

Topology-Controllable Scatternet Formation Method and Its Implementation

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Outlines

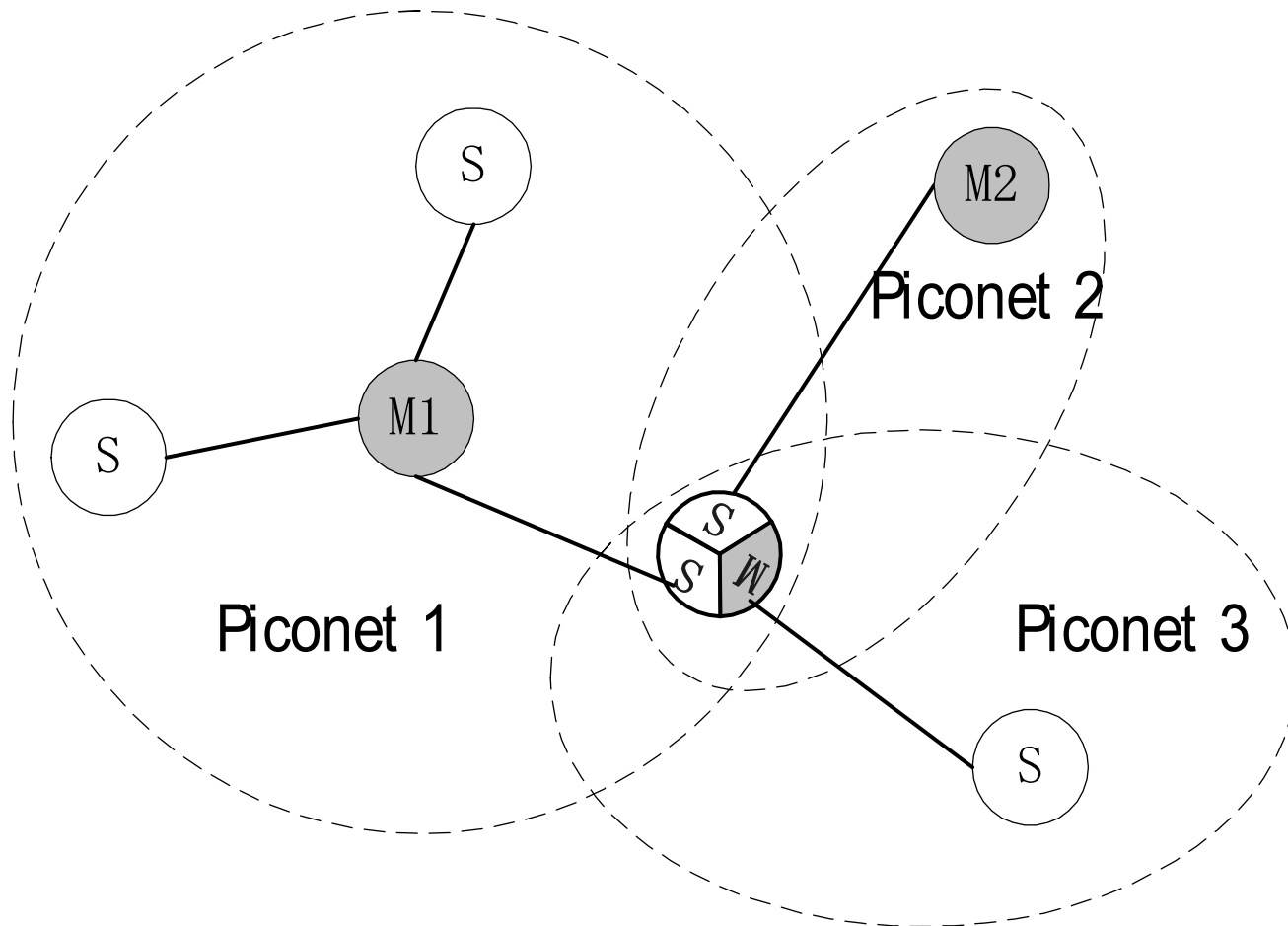
- Introduction
- Related works
- Topology-controllable scatternet formation
- Implementation and test results
- Conclusions

Features of Bluetooth network

- Master-slave relationship in piconet
- Discovery by inquiry/inquiry-scan, connection by page/page-scan
- Asynchronous timing between piconets, nodes in different piconets cannot hear each other
- Bridges communicate to different piconets in TDD

Scatternet formation is essential for BT network!

