and MCHs are default recovery points
- Attach and piggyback a Logic Hop Count field to a data packet
  - Each clusterhead increments one to this field and then forwards it to the virtual backbone
  - A clusterhead will set itself to an RP if the Logic Hop Count equals h
  - If a MCH receives the data packet, it will set the Logic Hop Count to zero



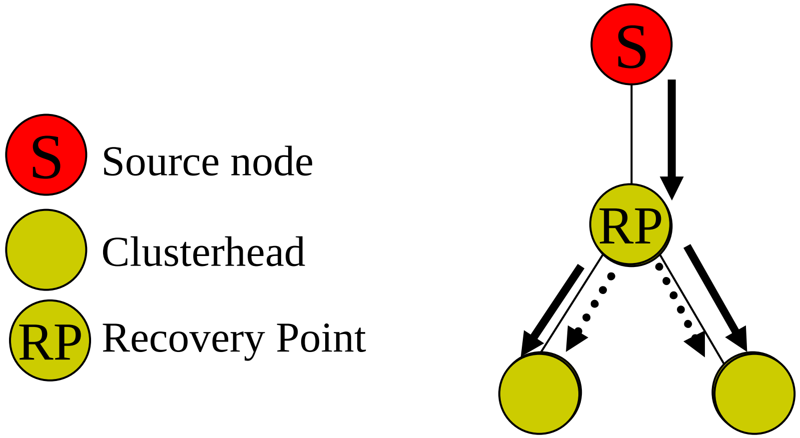
RP Mergence Scheme (1/2)

- To avoid excessive RP control overhead
  - Case 1: if a selected RP is adjacent to an MCH, it is unnecessary to establish an RP

