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The Broadcast Storm Problem in a Mobile Ad Hoc Network

Introduction

- Wireless communication and mobile devices.
- Mobile Ad hoc NETwork(MANET):
  - Unlimited possibility of movement.
  - No base station.
  - Multi-hop communication instead of single-hop.
- Used on battlefields or major disaster areas.

Network

- Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA).
- No global network topology information.
- No collision detection in channel.
- Broadcast as the simplest way of sending data.
- Main issues:
  - Redundant broadcasts.
  - Heavy contention.

Ideas

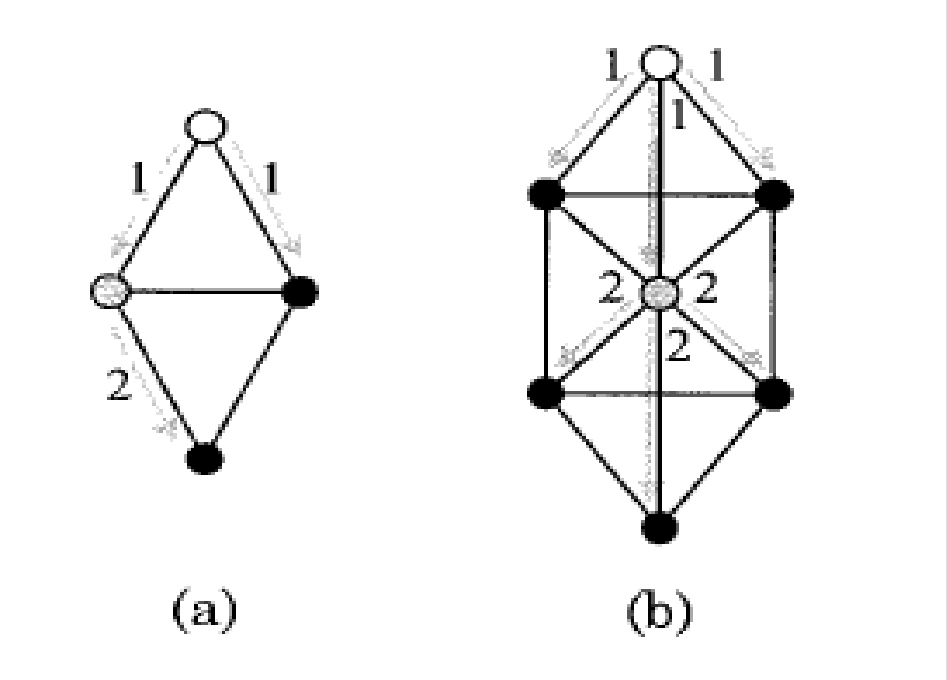
- Probabilistic scheme.
- Counter-based scheme.
- Distance-based scheme.
- Location-based scheme.
- Cluster-based scheme.

Broadcast features

- Spontaneous,
- Unreliable,
- Messages can be distinguished from each other (source id and sequence number).

Flooding

- Cost is n transmissions for n hosts in network.
- Many redundant broadcasts.
- Contention.



Mathematics

- Rebroadcast can increase coverage: 61% is maximum, 41% on average.
- With third node we have 19% on average. For k > 3 coverage is below 5%.
- Contention – 59% for three nodes, above 80% for at least 7.

Probabilistic scheme

- On receiving a broadcast message for the first time, a host will rebroadcast it with probability P.
- For P = 1 this solution is equivalent to flooding.
- Before rebroadcasting a node waits for random amount of time.

Counter-based scheme

- Counter c tells us how many times the message was received.
- When c is greater than a fixed value a node doesn't send the message.
- 1. Initialize c = 1 when the message is received for the first time.
- 2. Wait for a random amount of time and then send.
- 3. Message is on the air, exit.
- 4. c++, if c < C goto 2.
- 5. Don't send, exit.

Distance-based scheme

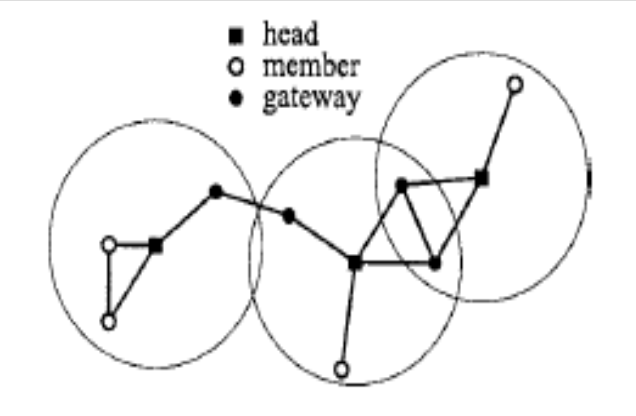
- Relative distance between nodes is used whether to send or not to sent the message.
- 1. Let d = distance to the broadcasting host when receiving the message for the first time.
- 2, 3 i 5 as before.
- 4. d = min(d, distance to the broadcasting host), if d > D goto 2.
- Distance can be estimated from the signal strength.

