UCAN: A Unified Cellular and Ad Hoc Network Architecture

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Disclaimer

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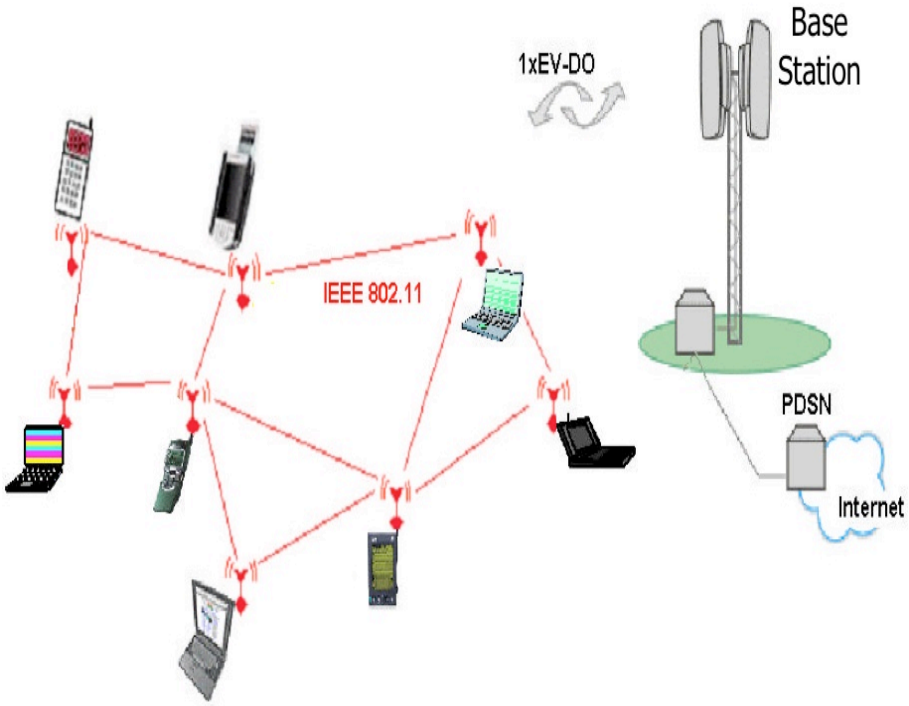
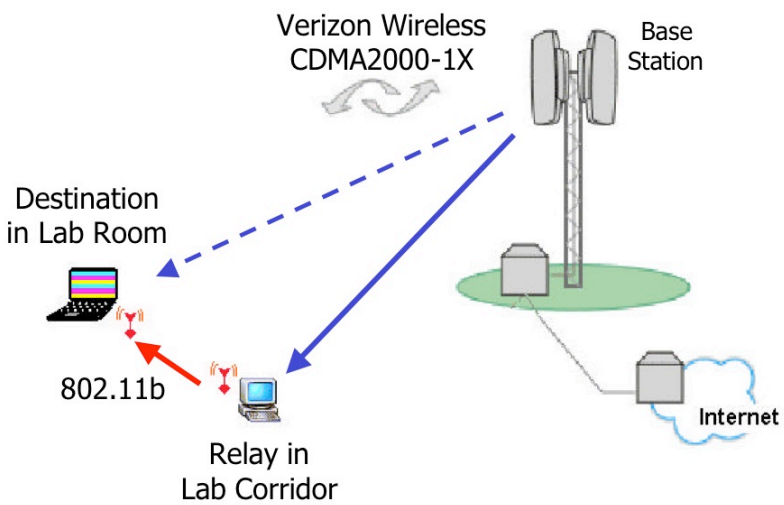
WAN versus LAN