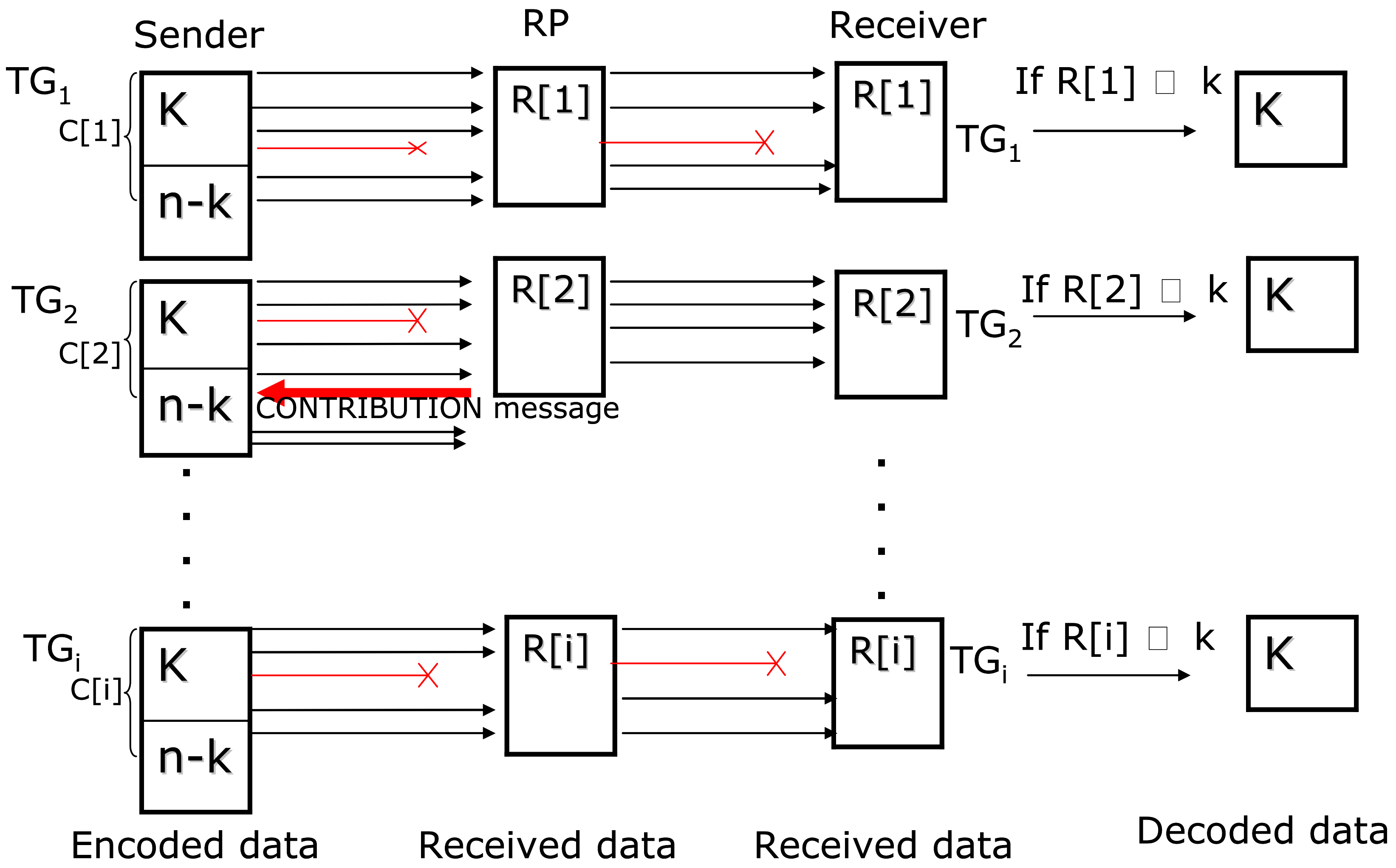


RP Mergence Scheme (2/2)

- To avoid excessive RP control overhead
  - Case 2: if there are more than one RPs that are the child nodes of a clusterhead, they will be merged



FEC Scheme


Sender
RP
Receiver
TG$_1$
C[1]
K
n-k
R[1]
R[1]
If R[1] □ k
TG$_1$
K
TG$_2$
C[2]
K
n-k
R[2]
R[2]
If R[2] □ k
TG$_2$
K
CONTRIBUTION message
TG$_i$
C[i]
K
n-k
R[i]
R[i]
If R[i] □ k
TG$_i$
K
Encoded data
Received data
Received data
Decoded data

RP Maintenance Scheme

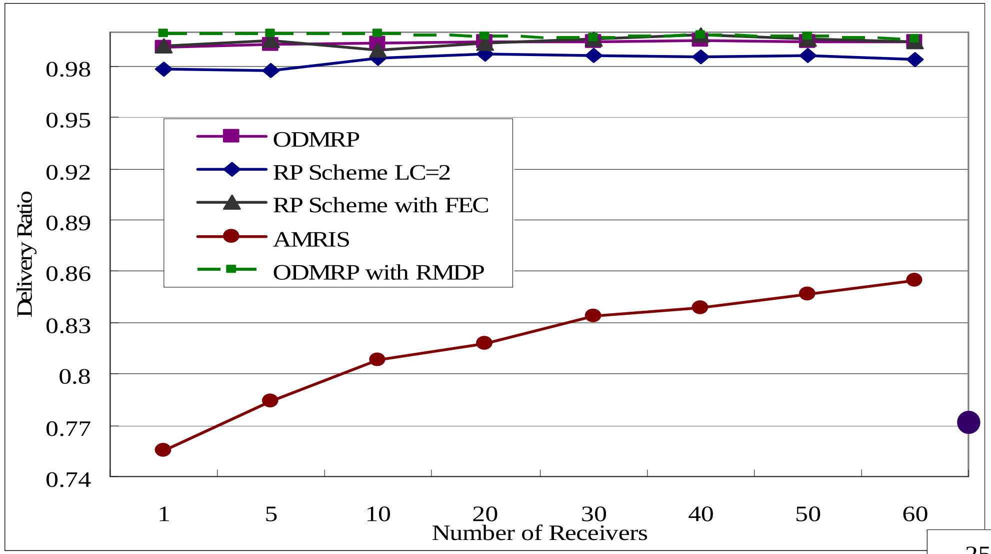
- Maintenance for packet releasing
  - After comparing data packet sequence number and resending lost packets
  - The upstream RP deletes data packets kept in its memory
- Maintenance for Node Joining
  - When a receiver joins a cluster
  - When an RP moves to anther MCH or RP and becomes an ordinary node
- Maintenance for Node Leaving
  - When an MCH only manages one receiver and the receiver leaves
  - When the RP or MCH leaves the cluster