Location-based scheme

- We use additional information provided by GPS module. This allows us to count the additional coverage.
- Threshold $0 < A < 0.61$.
- Calculations are difficult, so we use convex polygons.
- Send the message if and only if a node is not located within a convex polygon formed by circles' centres.
- We can lose no more than 22% of coverage.

Cluster-based solution

- Different kinds of nodes:



- Every node has its id which allows to determine role.
- Uses one of previous solutions whether to send or not to send.

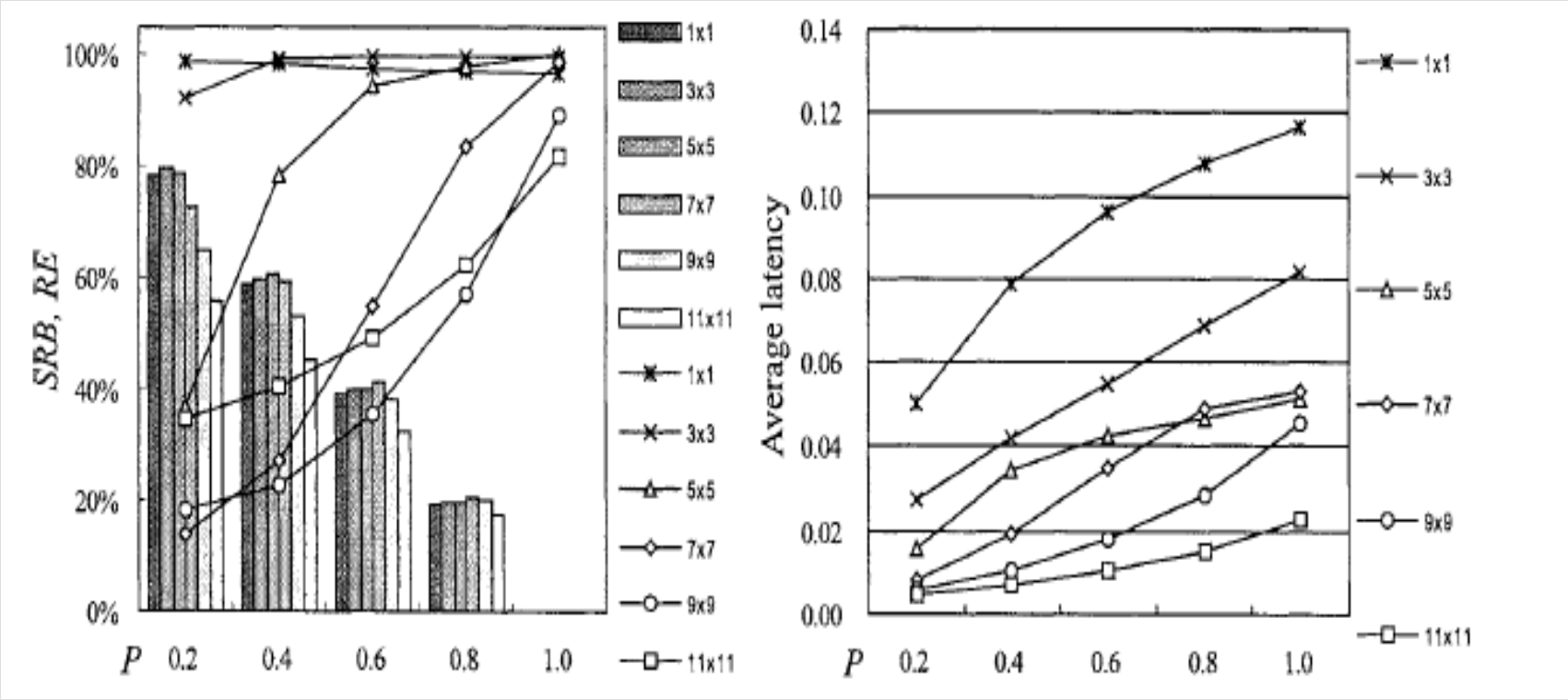
Tests

- Transmission range – 500 metres.
- Message size – 280 bytes.
- Speed – 1Mbps.
- 100 nodes.
- Map size – squares: 1, 3, 5, 7, 9, 11 (x 500m).
- Nodes are placed in a random way, they can move around.
- Random waiting from 0 to 31 units.