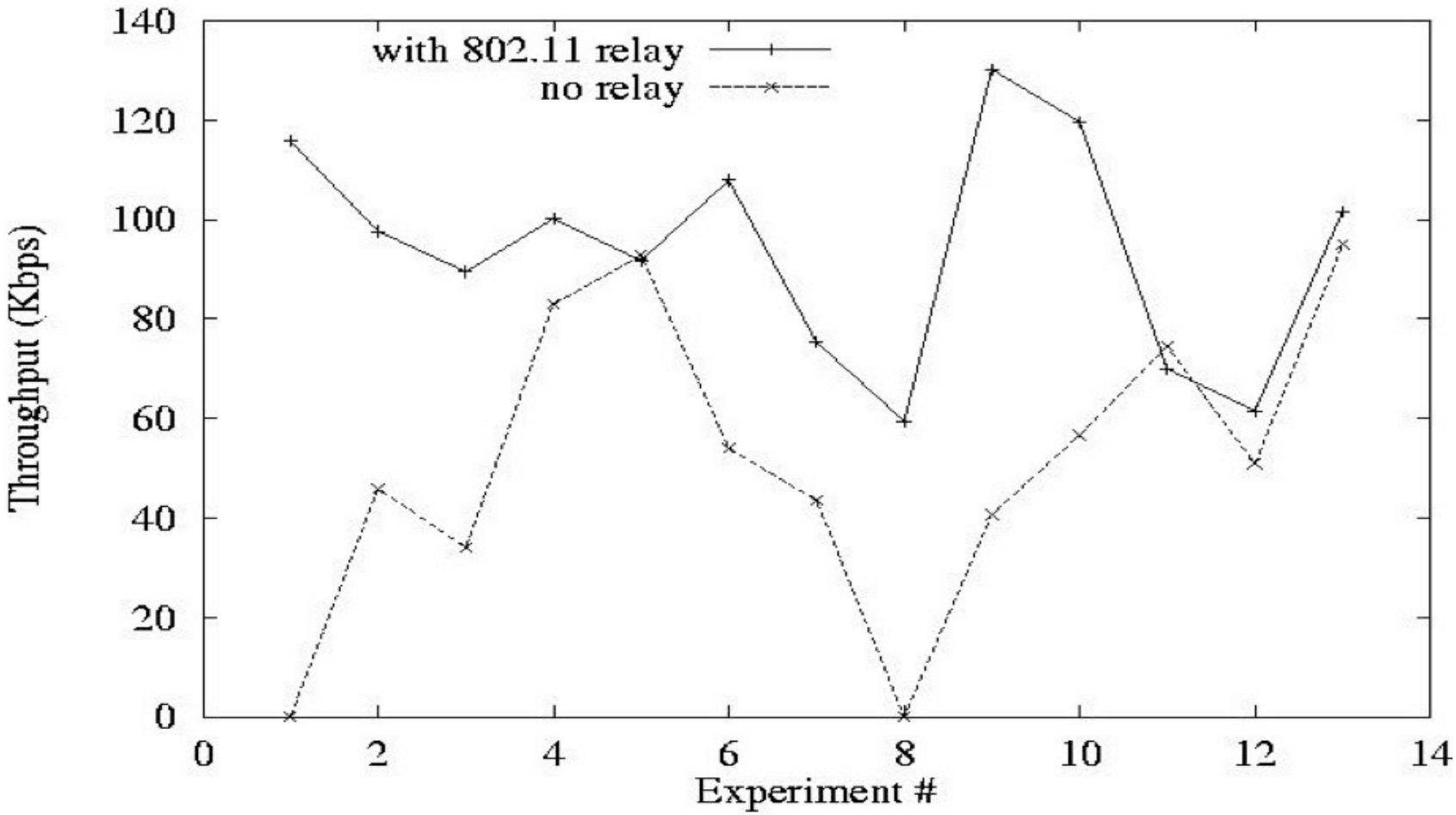
- 3G Network
  - 20km coverage
  - Low data rate
  - Infrastructure
- Wi-fi
  - 250m coverage
  - High data rate
  - Ad-Hoc possible

Experiment



- Laptop and Relay outfitted with Wi-fi and 3G interface.
- Test performed
  - No relay (3G only)
  - Sent to corridor (Wi-fi), relayed to base station (3G)