Experimental Environment for the Multicast Scheme

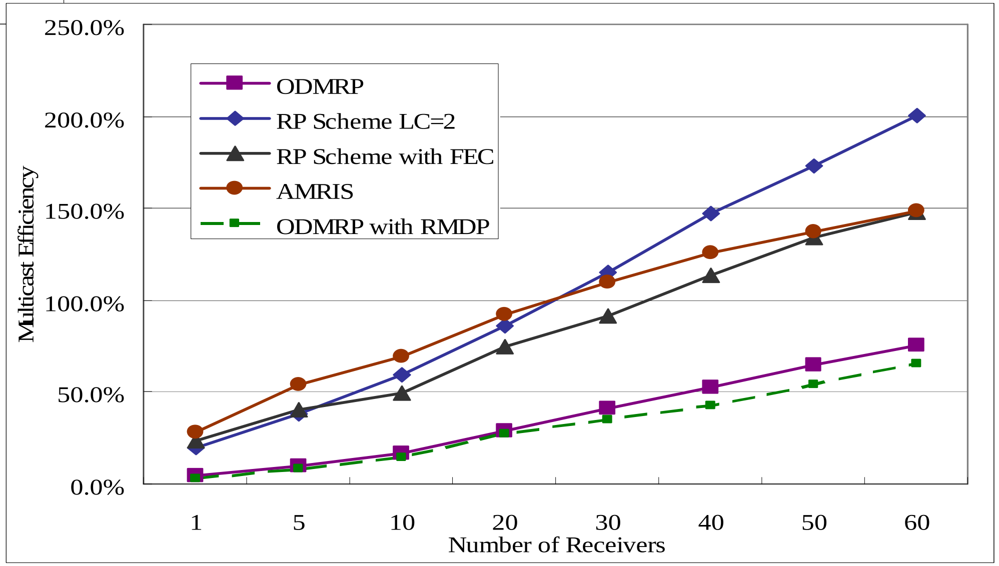
- Simulator: GloMoSim
- Nodes: 100
- Area: 1000m × 1000m
- Tx_range: 200m
- Mobility model: Random waypoint
    - Max Speed: 1m/s ~ 30m/s
- Number of senders : 1 ~ 50
- Number of receivers : 25 ~ 125
- Logic Hops : 2
- The ratio of redundant data (*R*) : 1.5

Experimental Results of the Multicast Scheme (1/2)