Scatternet – one example



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Related works – 1/2

- Many proposals
 - Bluetree(Zaruba): each node is master of its children nodes and slave of its parent node except for the root and leaves
 - Bluestars(Basagni): interconnected piconets(stars)
 - BTCP (Salonidis):Bluetooth Topology Construction Protocol, leader elected by wining votes
 - BT SIG: Sony(QoS), Samsung(on-demand), UBN(alternate net formation/communication if no. of links $< k$)

Related works – 2/2

- 3-phases: network discovery, leader election/link formation, scatternet formation
 - P1:symmetric/asymmetric inquiry/inquiry-scan
 - P2:(sub)leader elected by weight, or wait for paging (page neighbors if no page received)
 - P3:add/delete links to other piconets
- **No proposal for topology-controllable scatternet formation!**

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Scenarios

- Conference room, office, home
- All nodes are within radio coverages

Parameters controlling the topology

- Max. no. of slaves per piconet, S_{max}
- No. of piconets that a bridge node participates, M_p
- No. of loops in formed network, L

The above 3 parameters are key factors affecting network performance!

Algorithm

- No. of piconets

$$P = \left\lceil \frac{N + L - 1}{S_{\max}} \right\rceil$$

- No. of bridge nodes

$$B = \left\lceil \frac{P + L - 1}{M_p - 1} \right\rceil, \text{ for } P \geq 2$$

Control the topology

No. of nodes	Topology	Parameters
3	Line, star	$L=0, S_{max} \geq 1, M_p=2$
	Ring	$L=1, S_{max}=2, M_p=2$
4 or more	Line	$L=0, S_{max}=2, M_p=2$
	Star	$L=0, S_{max} \geq 2, M_p \geq 2$
	Ring	$L=1, S_{max}=2, M_p=2$
	Mesh	$L \geq 2, S_{max} \geq 2, M_p \geq 2$

Protocol – 1/3

Phase 1: Network discovery

- Super master inquiries to collect BT addresses and clock offsets of other nodes.
- All other nodes stay in inquiry-scan.
- Only super master knows complete information.

Protocol – 2/3

Phase 2: Topology calculation, bridge/master nodes negotiation and piconet information distribution

- Super master calculates P and B .
- Negotiate with nodes one-by-one to decide bridges/masters that require more resources.
- Distribute bridge nodes equally among piconets.
- Assign rest nodes to each master till $\text{slave} + \text{bridge} = S_{max}$.
- Send to each master info. of its slaves and bridges.
- Send to each bridge the no. of piconets and IDs.

Protocol – 3/3

Phase 3: Piconets and scatternet formation

- Master received piconet info. connects to all its slaves and bridge nodes.
- Inform super master after forming its piconet.
- Scatternet is formed as super master received acks from all masters.