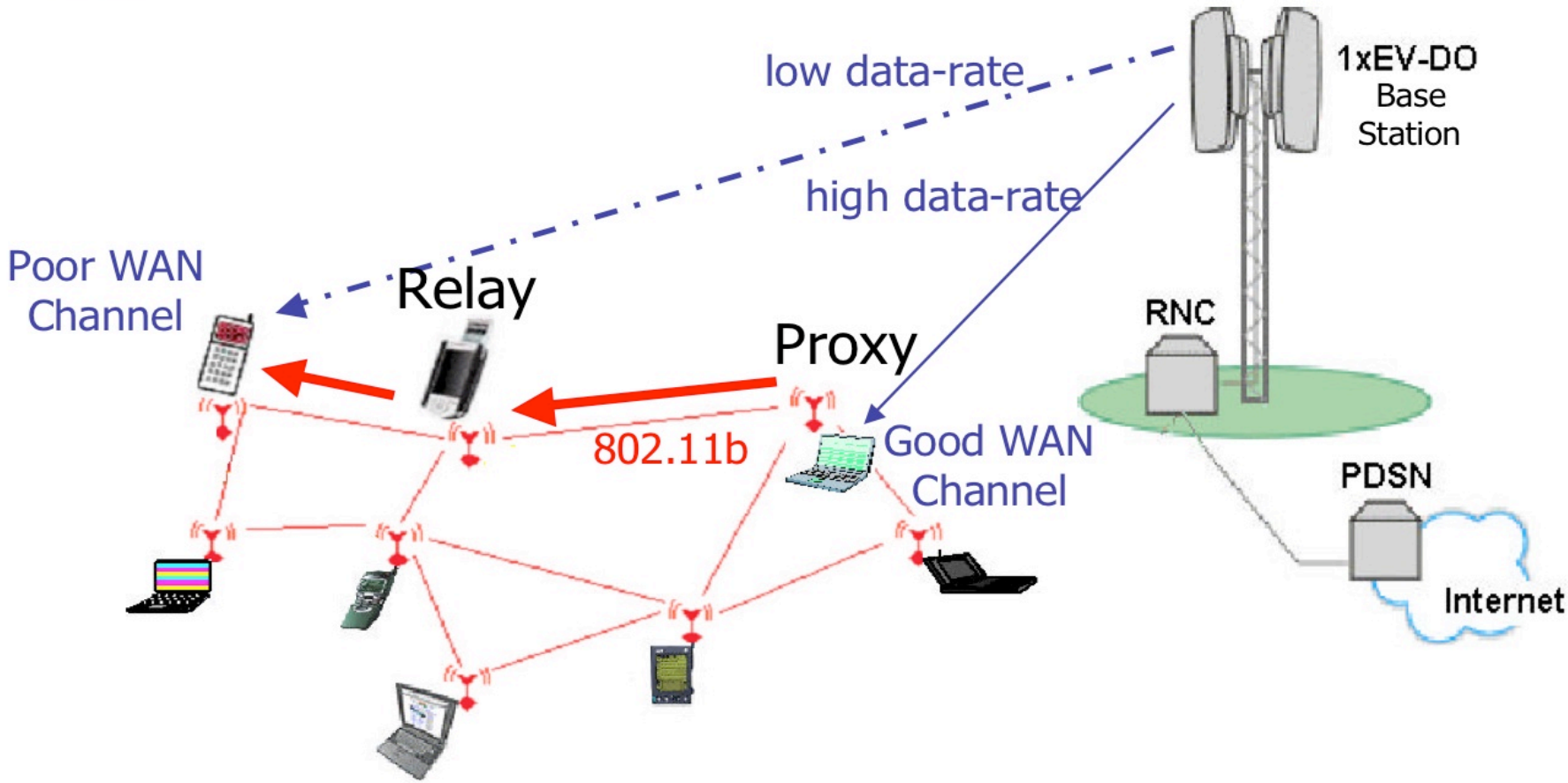
Results


with 802.11 relay
no relay
Throughput (Kbps)
Experiment #
0
20
40
60
80
100
120
140
0
2
4
6
8
10
12
14

Three Observations

- Only managed infrastructure networks can provide “always on” availability
- Ad hoc networks are cost effective given the popularity of Wi-fi enabled devices
- Wi-fi provides much higher data rates than 3G