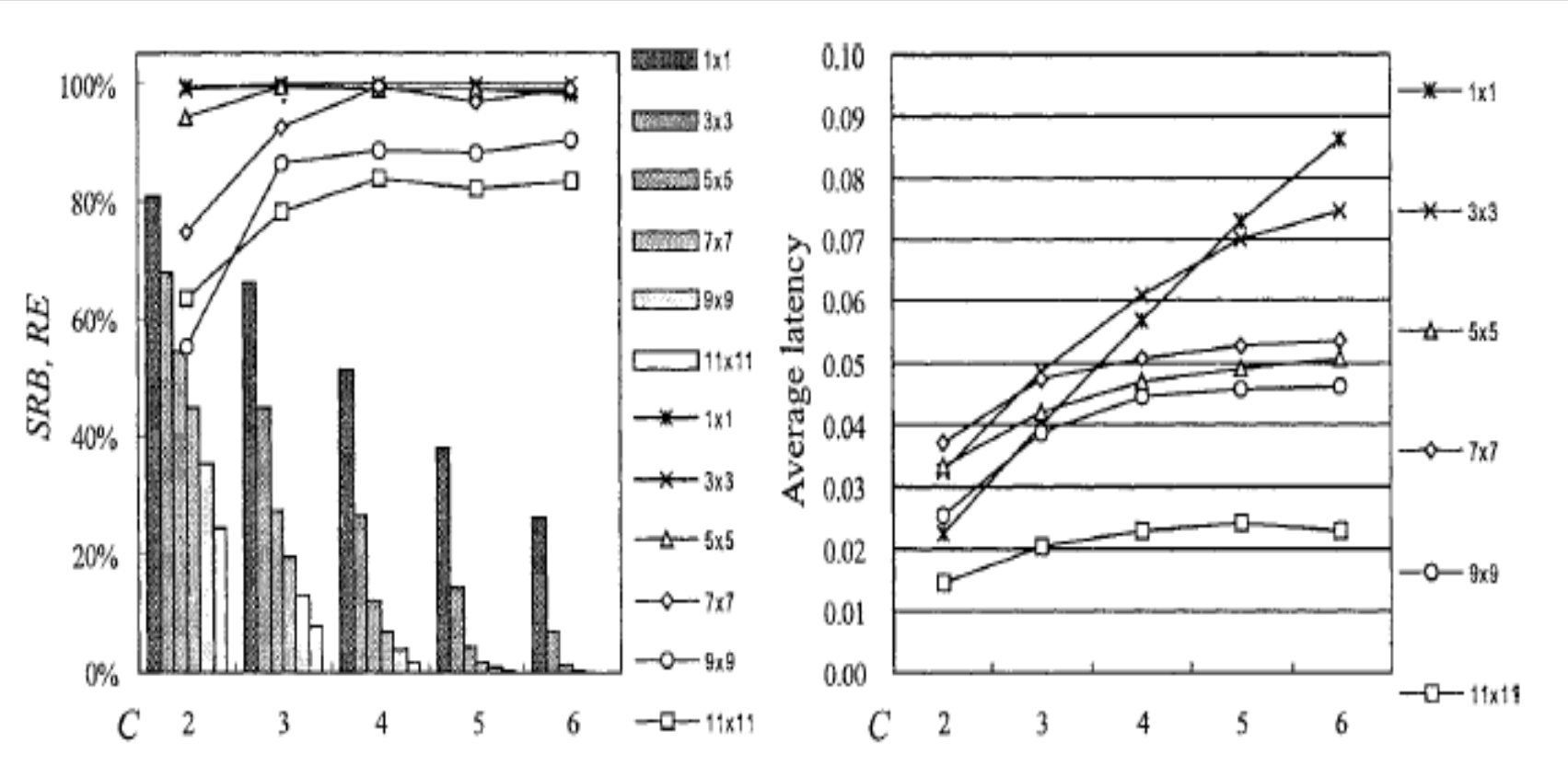
Performance metrics

- Reachability (RE),
- Saved Rebroadcasts (SRB): (r - t) / r,
- Average latency.

