

Query Control Mechanisms for the Zone Routing Protocol (ZRP)

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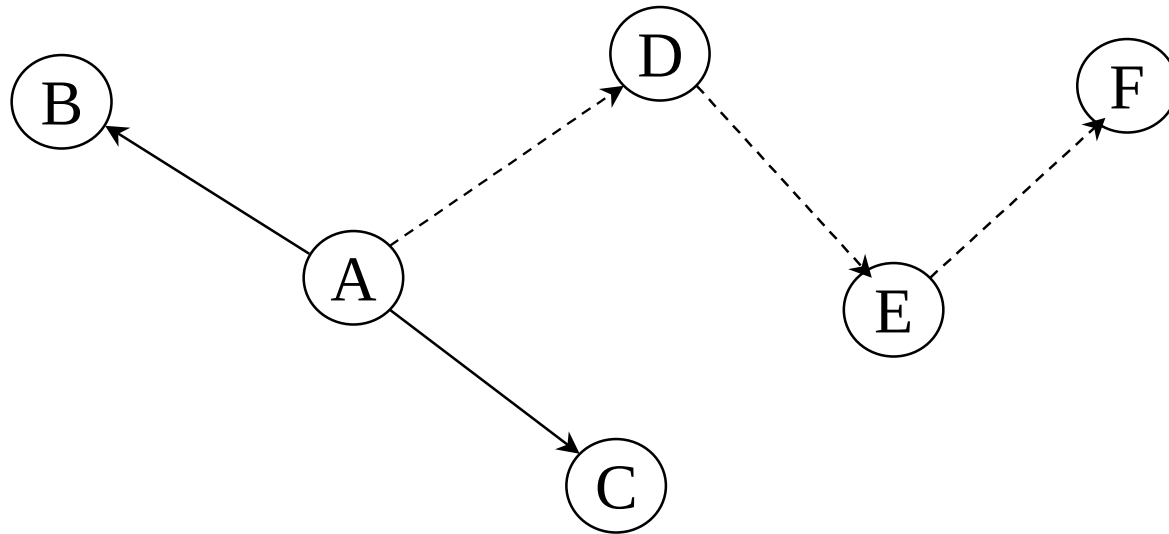
Agenda

- ◆ Introduction -
Routing in Mobile Ad-Hoc Networks
- ◆ The Zone Routing Protocol (ZRP)
- ◆ Query Control Mechanisms
- ◆ Simulation Description
- ◆ Results
- ◆ Conclusions

Mobile Ad-Hoc Networking

- ◆ Rapidly deploy a regional (~ 100 m - 100 km) network of mobile hosts, anywhere.
- ◆ Why? Coordinate Efforts of Distributed Systems
 - military (battlefield communications)
 - law enforcement
 - construction
 - emergency response

Mobile Ad-Hoc Networking

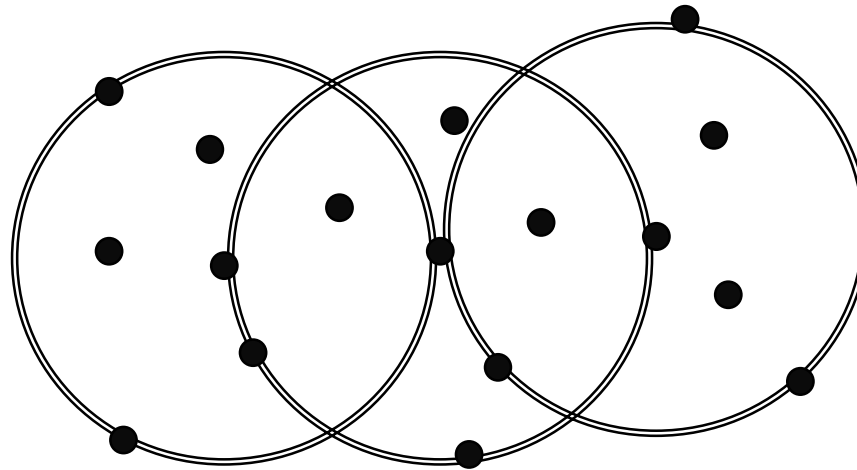


- no infrastructure !
- short range direct communication: A-B , A-C
- nodes act as relays: multihop routing: A-D-E-F

Traditional Routing Schemes

- ◆ Proactive (i.e. distance vector, link state)
 - maintain up-to-date view of network
 - extremely high traffic
 - most routes are not used
- ◆ Reactive (i.e. route query - response)
 - acquire routes on demand
 - high traffic
 - route query delays