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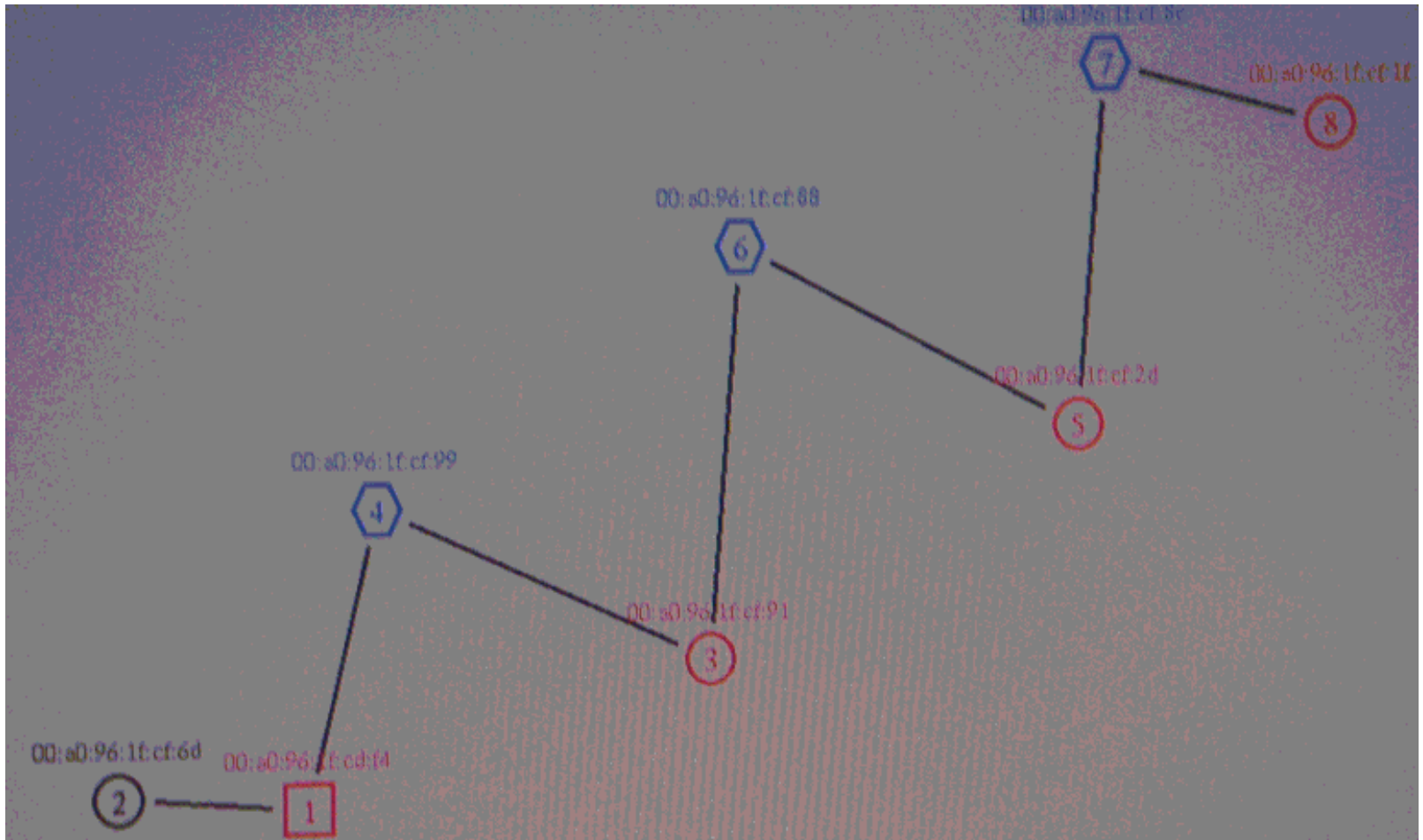
Implementation

- Based on laptop and commercially available Bluetooth devices.
- Use C in Linux OS.