The Basic Idea



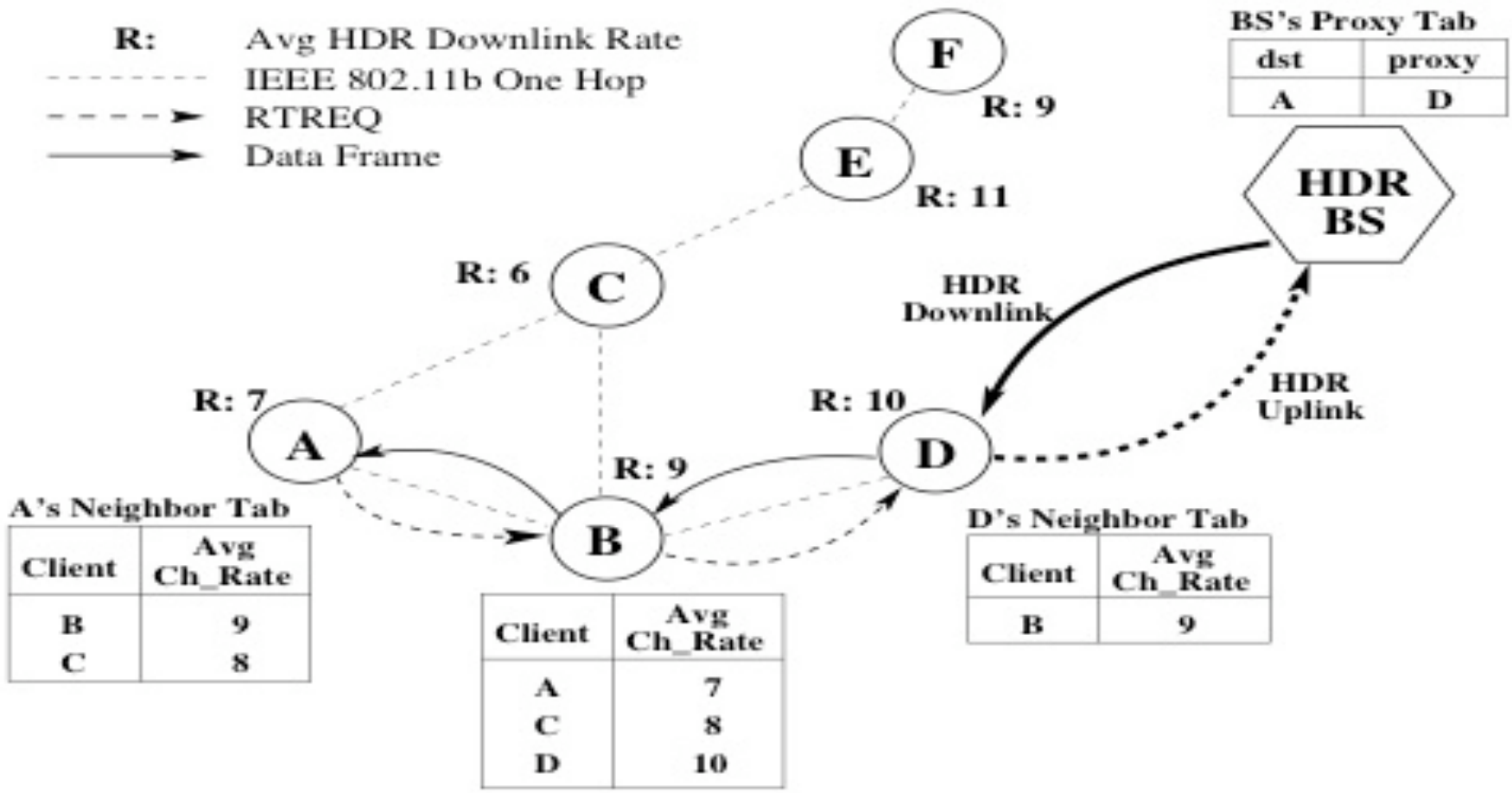
3 Challenges

- How does the receiver find out who to use as a proxy/relay node?
- What if the path gets broken or the proxy 3G signal fades
- How do you convince someone to act as a relay or proxy for someone else?

Proxy discovery

- 2 algorithms:
  - “Greedy”
  - “On-Demand”
- Greedy
  - Each node keeps track of the 3G link strength of each immediate neighbor
- On-Demand
  - Broadcasts to all neighbors, neighbors then contend to act as relay or proxy