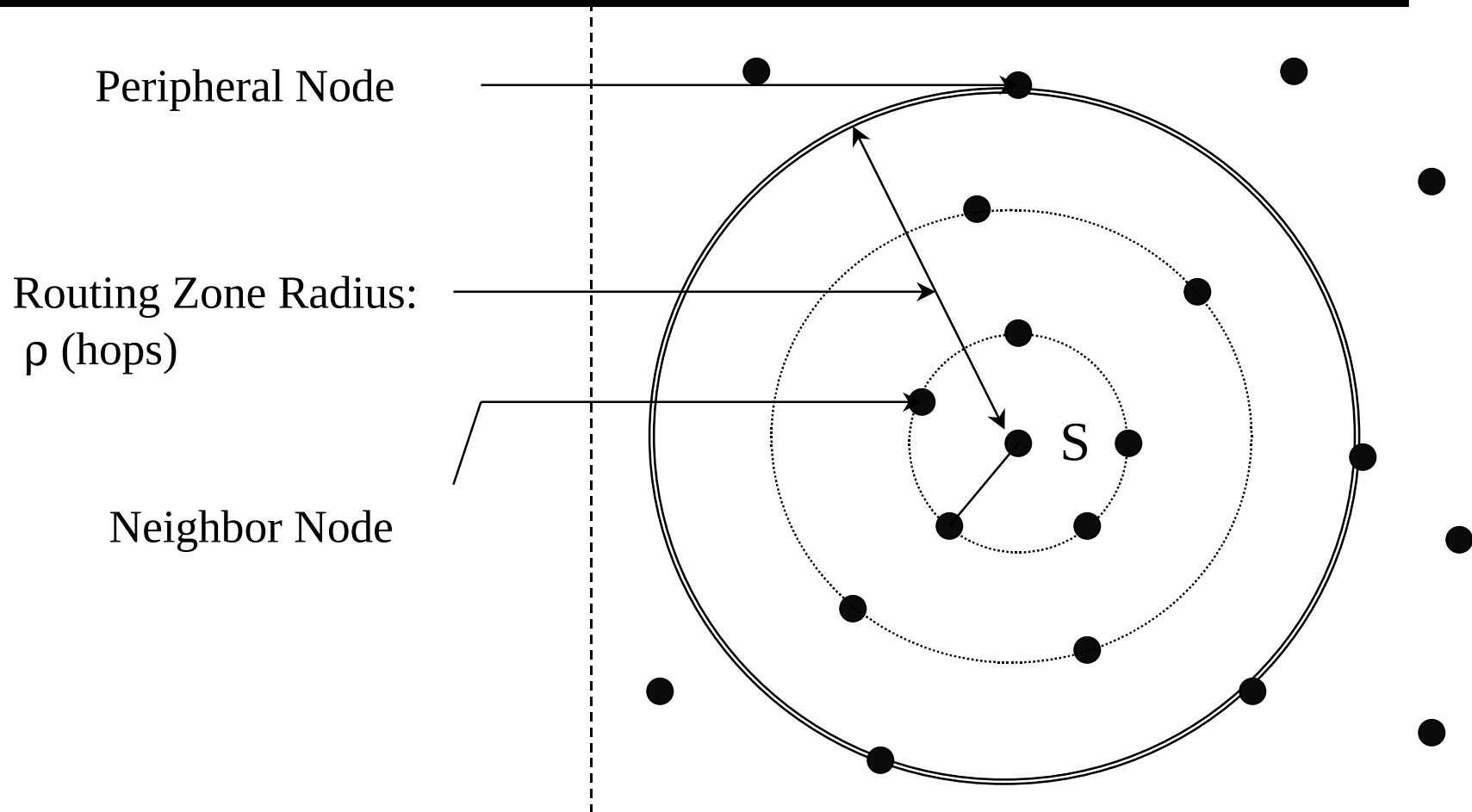
A Hybrid Approach: Introducing the Routing Zone



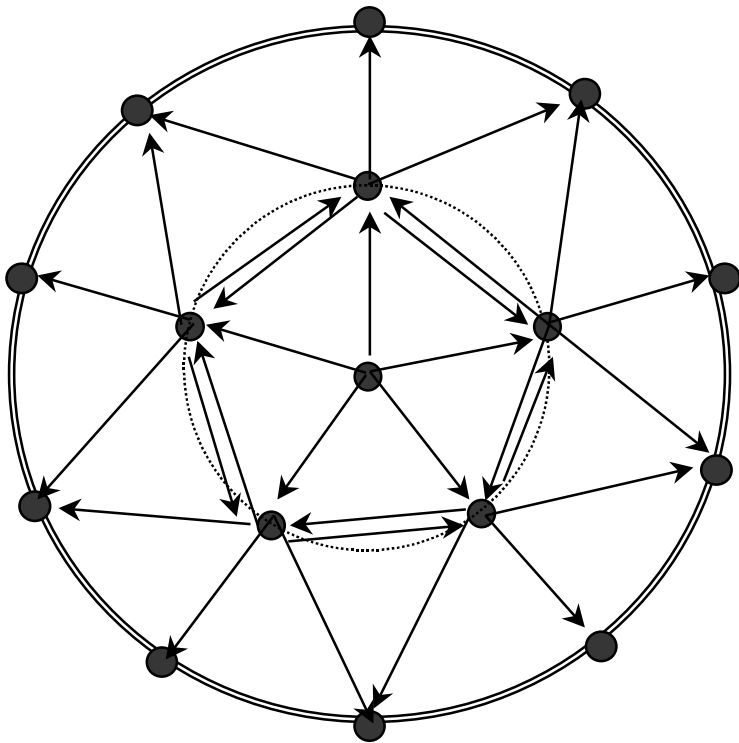
Each node:

- ◆ **Proactively** tracks topology within its own routing zone
- ◆ **Reactively** acquires routes to nodes beyond routing zone by querying between overlapping zones