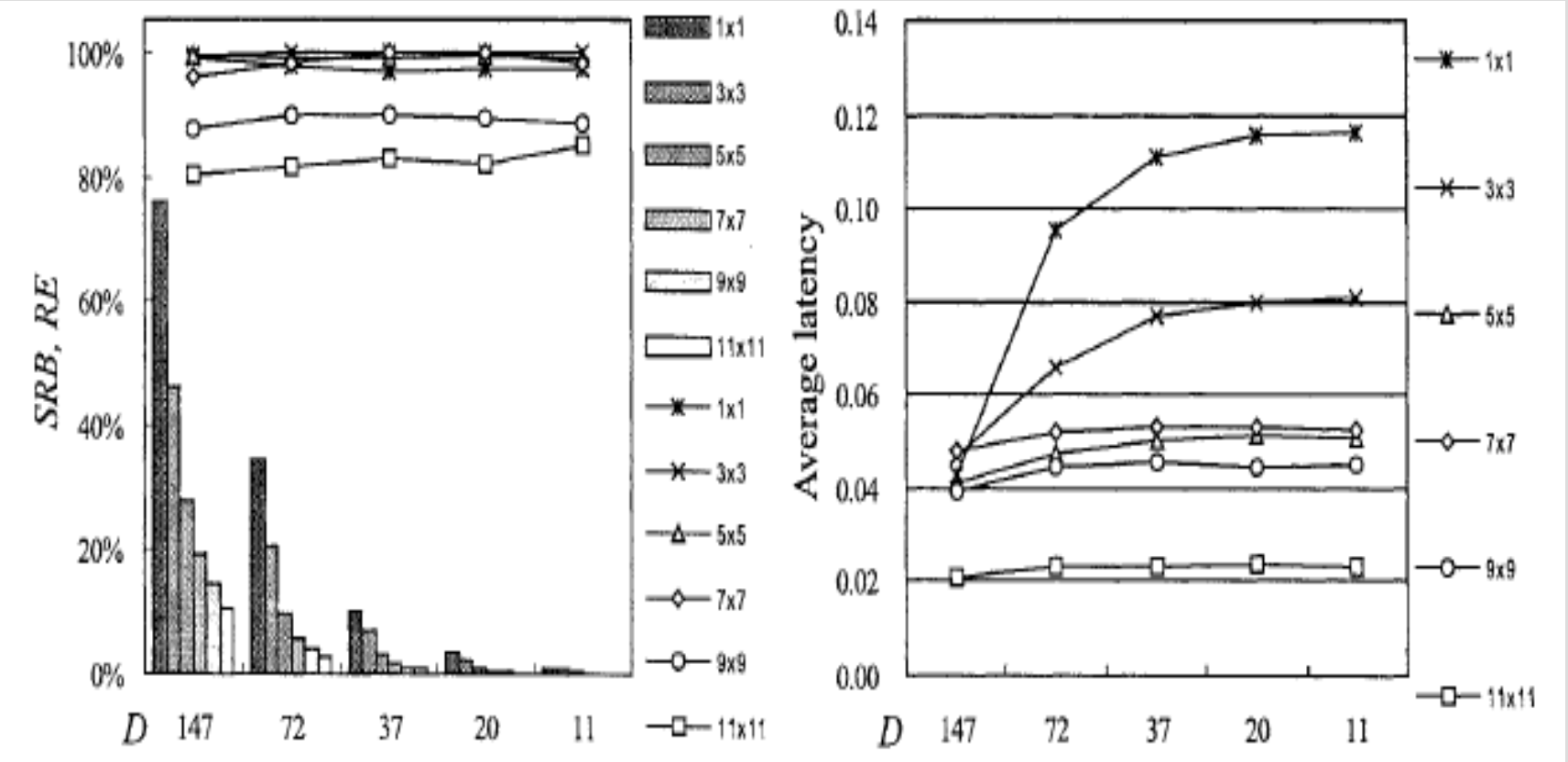
Probabilistic scheme



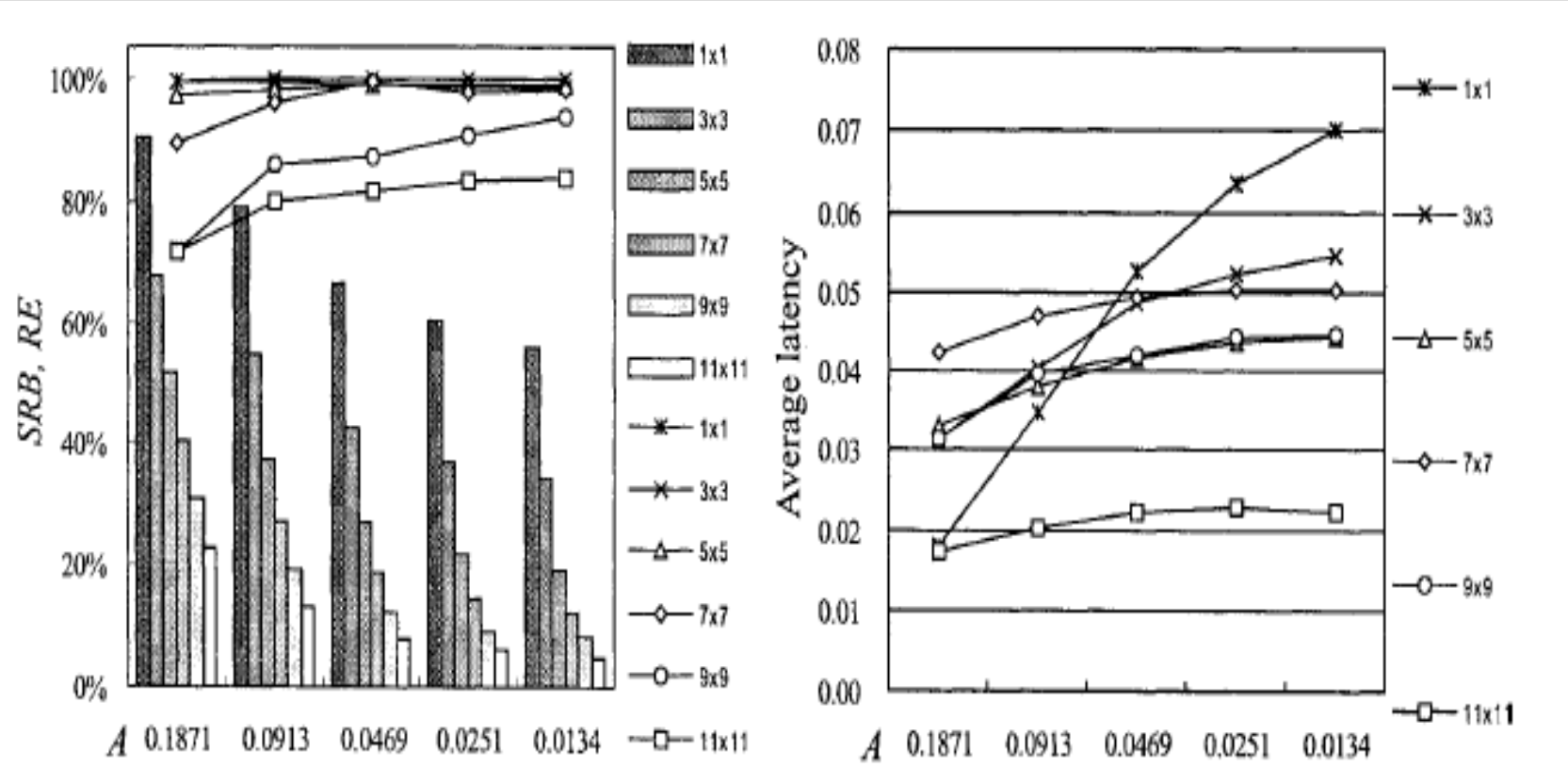
Counter-based scheme



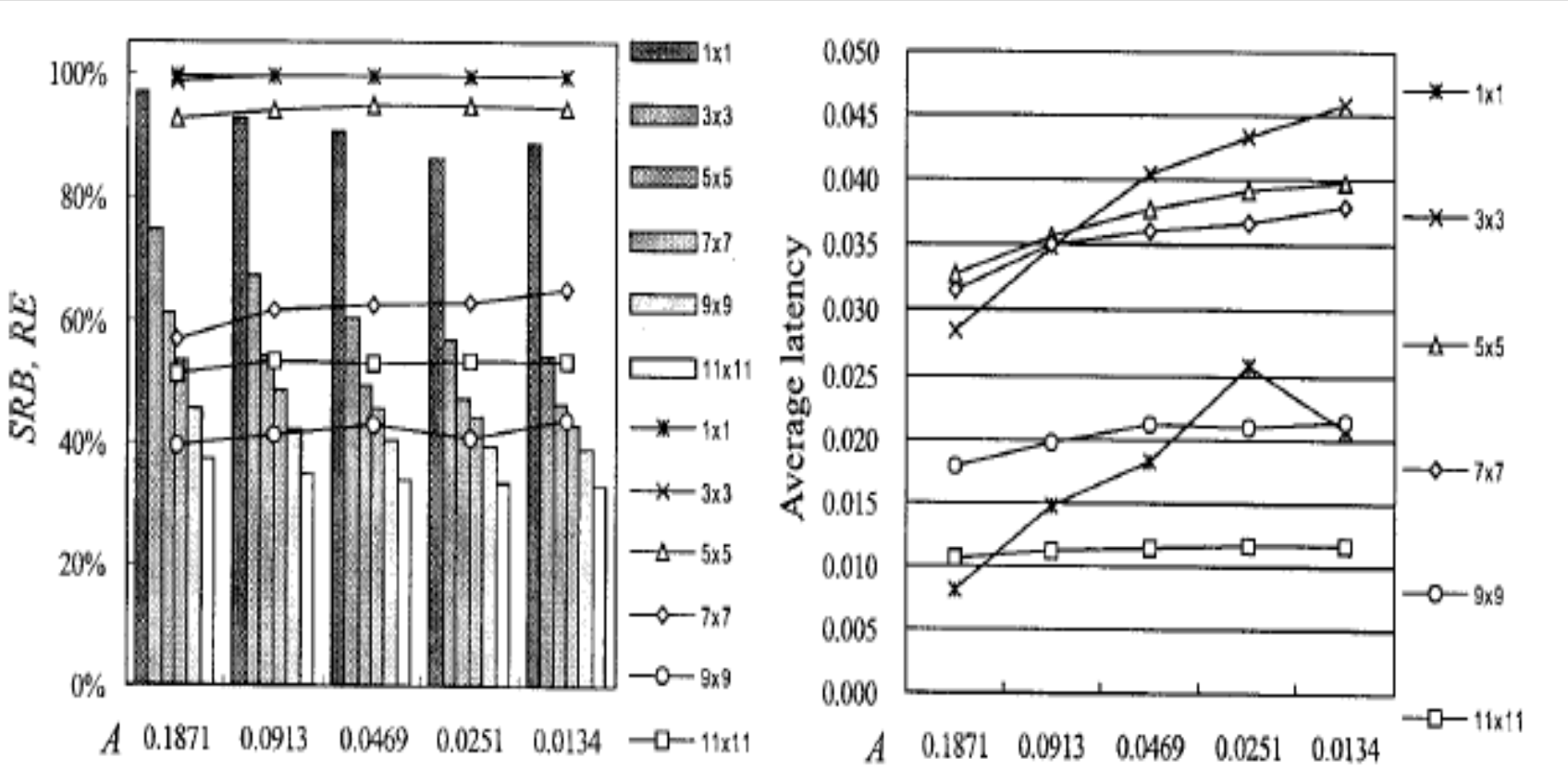
Distance-based scheme



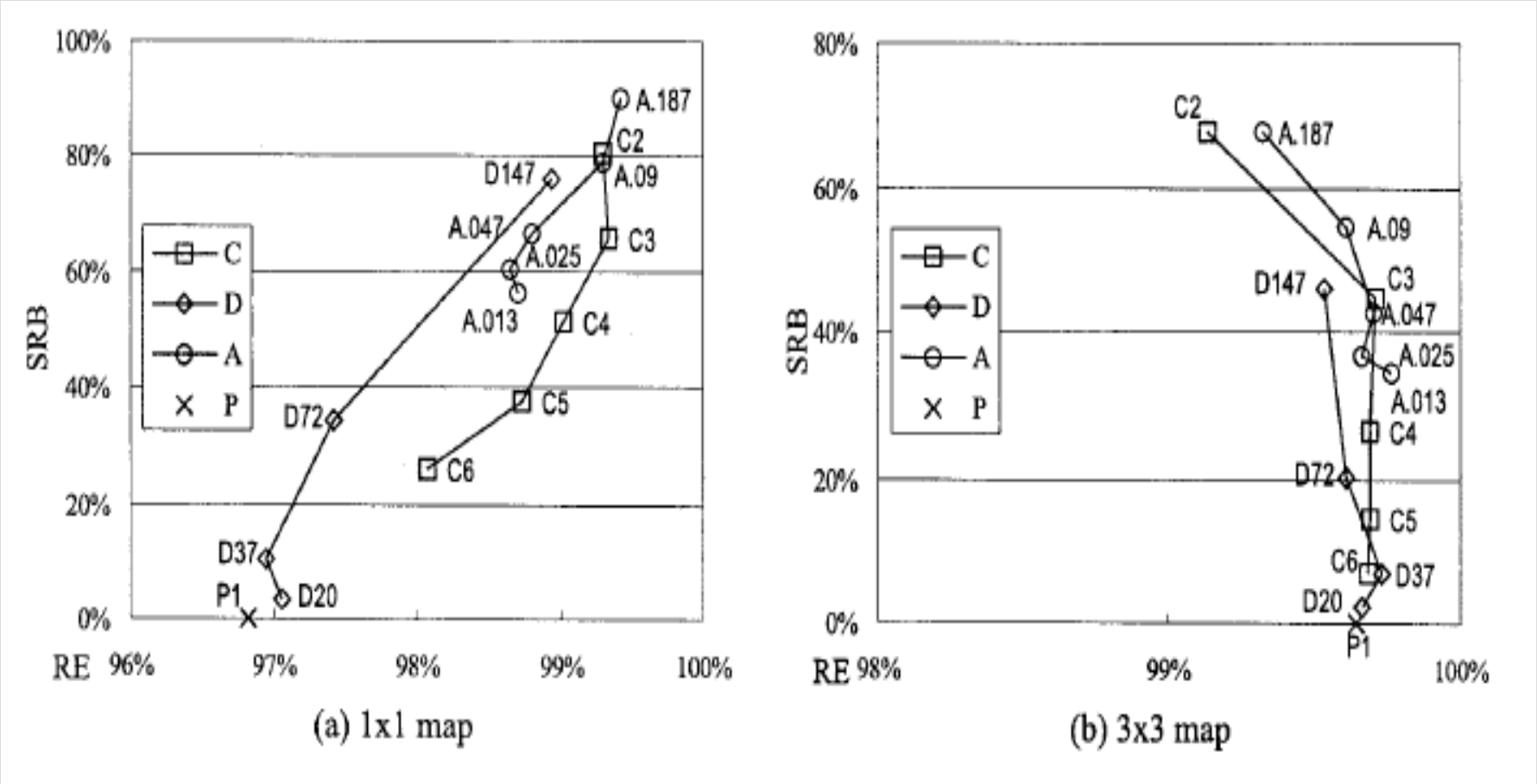
Location-based scheme



