BlueScouts: A Scatternet Formation Protocol Based on Mobile Agents

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BlueScouts: A Scatternet Formation Protocol Based on Mobile Agents

Presentation Outline

- Introduction
- Scatternet formation through mobile processing
- BlueScouts: On-demand scatternet formation
- Simulation results
- Conclusions

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Introduction

What is Bluetooth?

- Global standard for short-range wireless communications
- 10 meters @ 721 Kbps / 3 Mbps (Enhanced Data Rate - EDR)
- Enables data and voice communications - WPAN
- High level of hardware integration & low power consumption
- Ideal for PDAs, cell phones, etc.
- Economic impact: shipping currently estimated at 2 million Bluetooth-enabled products per week worldwide

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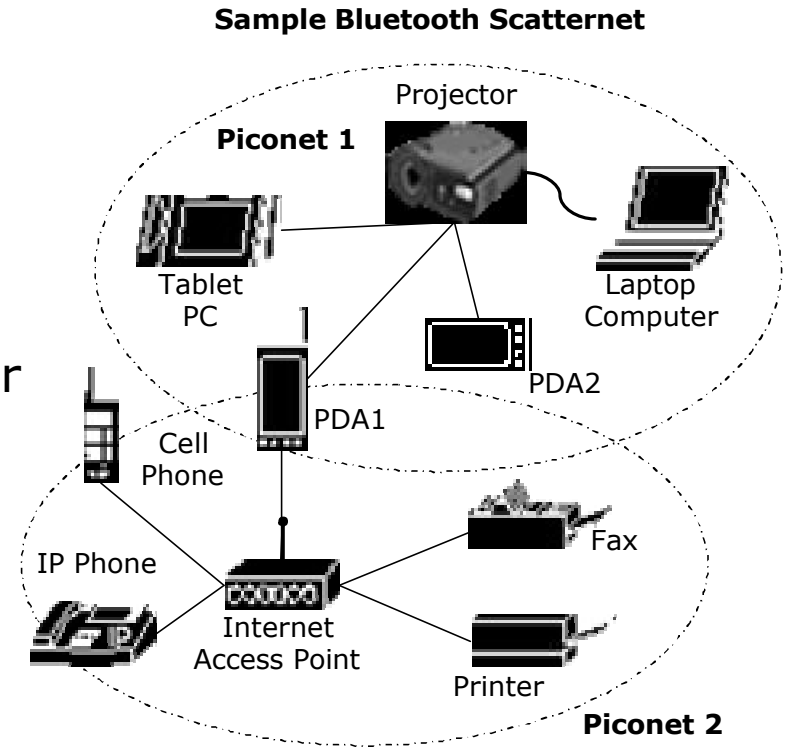
Introduction

Bluetooth Primitives

- Bluetooth device discovers neighbouring devices via inquiry process
- Devices assume either a master or slave role. A master handles up to seven slaves in active communications connected in a star-shaped topology - *piconet*
- Piconets may be interconnected via bridges to create a *scatternet*



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Introduction

Issues

- Problem definition: How do we create scatternets efficiently?
- Several existing proposals: Bluestar, Bluemesh, Bluenet, Bluetrees, TSFP, SFP, DTC, etc.
- Assumptions often made by existing SFPs:
  - Synchronous start/operation: Devices are somehow able to initialize the protocol at the same time, and must wait for partial computations from other devices to proceed with own decisions
  - All BDs must be within radio range of each other
  - Additional BDs cannot join the scatternet at a later time

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Scatternet Formation Through Mobile Processing

Our proposed solution

- Limitations of existing approaches attributed to the communication models they employ
- We propose a novel mobile agent-based solution
- Contrary to what existing schemes do, we decouple device discovery from actual topology formation
- Eliminates constraints often seen in existing approaches:
  - ✓ Protocol runs in a *fully asynchronous fashion*
  - ✓ Absolute radio coverage among all BDs *no longer a constraint*
  - ✓ Scatternet *can grow dynamically*

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Scatternet Formation Through Mobile Processing

Our proposed solution (cont'd)

- Employed *Wave* as our mobile processing implementation tool to code 'light-weight' mobile agents
- *Wave*'s key features:
  - An internal mechanism for automated spatial coordination of mobile agents (*Track Layer*)
  - An scripting-like language that enables highly compact agent code, leading to reduced bandwidth consumption
  - External interfacing, enabling the interpreter to utilize existing resources (e.g. Bluetooth HCI APIs)
- Other agent platforms can be used, but would require much more programming to accomplish the same objective