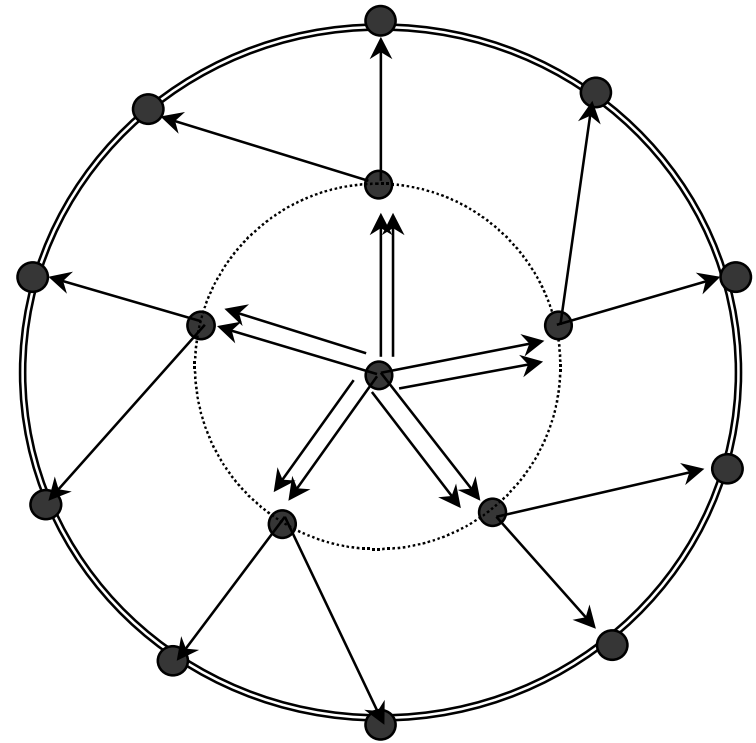
Anatomy of a Routing Zone



Bordercasting

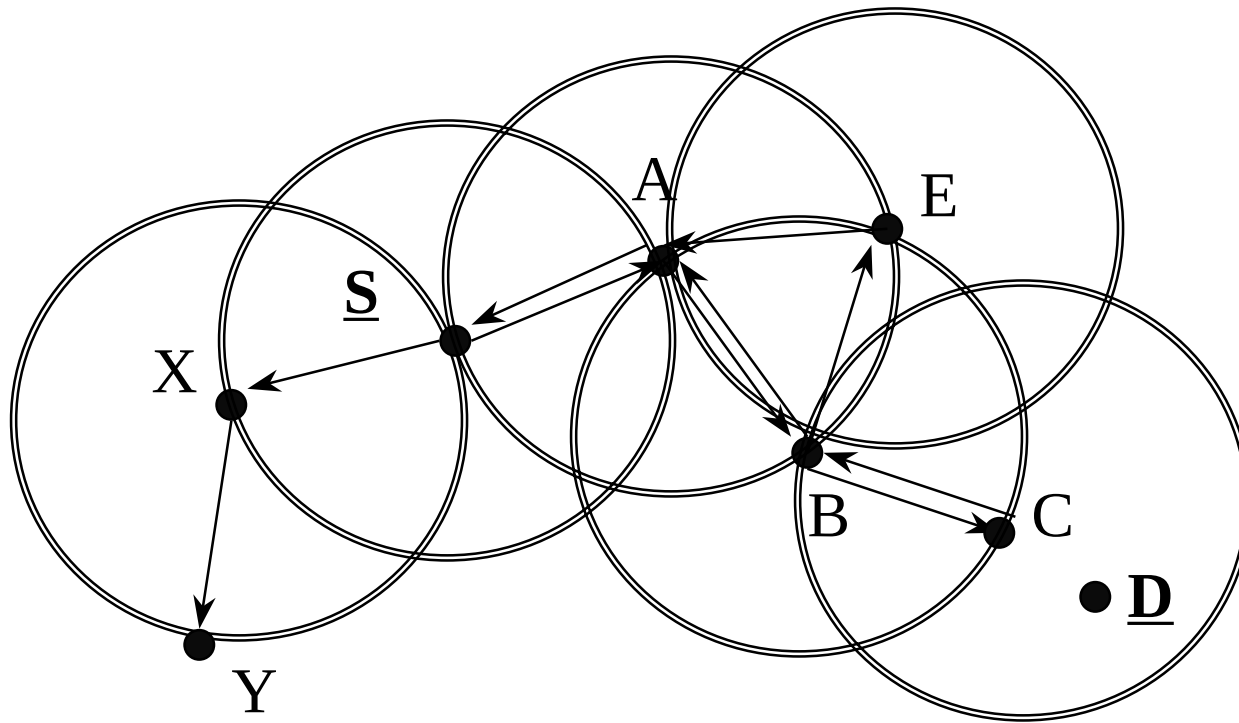


flooding: 30 transmissions



bordercasting: 20 transmissions

Route Discovery Example



- 1) S-X-Y: terminates because Y has no peripheral nodes
- 2) S-A-B-E-A: terminates because thread returned to A
- 3) S-A-B-C: successful discovery !