- Delivery Ratio vs. Number of Receivers

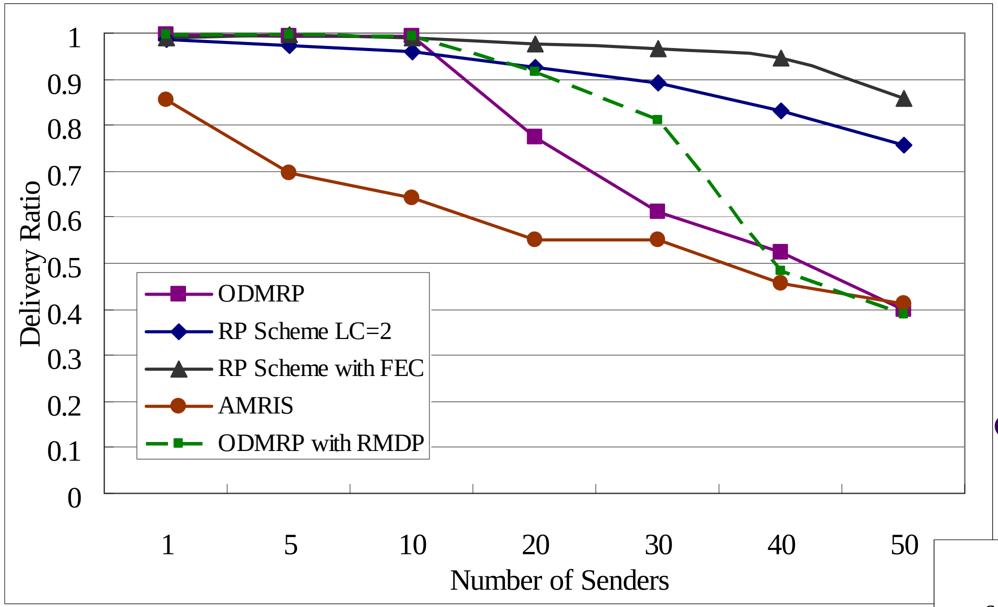


- Multicast Efficiency vs. Number of Receivers

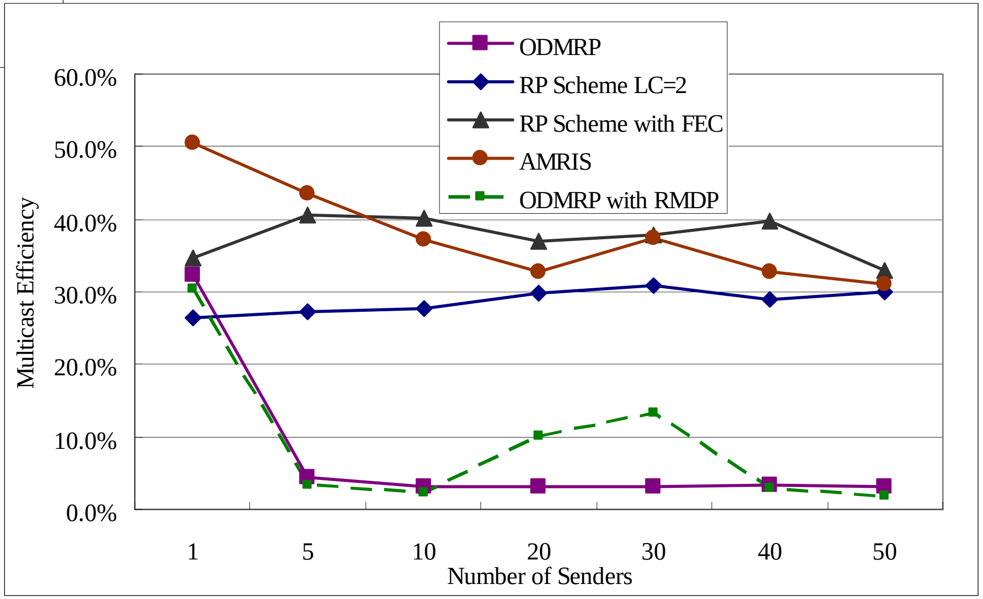


Experimental Results of the Multicast Scheme (2/2)

- Delivery Ratio vs. Number of Senders



- Multicast Efficiency vs. Number of Senders



Conclusions

- In this work, we proposed a reliable multicasting protocol using the RP and FEC schemes for MANETs.
- The RP scheme can be used to recover lost packets
- The FEC scheme can be used to enhance the reliability of data transmission
- The RP mergence and maintenance schemes can avoid excessive control overhead and reduce the node mobility problem
- The experimental results show that the proposed scheme can achieve high delivery ratio and high multicast efficiency