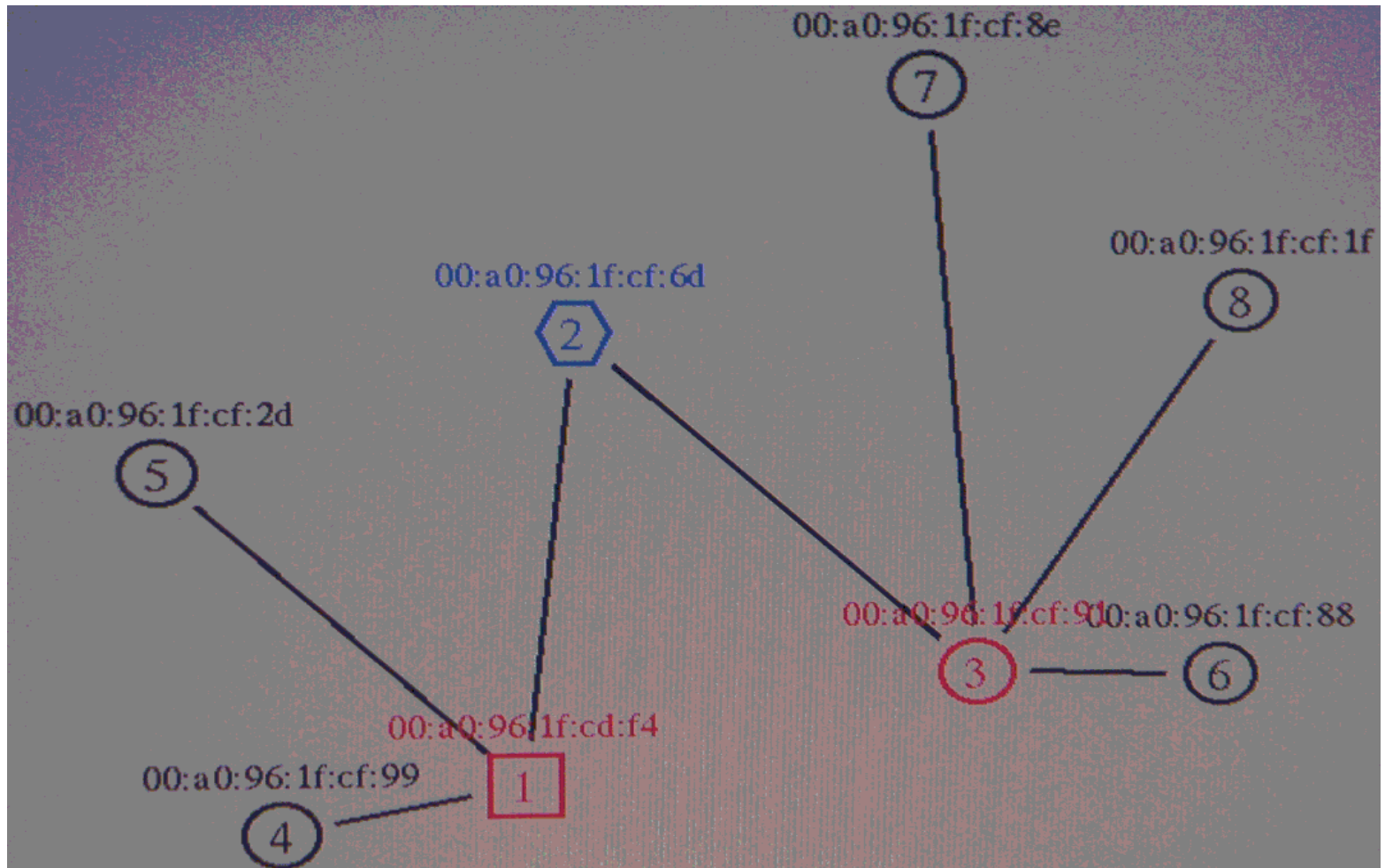
Reliability

- Tested with field experiments more than 500 trials.
- Expected topologies are obtained by given control parameters.
- Rate of successful scatternet formation: >98%
- AODV routing and IP traffic flow over the formed scatternet.