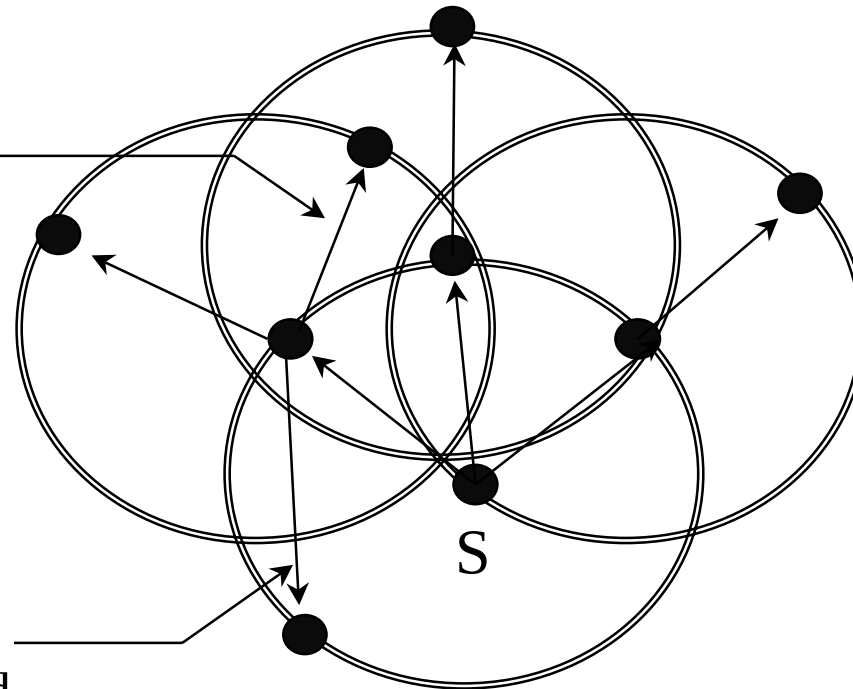
Benefits of Routing Zones

- ◆ Proactive: maintain routing zone
 - routing traffic significantly reduced
 - routes used more often
- ◆ Reactive: query only peripheral nodes
 - fewer query packets
 - shorter query packets *
 - reduced delay
 - routes more robust

Routing Zones Overlap

thread enters a zone previously
queried by another thread

thread loops back onto a
zone which it already queried.



Overlapping Zones May Lead to Excess Control Traffic

Encourage Outward Propagation of Queries

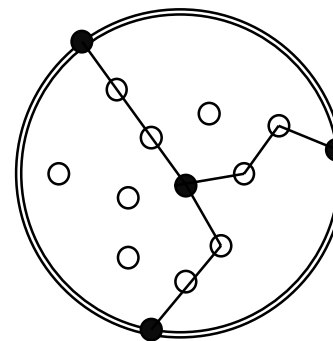
- ◆ Terminate threads that return to a queried node (not strong enough)
- ◆ Terminate threads that return to a queried zone
 - threads that loopback on themselves
 - threads that overlap with other threads
- ◆ Prevent overlap

Query Control Mechanisms

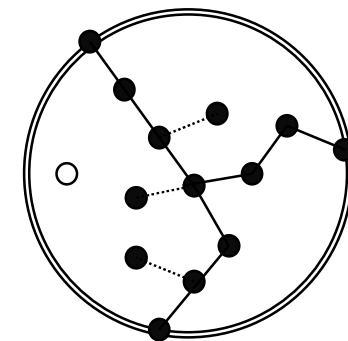
Terminate threads when they appear in previously queried zones

- Query Detection (QD)

intermediate nodes can
detect passing threads



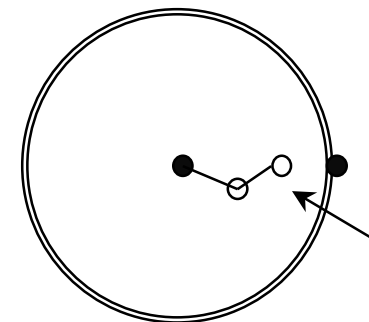
w/o QD



w/ QD

- Early Termination (ET)