Greedy



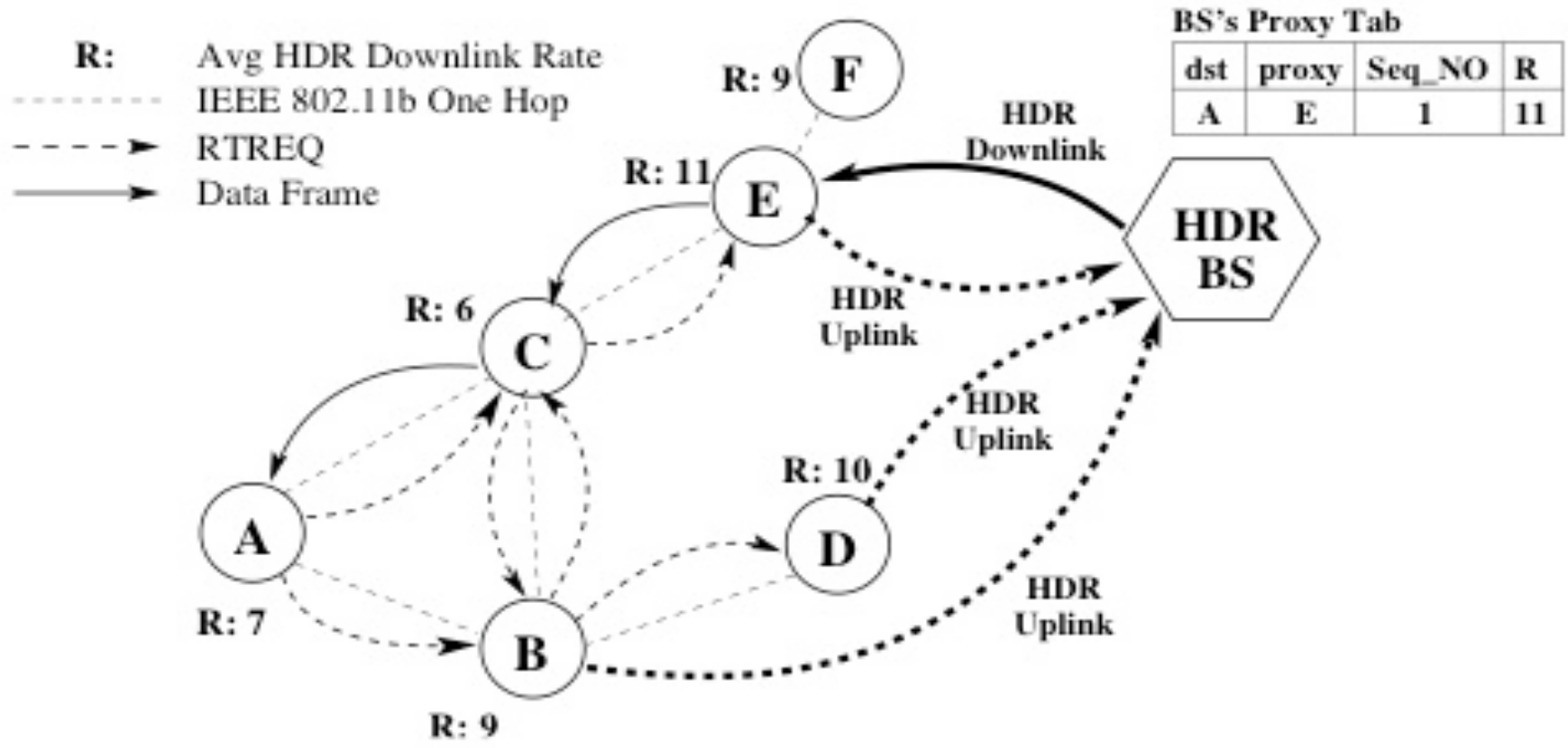
dst	proxy
A	D

Client	Avg Ch_Rate
B	9
C	8

Client	Avg Ch_Rate
A	7
C	8
D	10

Client	Avg Ch_Rate
B	9

On-Demand



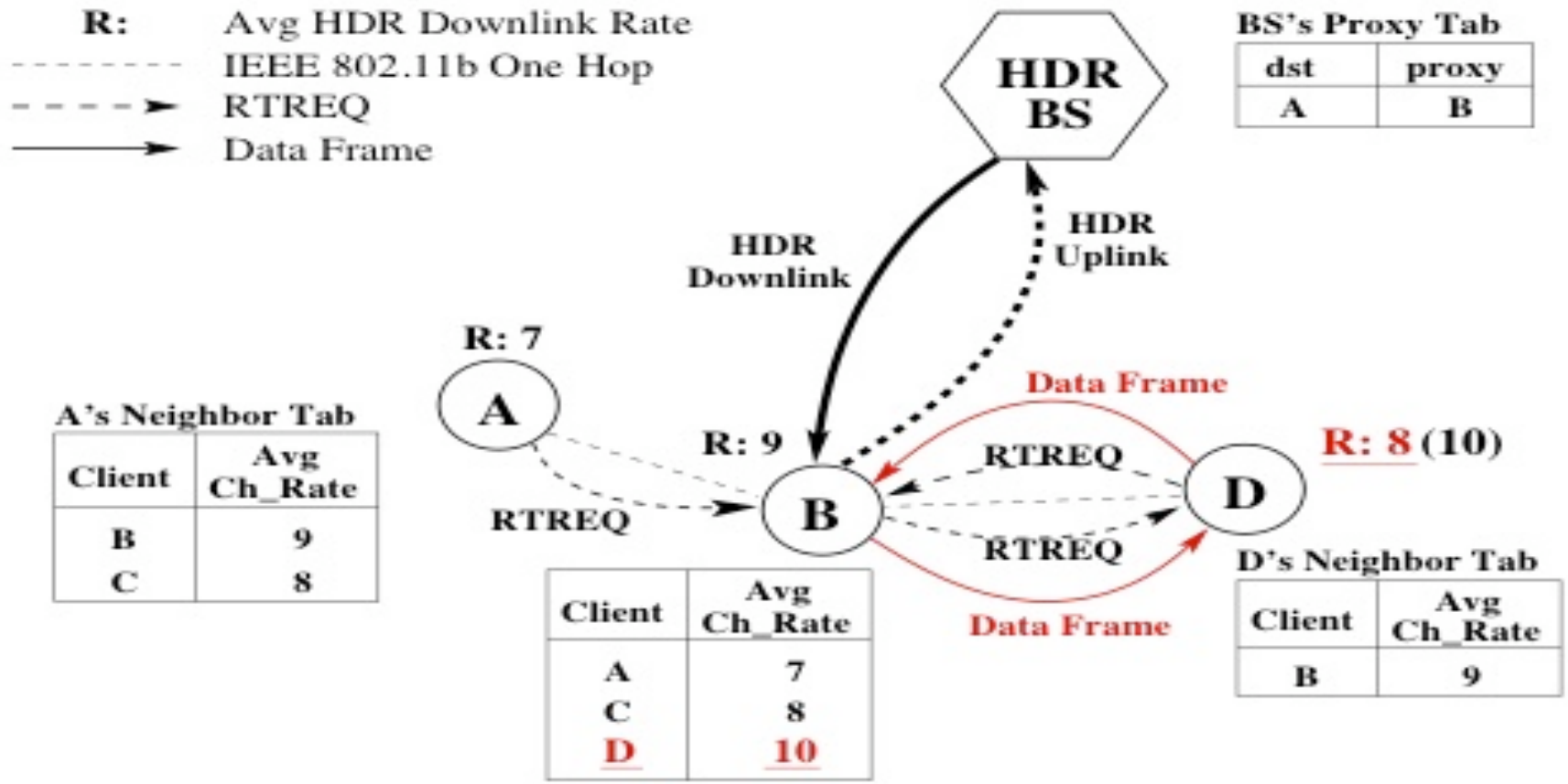
BS's Proxy Tab

dst	proxy	Seq_NO	R
A	E	1	11

Problems

- Routing loops
- Mobile clients can move out of range of Wi-fi, breaking route
- HDR link in proxy can fade to lower than receiving host

Routing Loops



Routing Loops

- Solutions?
  - Include entire route path in the RTREQ message.
- Also helps in secure crediting

Routing Failures and Recovery

- What if one of the nodes (receiver, relay, or proxy) moves out of range and breaks the route?
  - Solution: That client notifies base station through 3G, which then notifies receiver of route failure.

Proxy Problems

- What if the 3G link of the receiver, after the route has been established, becomes higher than the proxy?
  - Solution: have proxy send HDR link strength to receiver on data packets, allowing the receiver to keep track of whether proxy has better downlink strength.

Incentives

- We want to encourage nodes to act as proxies or relays, but how?
  - Decreases battery life
- Secure Crediting
  - Giving credit to those nodes that act as proxies/relays, rewarding them for doing so

Secure Credit

- Assigning Credits: two abuses can occur
  - Addition of extra clients
  - Deletion of legitimate clients