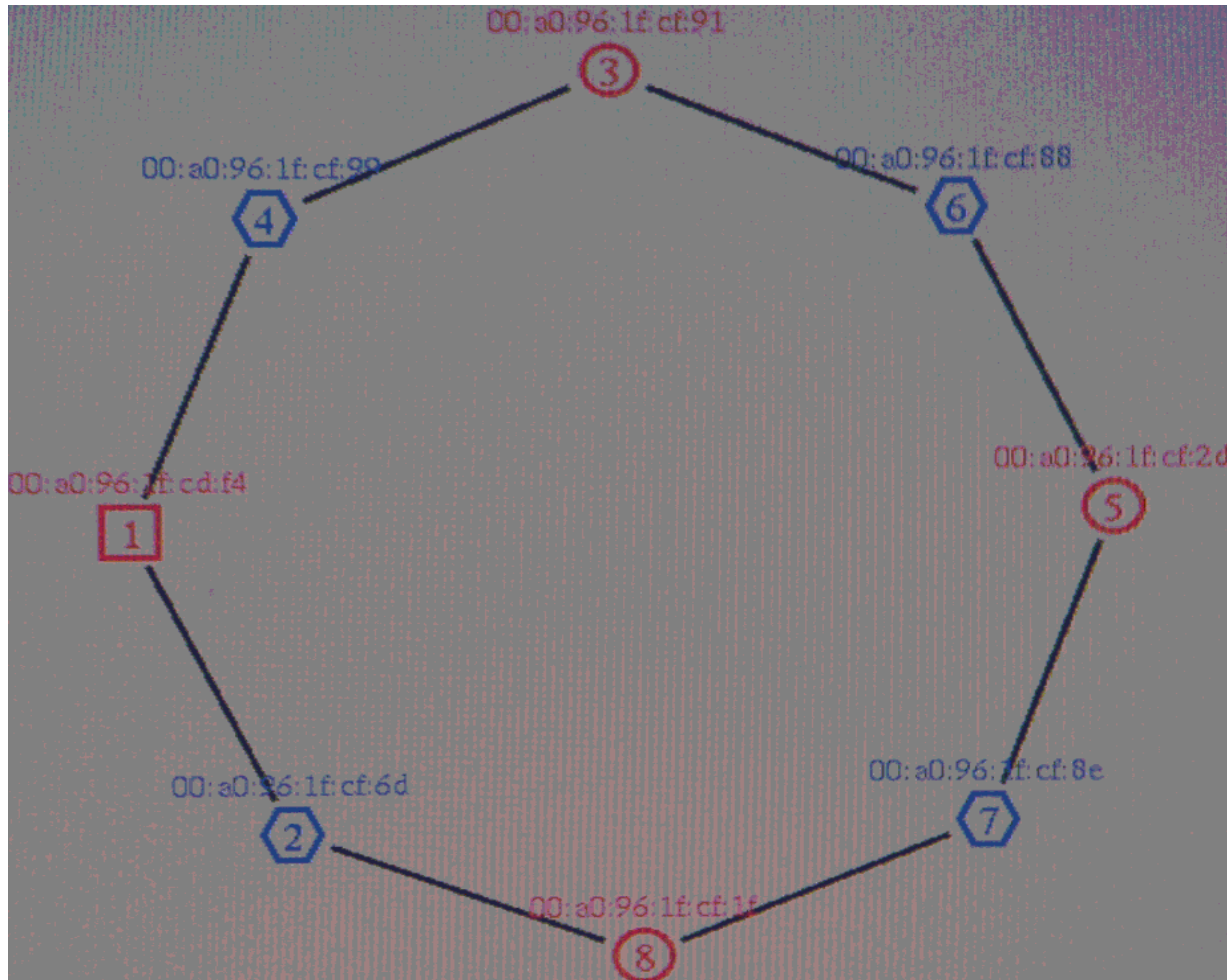
Line – $N=8$, $L=0$, $S_{max}=2$, $M_p=2$



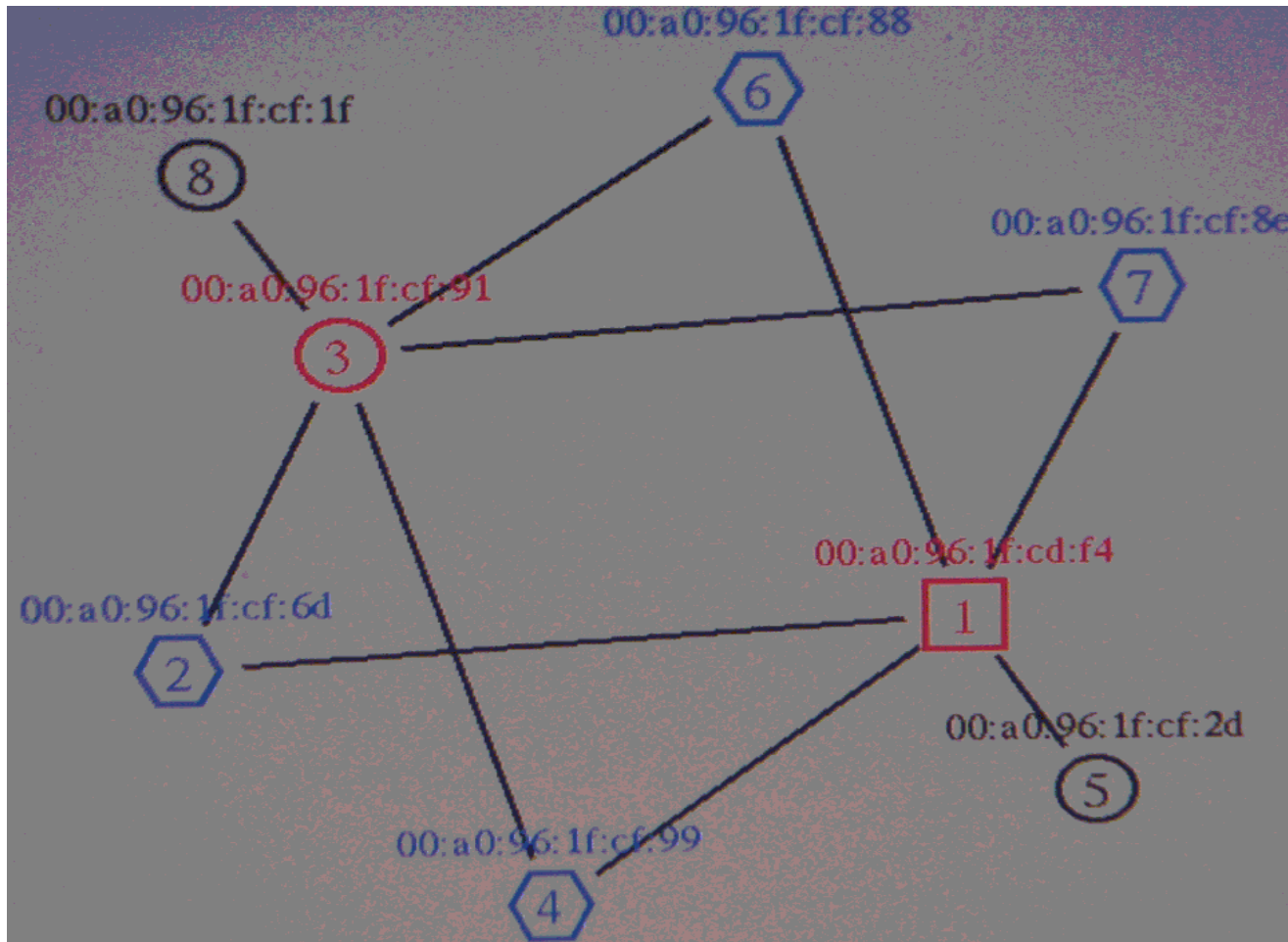
Star – $N=8$, $L=0$, $S_{max}=4$, $M_p=2$