intermediate nodes can terminate
previously detected threads

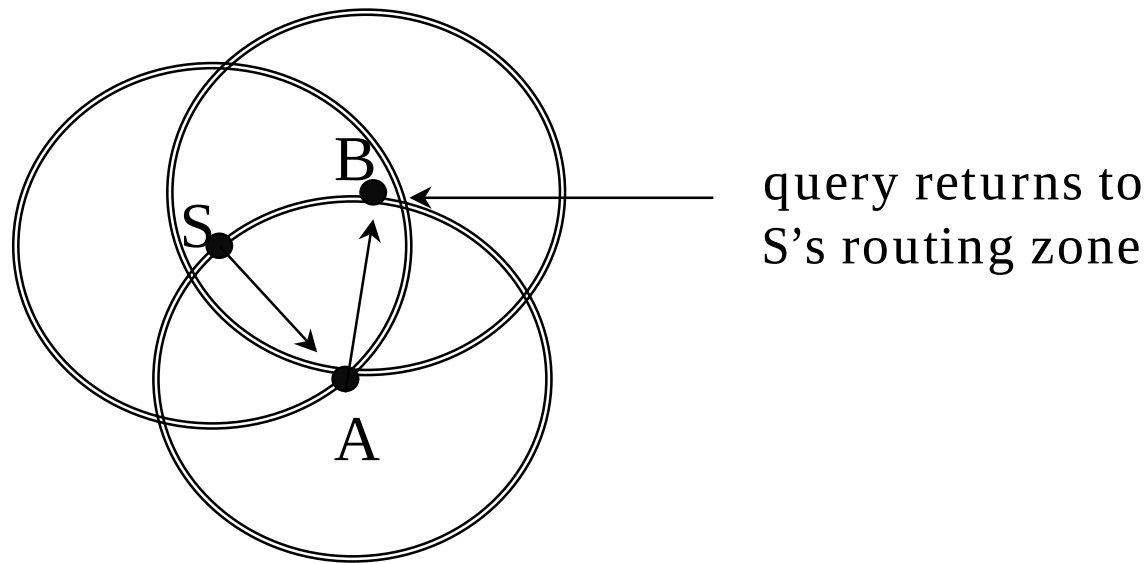


previously
detected
query

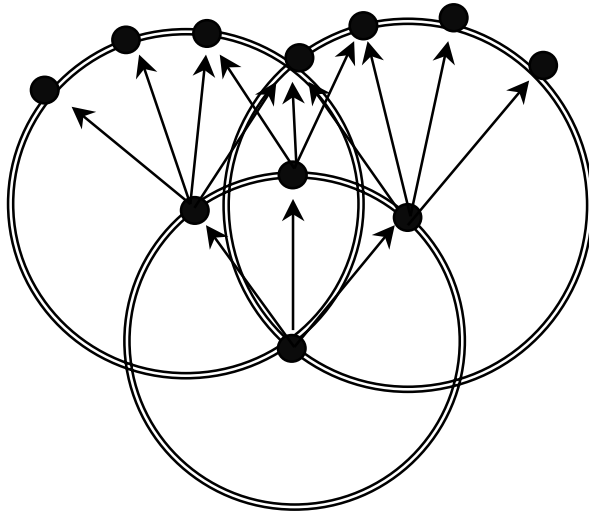
Query Control Mechanisms (cont'd)

Special Case: thread loops back on itself

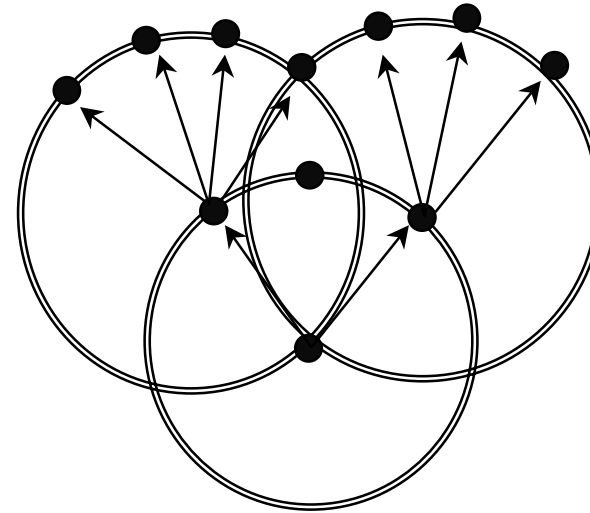
- Loopback Termination (LT) (100% effective)
use accumulated route to identify loopback condition



Query Overlap Prevention: Selective BorderCasting (SBC)



full bordercasting



selective bordercasting

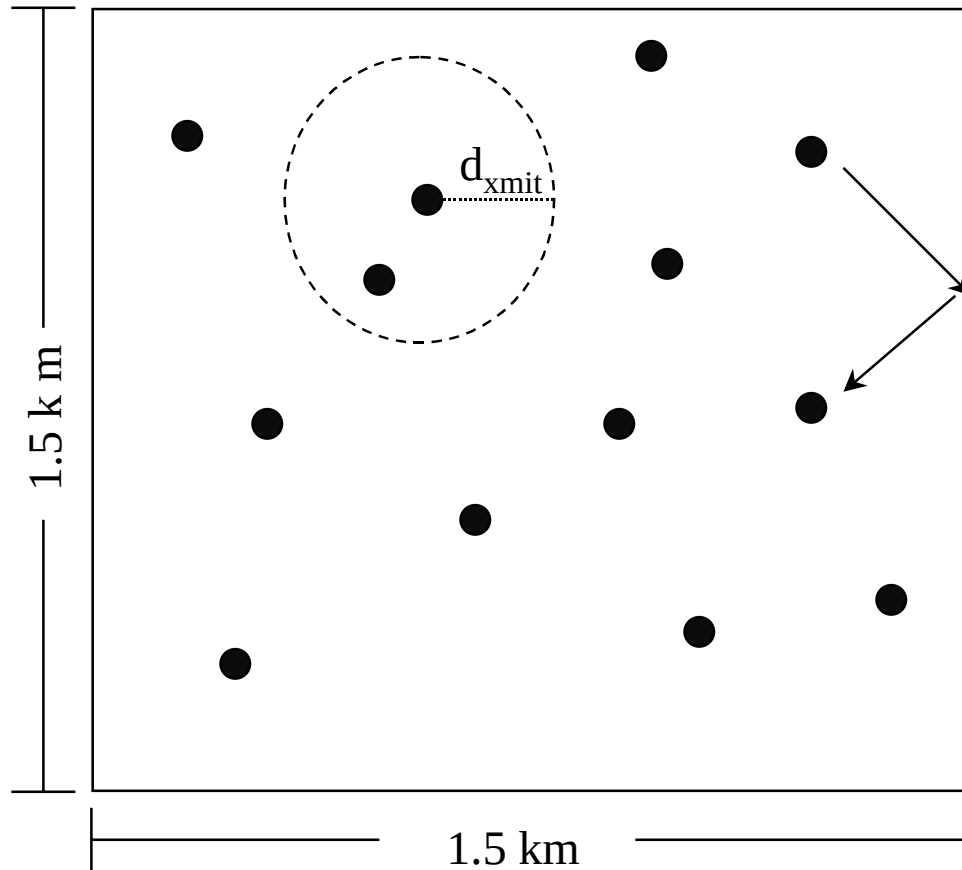
Cover a given set of “outer” peripheral nodes with the
fewest “inner” peripheral nodes

Implementing Selective Bordercasting

- ◆ Extended Routing Zone (at least 2ρ hops):
- ◆ For each received query packet . . .
 - Compute “best” SBC assignment
 - Send SBC assignments

Do the benefits offset the cost?