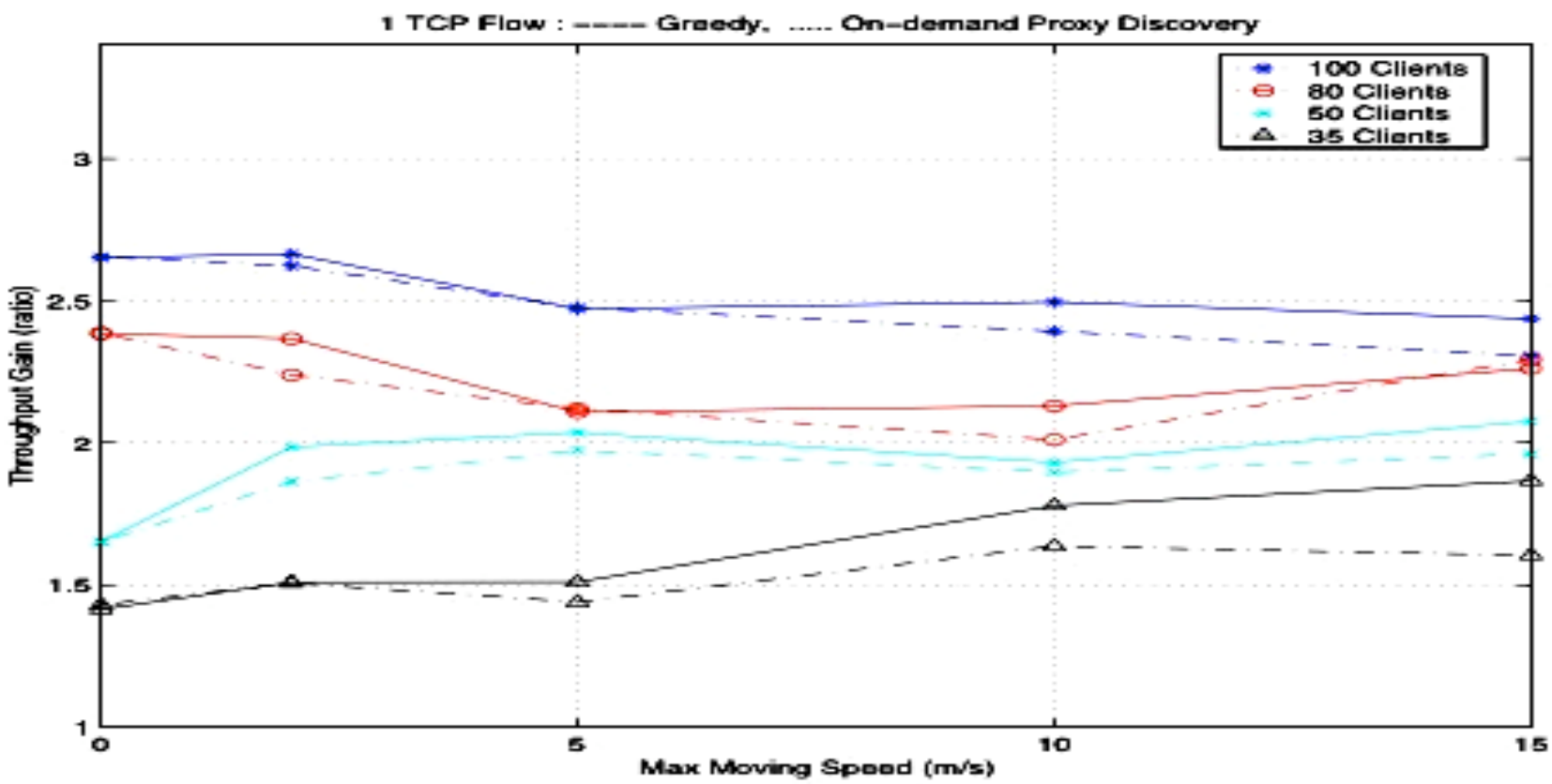
Fairness

- $T_i(t)$ - The average throughput in a past time window for node i
- $R_i(t)$ - The instantaneous downlink rate for node i at time t
- Proportional fairness schedule chooses the client with the smallest T/R ratio at every time slot