Appendix

Related Work (1/2)

- Reliable Multicast Protocols
  - ARQ-based multicast protocols [20, 51, 59, 60]
    - Detecting packet losses and notifying the sources to retransmit the lost packets
  - Gossip-based protocols [13, 43]
    - Lost packet recovery is performed locally
  - Hybrid ARQ-FEC based schemes [50, 56]
    - Uses the FEC technique to encode the data packets to redundant data packets
    - Use the ARQ technique to repair the lost packets from sources

Related Work (2/2)

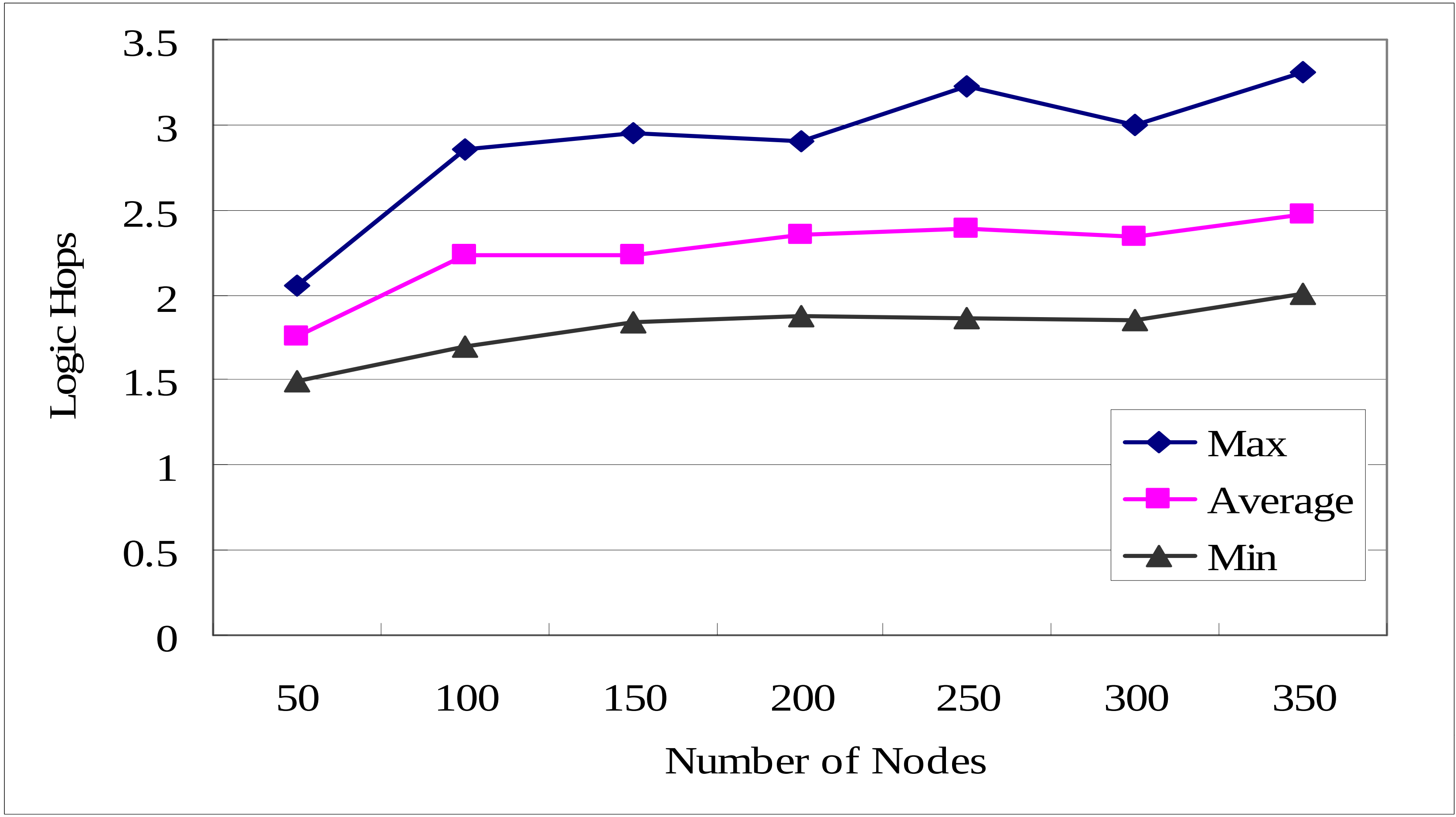
- Previous work
  - Clustering [36]
    - Distributed label clustering algorithm
    - Small number of clusters
    - A stable scheme
  - Virtual backbone [37]
    - Minimal Steiner tree
    - Small number of backbone nodes
    - A stable route