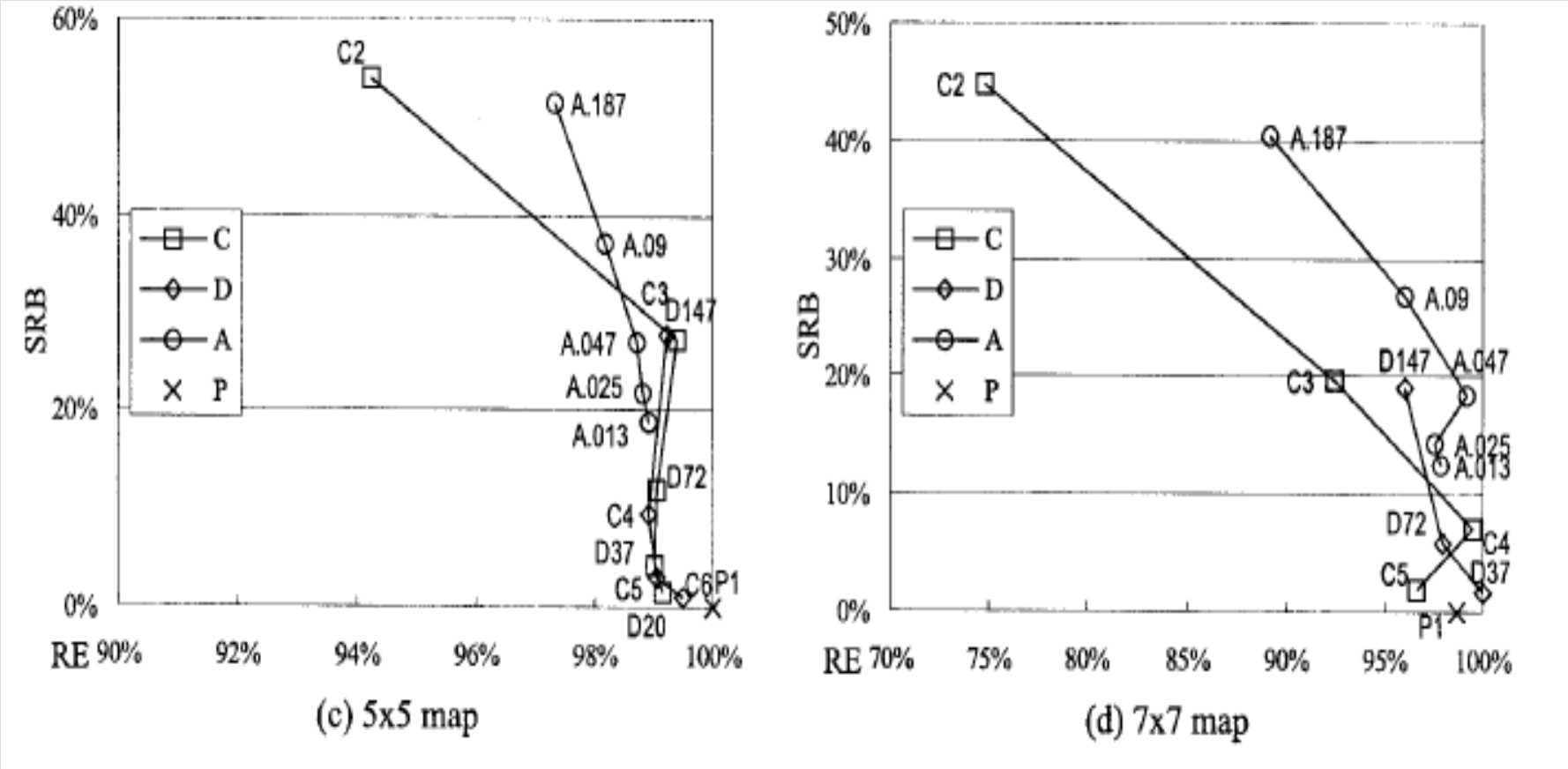
Cluster-based



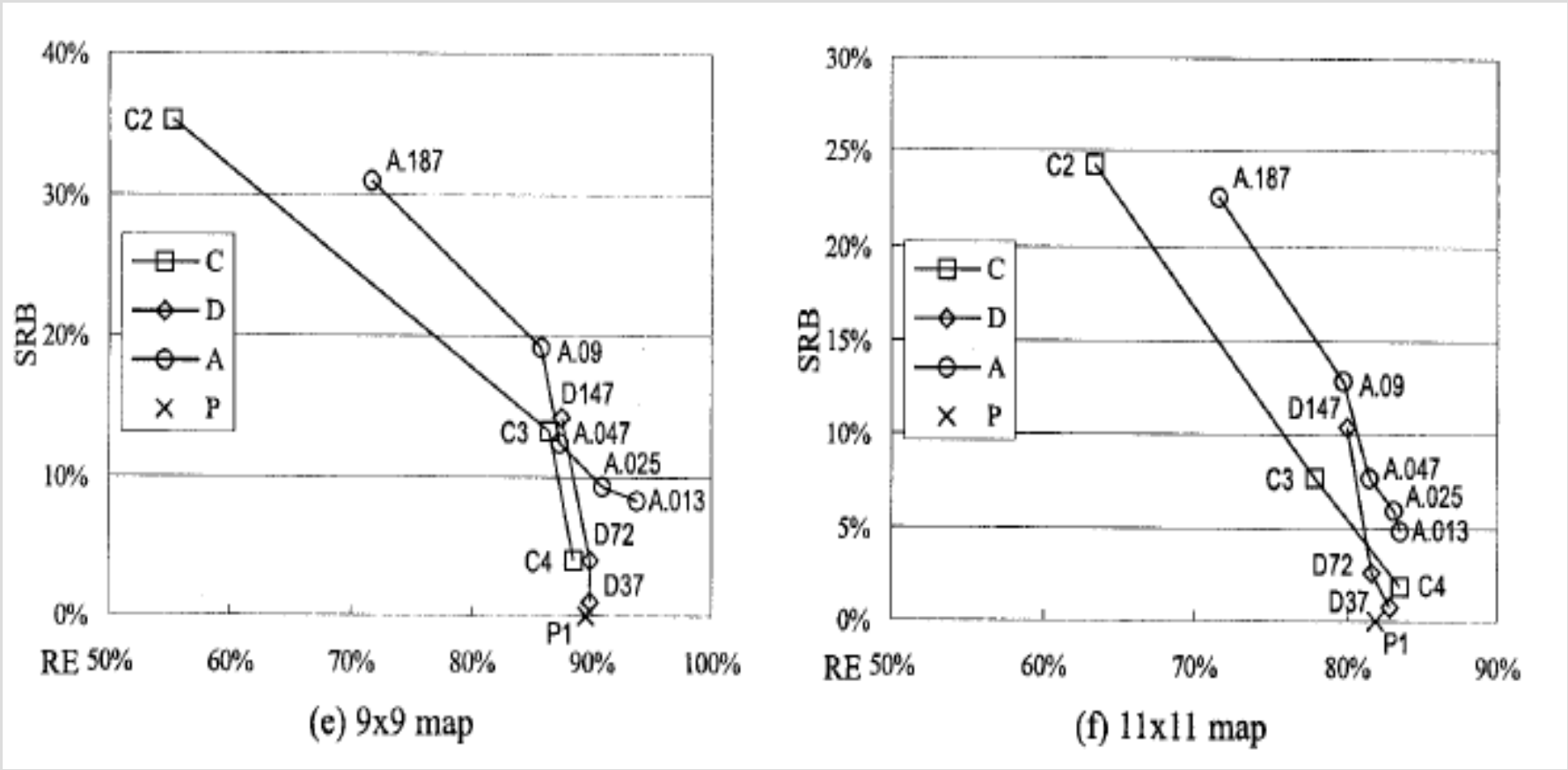
RE / SRB


100%
80%
60%
40%
20%
0%
SRB
RE 96%
97%
98%
99%
100%
C
D
A
P
A.187
C2
A.09
D147
A.047
A.025
C3
A.013
C4
C5
D72
C6
D37
P1
D20
(a) 1x1 map
80%
60%
40%
20%
0%
SRB