Simulation Model



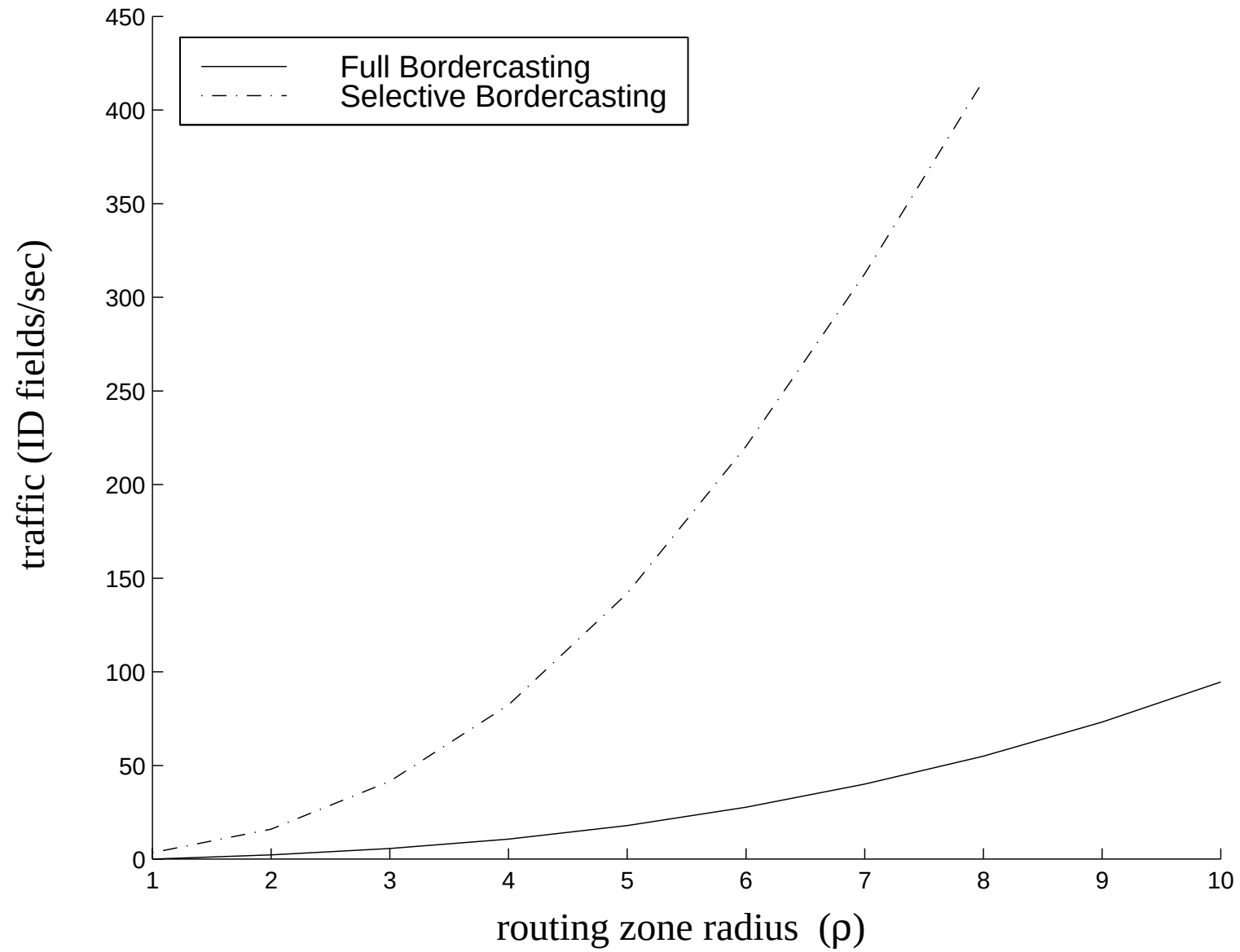
Static Simulation Parameters

d_{xmit}	100m
# nodes	500

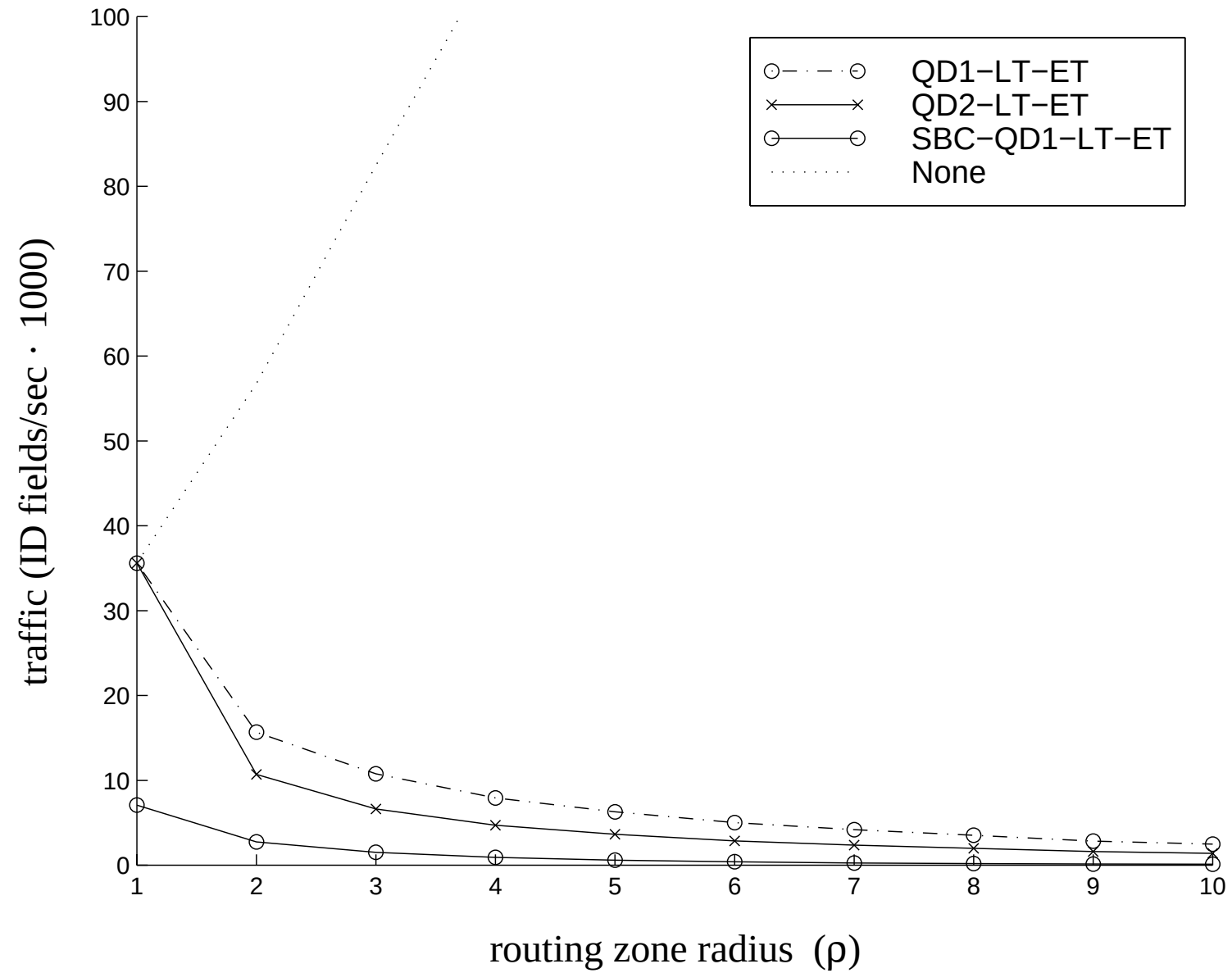
Variable Simulation Parameters

v	10 - 75 m/s
ρ	1-10 hops
R_{query}	0.1 - 10 queries/sec

IARP Traffic per m/s

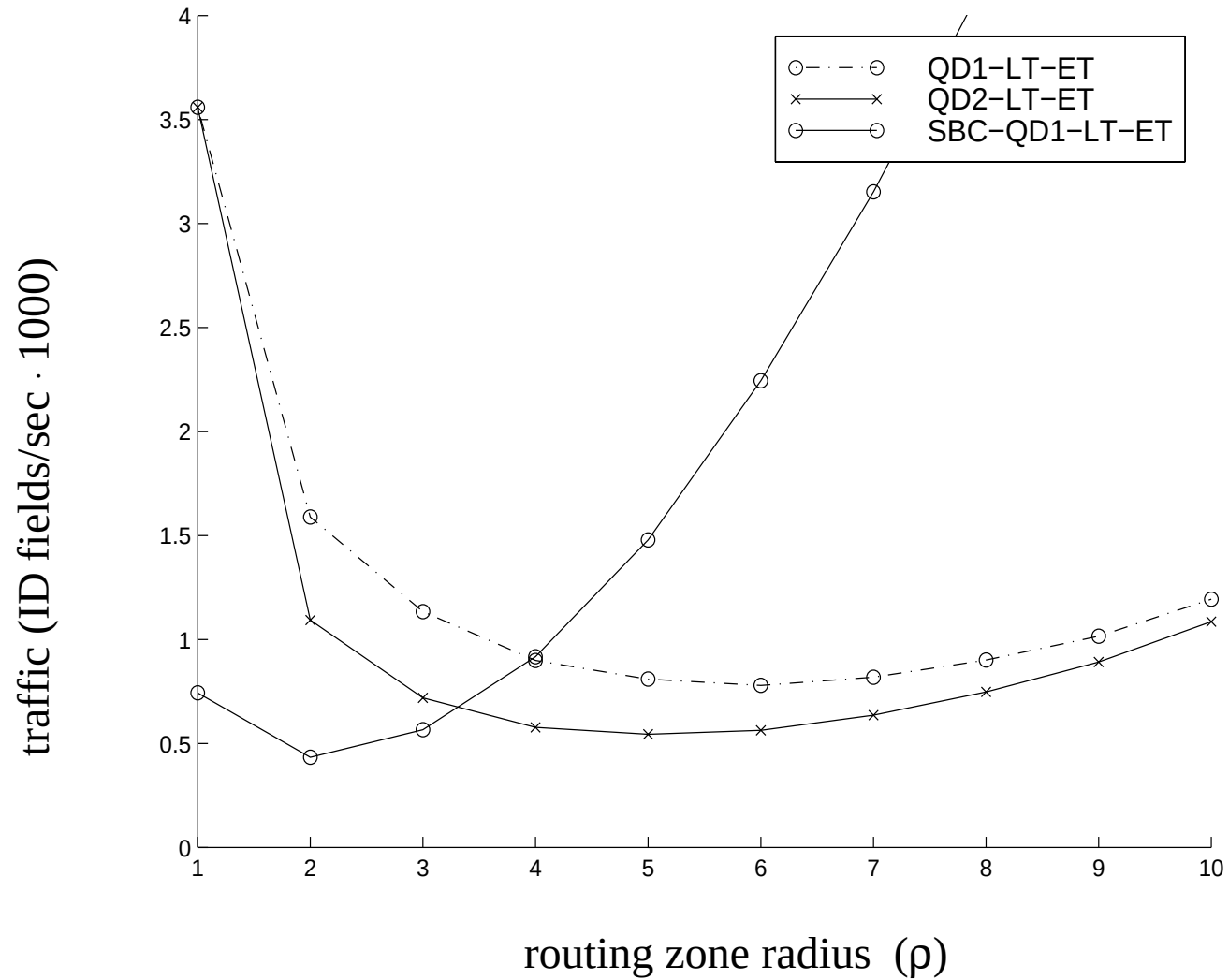