Comparisons of Various Schemes

	Multicast structure	Hierarchical structure	Recovery strategy
RP scheme with FEC	Shared Tree	Yes (clustering + virtual backbone)	Gossip + FEC
RP scheme	Shared Tree	Yes (clustering + virtual backbone)	Gossip
ODMRP with RMDP	Mesh	No	ARQ + FEC
ODMRP	Mesh	No	No
AMRIS	Shared Tree	No	No

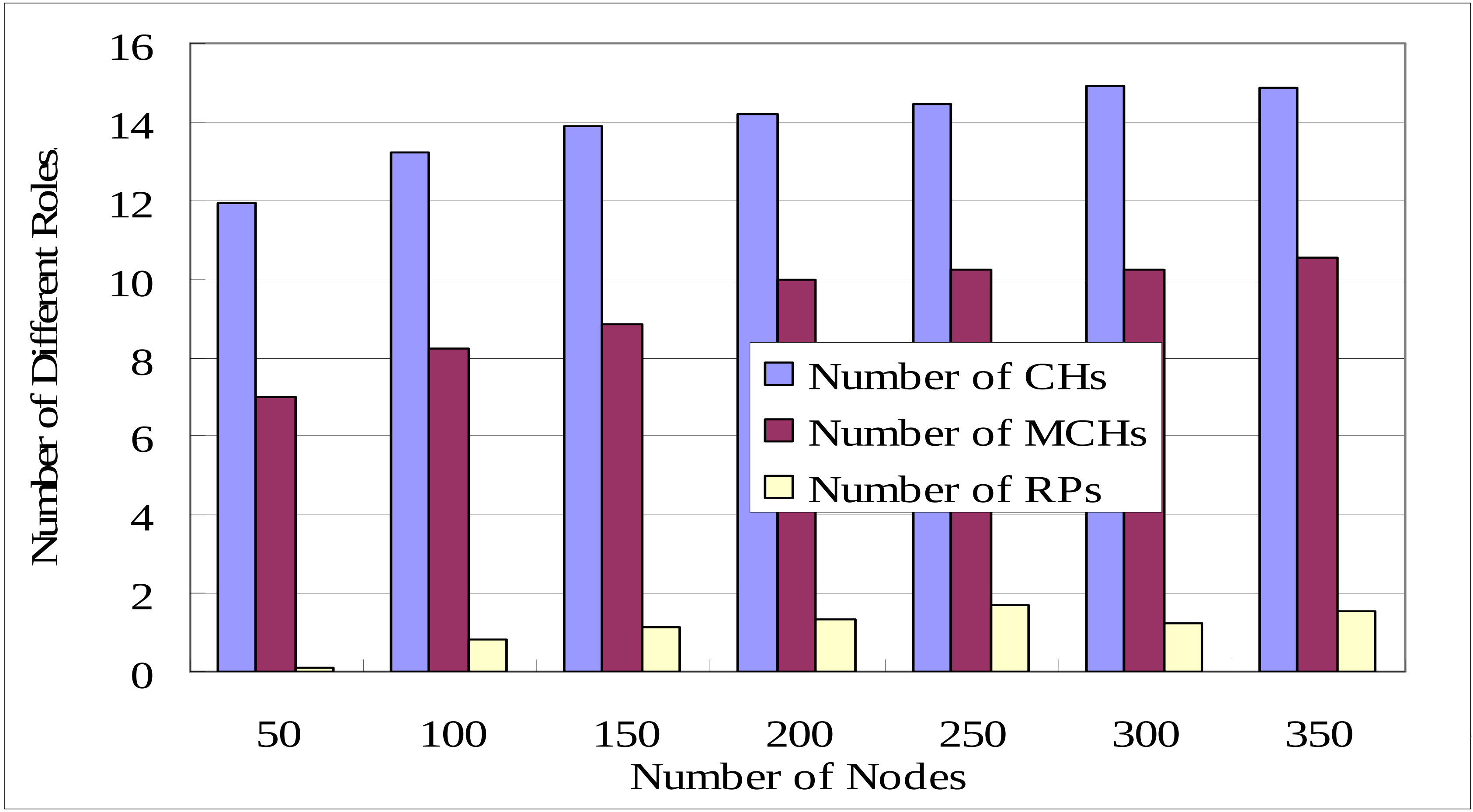
Experimental Results of the Multicast Scheme