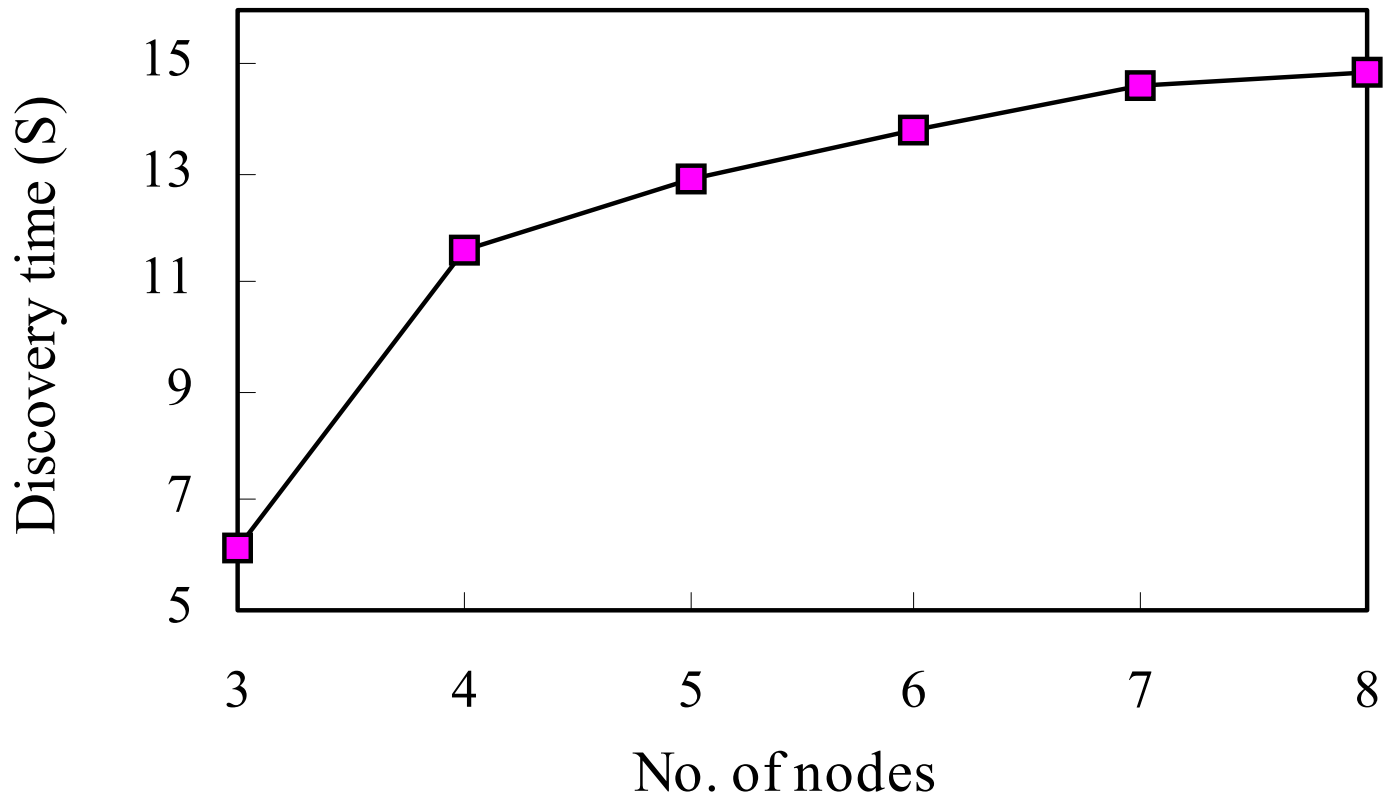
Ring – $N=8$, $L=1$, $S_{max}=2$, $M_p=2$