IERP Traffic per Route Discovery

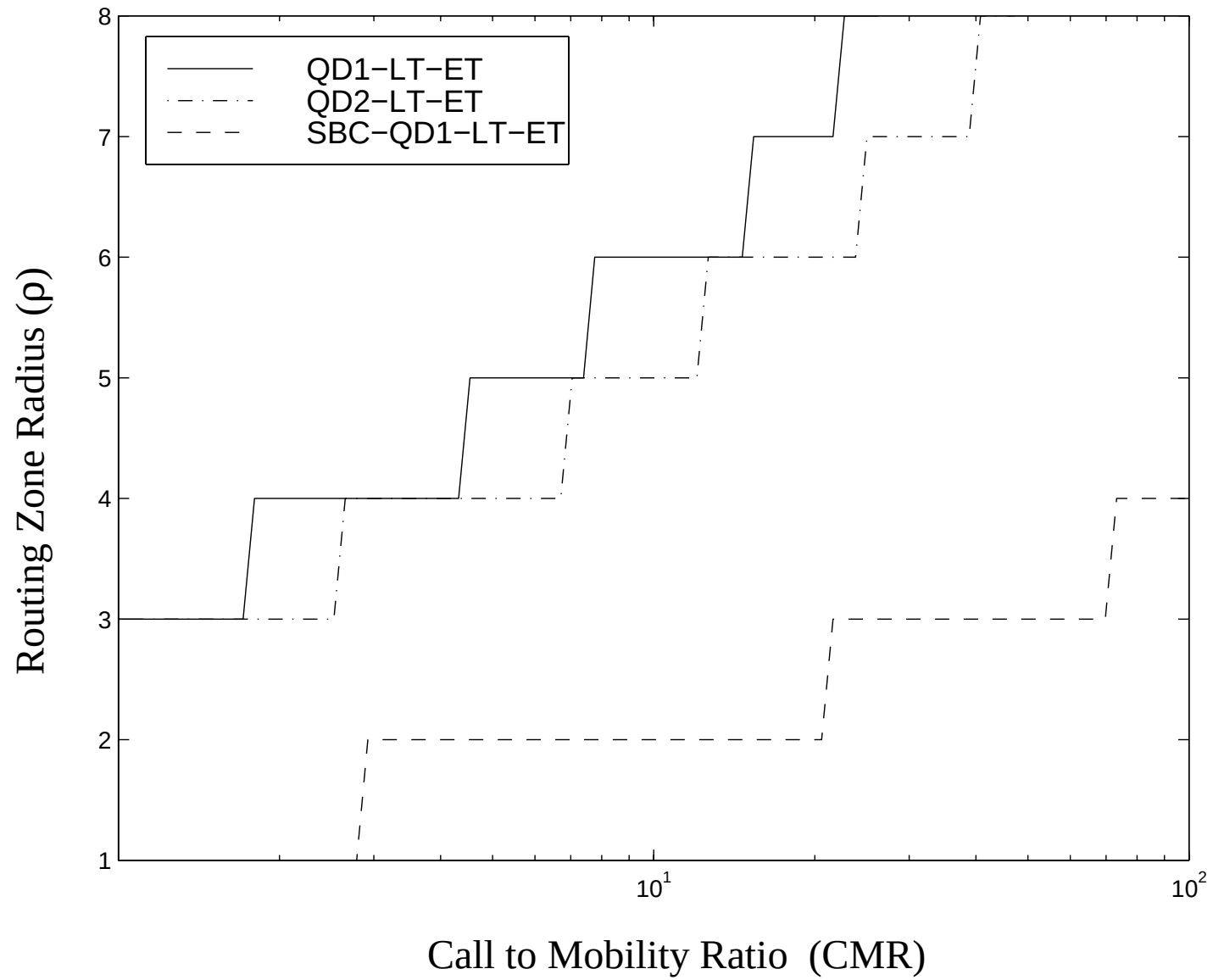


Total ZRP Control Traffic

$$v = 10 \text{ [m/sec]} \quad R_{\text{query}} = 0.1 \text{ [query/sec]}$$



Optimal ZRP Configuration



Conclusions

- ◆ ZRP can perform worse than flooding without proper query control mechanisms.
- ◆ QD, ET and LT provide significant improvements compared with purely reactive ($\rho = 1$) and purely proactive schemes ($\rho \rightarrow \infty$).
- ◆ Optimal ZRP radius is an increasing function of the Call-to-Mobility Ratio (CMR).
- ◆ Use of SBC depends on delay and computational complexity considerations.