RE 98%
99%
100%
C2
A.187
A.09
D147
C3
A.047
A.025
A.013
C4
D72
C5
C6
D37
D20
P1
(b) 3x3 map

RE / SRB


60%
40%
20%
0%
SRB
C
D
A
P
C2
A.187
A.09
C3
D147
A.047
A.025
A.013
D72
C4
D37
C5
C6P1
D20
RE 90%
92%
94%
96%
98%
100%
(c) 5x5 map
50%
40%
30%
20%
10%
0%
SRB
C2
A.187
A.09
C3
D147
A.047
A.025
A.013
D72
C4
C5
D37
P1
RE 70%
75%
80%
85%
90%
95%
100%
(d) 7x7 map

RE / SRB


40%
30%
20%
10%
0%
SRB
C2
A.187
C
D
A
P
A.09
D147
C3
A.047
A.025
A.013
D72
C4
D37
P1
RE 50%
60%
70%
80%
90%
100%
(e) 9x9 map
30%
25%
20%
15%
10%
5%
0%
SRB
C2
A.187
C
D
A
P
A.09
D147
C3
A.047
A.025
A.013
D72
C4
D37
P1
RE 50%
60%
70%
80%
90%
(f) 11x11 map

Conclusion

- Only two solutions are worth mentioning.
- Counter-based scheme is easy to implement and provides satisfactory results.
- The best is location-based scheme.