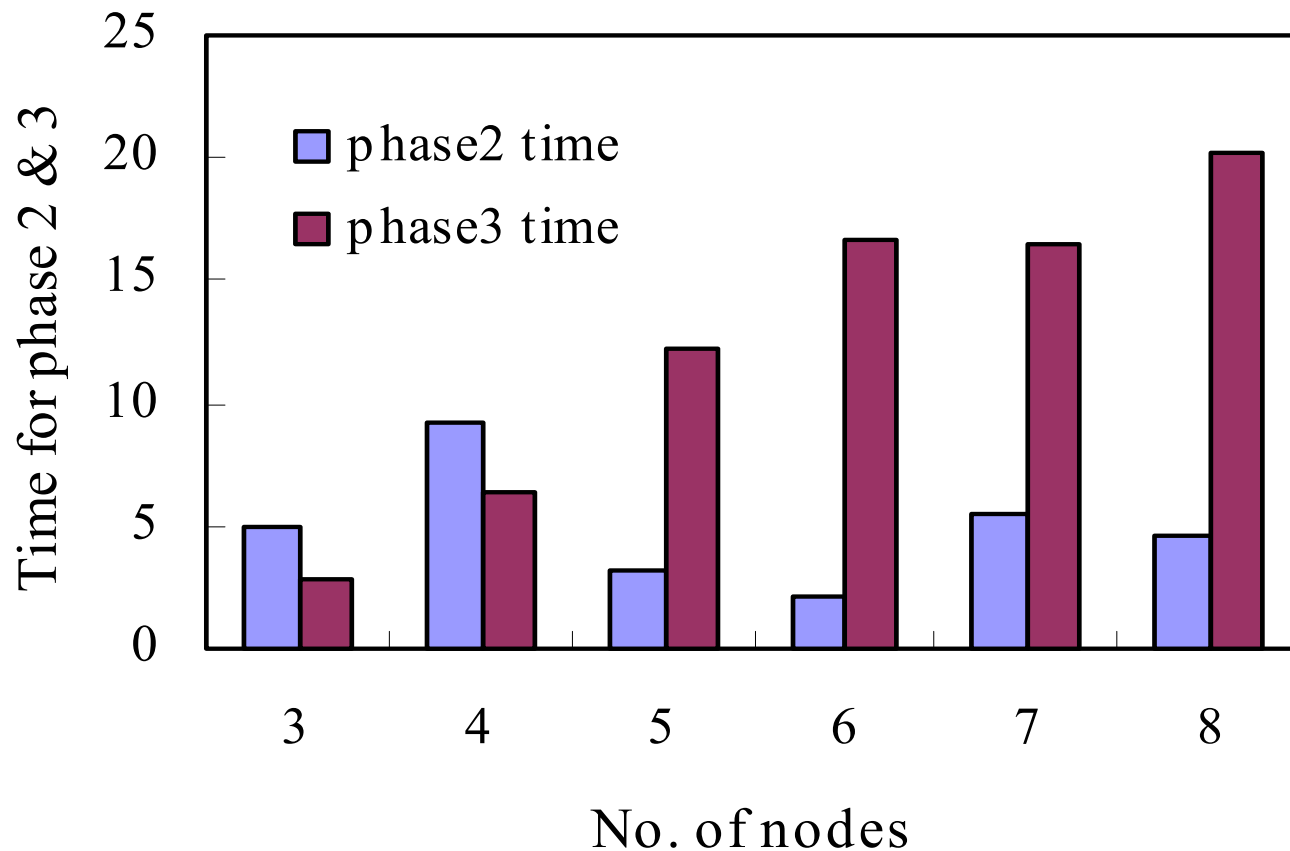
Mesh – $N=8$, $L=3$, $S_{max}=5$, $M_p=2$