- Logic Hops between MCHs vs. Number of Nodes

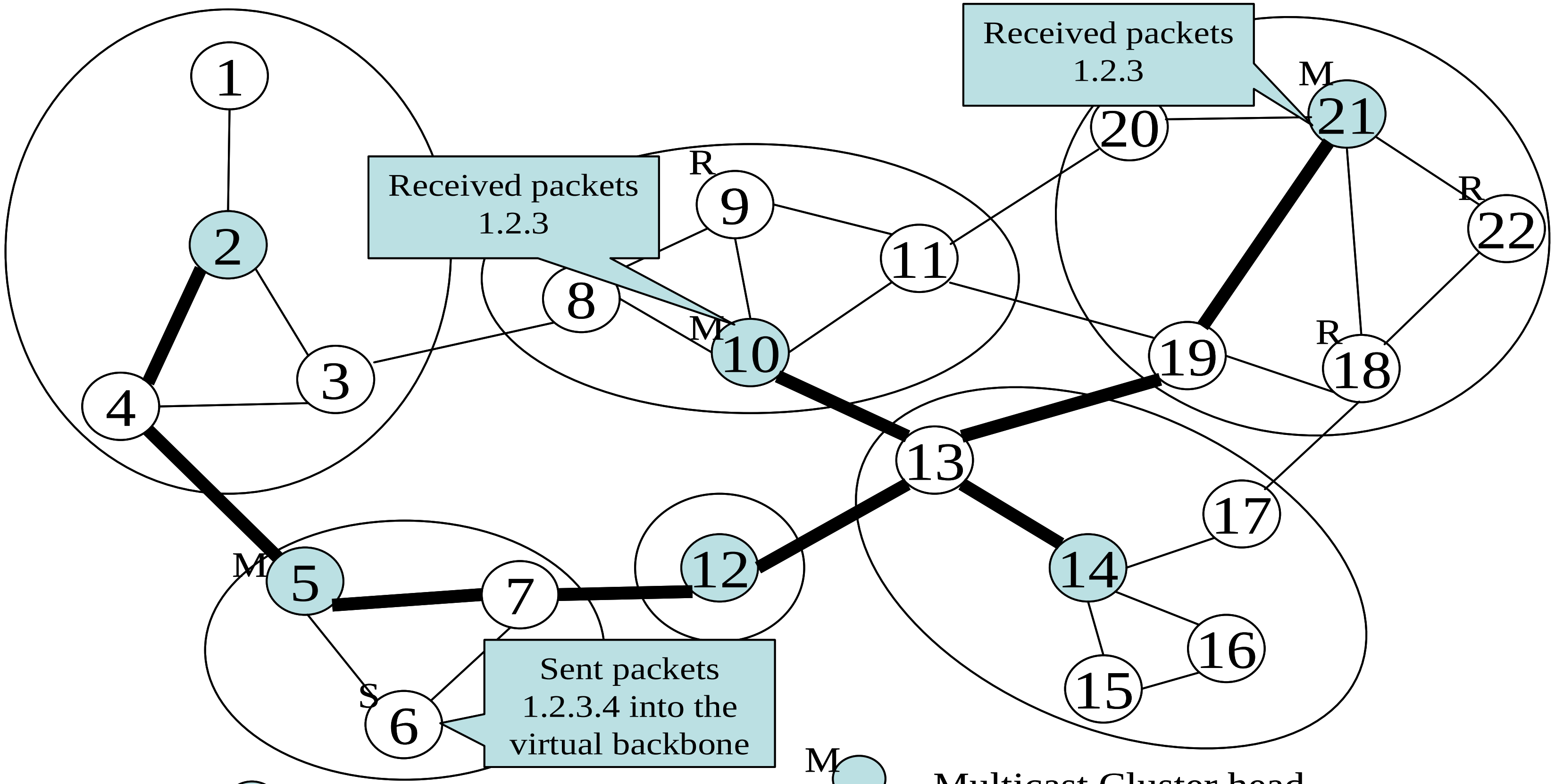


Experimental Results of the Multicast Scheme

- Number of Different Roles vs. Number of Nodes



An Example of Packet Loss Problem



Received packets 1.2.3

Received packets 1.2.3

Sent packets 1.2.3.4 into the virtual backbone

● Clusterhead

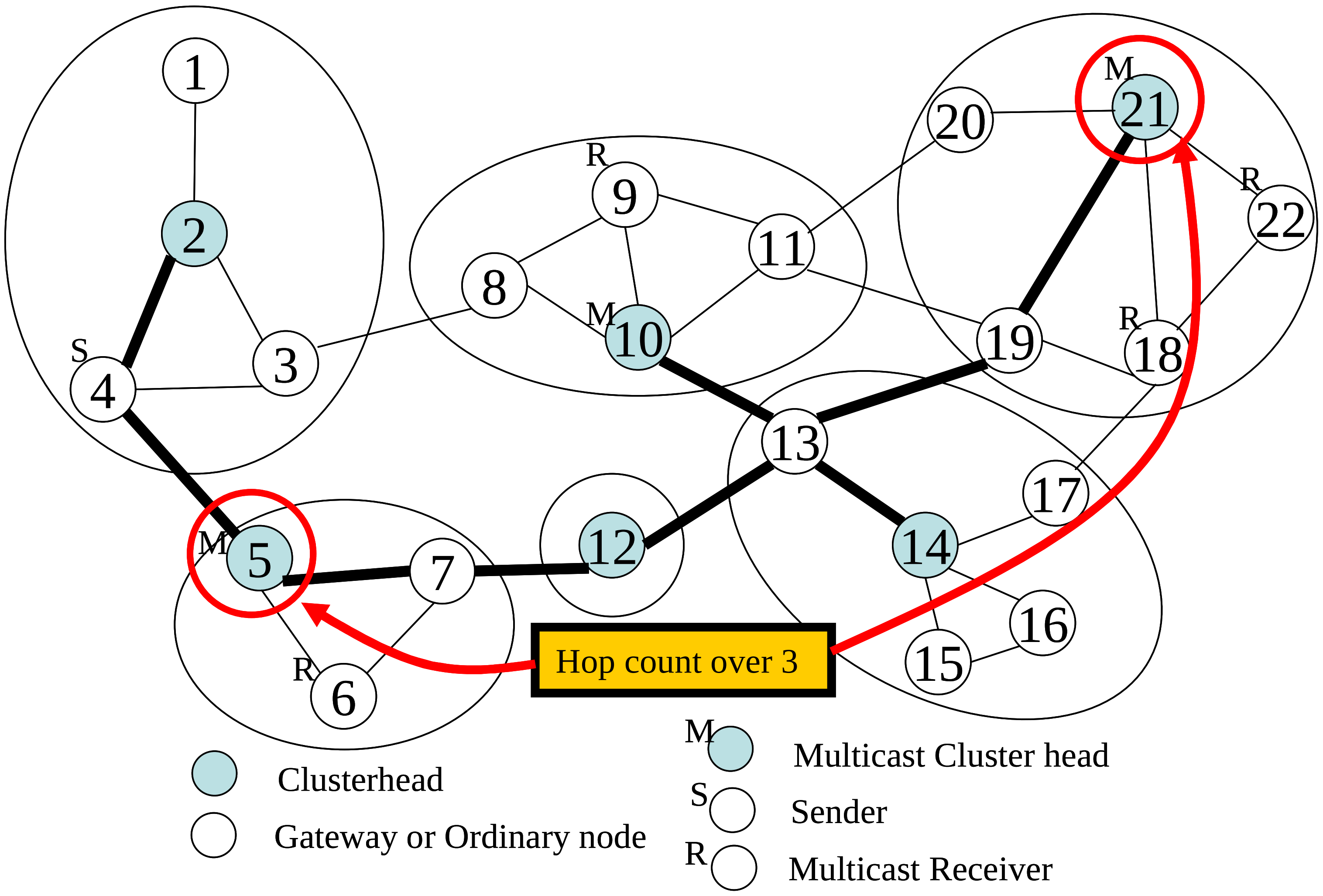
○ Gateway or Ordinary node

M ● Multicast Cluster head

S ○ Sender

R ○ Multicast Receiver

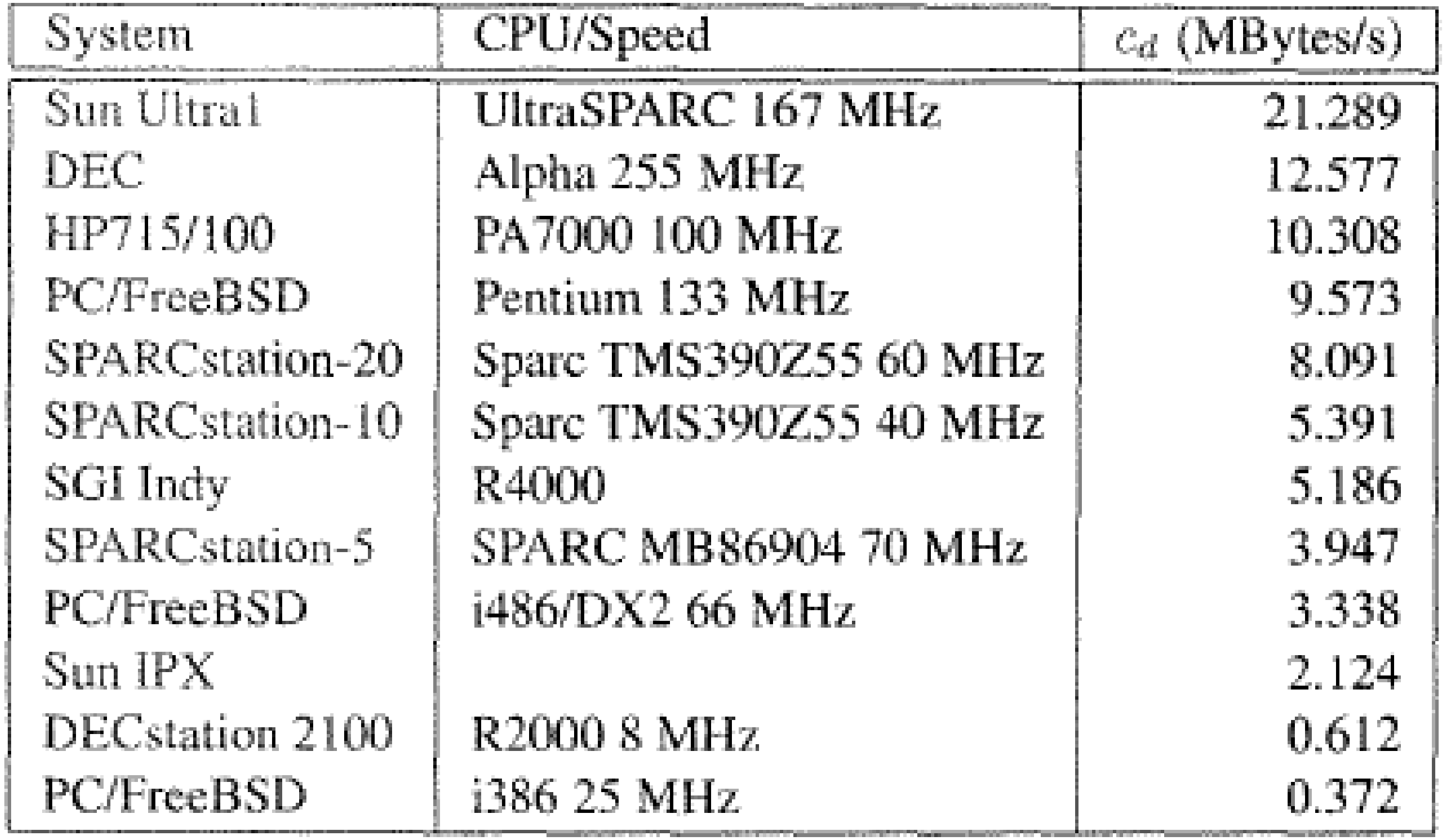
The Problem of HOP_COUNT field is set to 3



FEC Scheme

- Before sending data,
  - The sender separates the data file into many transmission groups (TGs)
  - An (n, k) RS code is applied to each group
  - After encoding the data file, the sender transmits partial redundant data to receivers
- When an RP or receiver receives a data packet
  - It will use the counter R[i] to record how many data packets have been received for each TG_i
  - Detects and recovers the packet loss
- For the receiver, if the R[i]□k
  - It can decode the data packets for TG_i to the original data packets

Speed of the encoding/decoding process on various architectures



System	CPU/Speed	c_d (MBytes/s)
Sun Ultra1	UltraSPARC 167 MHz	21.289
DEC	Alpha 255 MHz	12.577
HP715/100	PA7000 100 MHz	10.308
PC/FreeBSD	Pentium 133 MHz	9.573
SPARCstation-20	Sparc TMS390Z55 60 MHz	8.091
SPARCstation-10	Sparc TMS390Z55 40 MHz	5.391
SGI Indy	R4000	5.186
SPARCstation-5	SPARC MB86904 70 MHz	3.947
PC/FreeBSD	i486/DX2 66 MHz	3.338
Sun IPX		2.124
DECstation 2100	R2000 8 MHz	0.612
PC/FreeBSD	i386 25 MHz	0.372