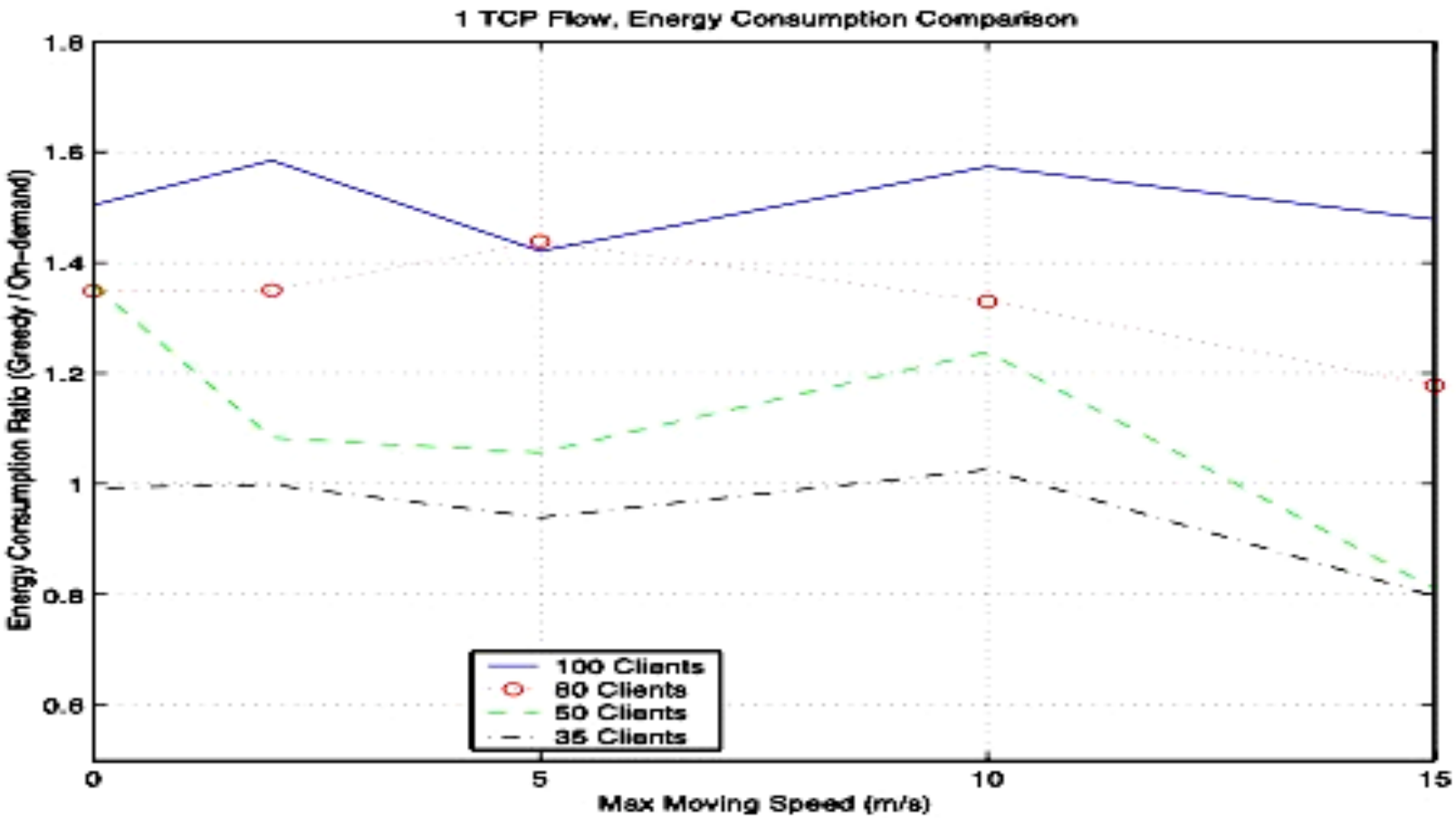
Question

- What T and what R do you use?
  - Cannot use simply either the destination or the proxy's values. Why?
- T
  - Update T with the number of bits that the base station transmits to it, either directly or through a proxy
- R
  - What would happen if we used the proxy's R?

Simulation Results: Throughput



Simulation Results: Energy Cost



Simulation Summary

- Throughput
  - 1 Average neighbor: 50% gain in throughput
  - 4 Average neighbors: 210% gain in throughput
- Node mobility does not greatly affect results, but node density does.

Simulation Summary

- Greedy proxy discovery
  - Uses 1.5 times the amount of energy on 802.11 than on-demand
- On-Demand proxy discovery
  - Uses up to 7 times higher overhead (sending additional data to base station) on 3G

Outstanding Issues?

- Additional hardware costs
  - 3G and 802.11
- Energy consumption
  - Power consumed for every time node acts as receiver, relay, or proxy
- Proxy discovery
  - Does not take into account 802.11 congestion when determining route