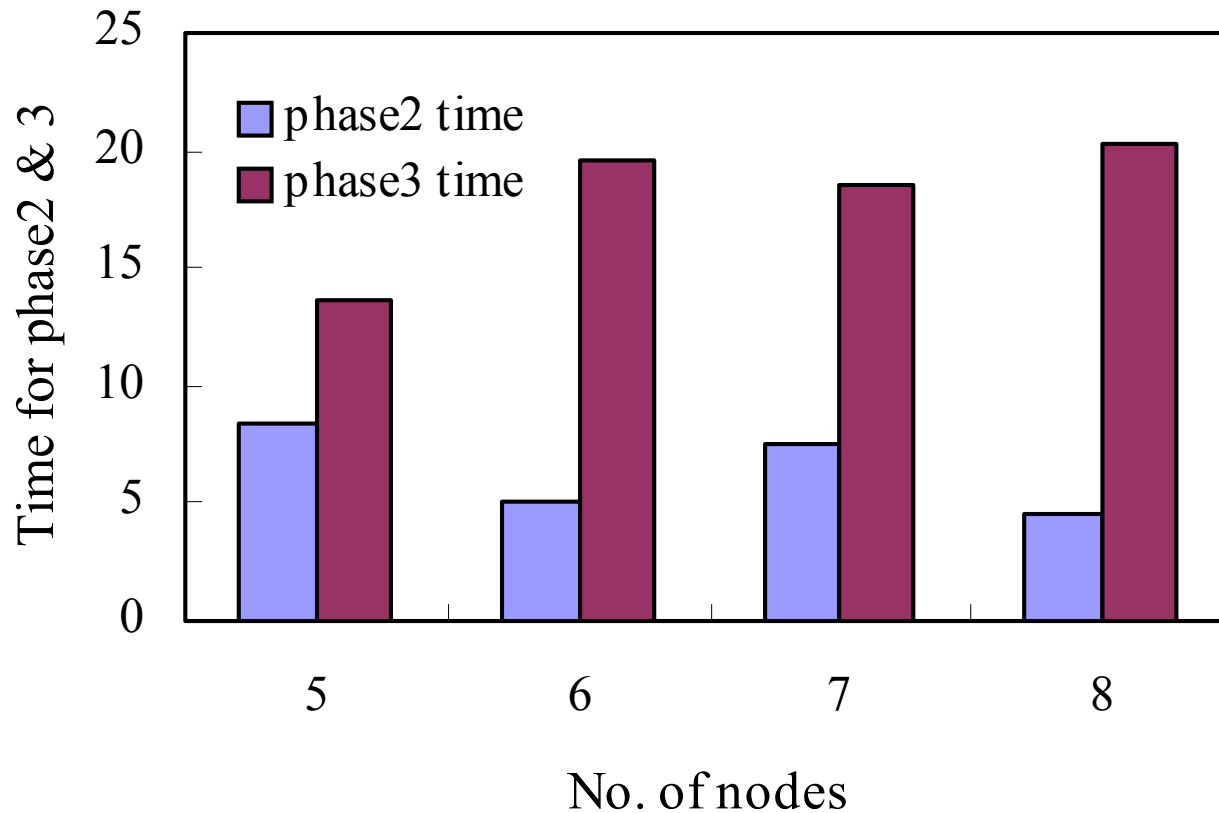
Time to discover all nodes



Scatternet with 2 piconets



Scatternet with 3 piconets



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Conclusions

- **Proposed a Bluetooth scatternet formation method.**
 - Network topology can be controlled: **line, ring, star, mesh**
 - Bottleneck nodes such as bridges and masters can be negotiated.
- **Implemented and tested.**
 - Expected network topologies can be obtained.

Questions?