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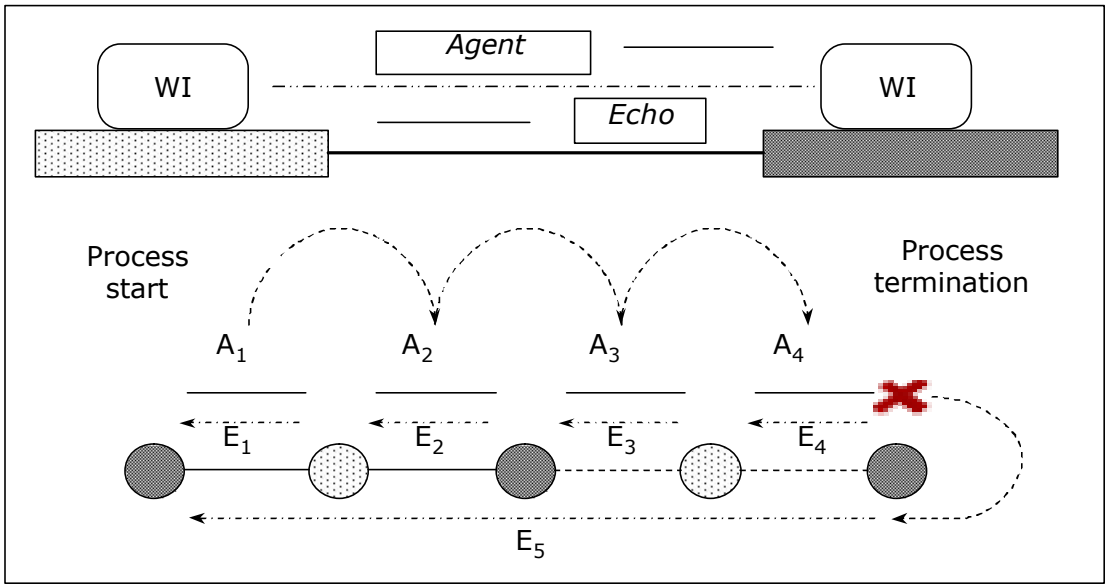
BlueScouts: On-Demand Scatternet Formation

Agent spreading mechanism

Wave agents spread through the existing links in a controlled fashion and recursively signal back the state of the last computation's outcome (false, done, true, abort), leading up to the further replication of the mobile process or its termination.



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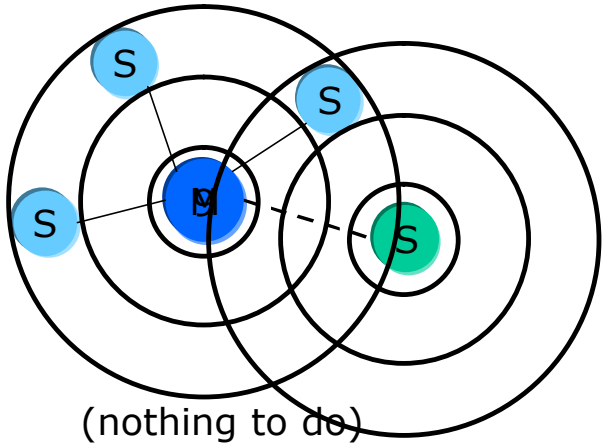
BlueScouts: On-Demand Scatternet Formation

BlueScouts in action

Case 1: A BD is discovered by a master and becomes slave



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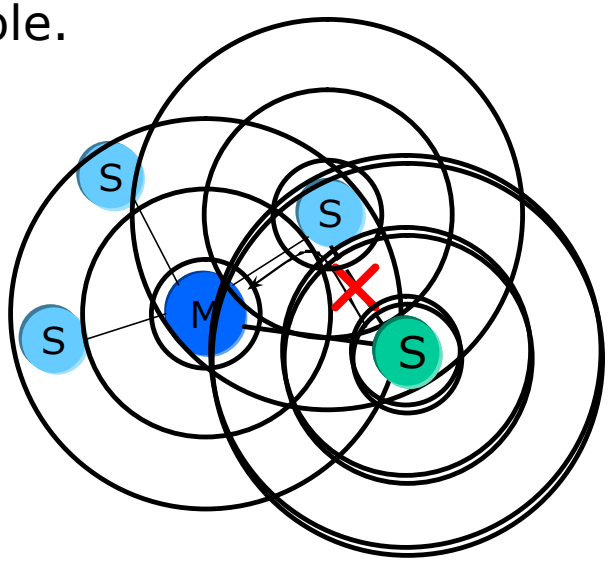
BlueScouts: On-Demand Scatternet Formation

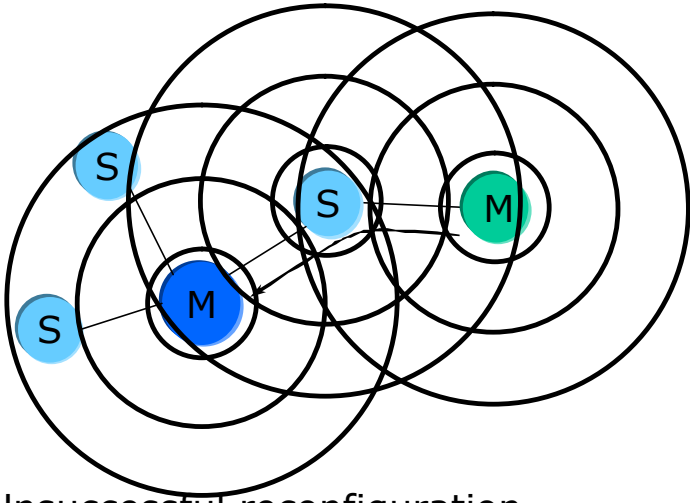
BlueScouts in action

Case 2: A BD is discovered by a slave and becomes master. Agents are launched in an attempt to reconfigure the new BD's role.



Successful reconfiguration

or…



Unsuccessful reconfiguration
(a scatternet is formed)

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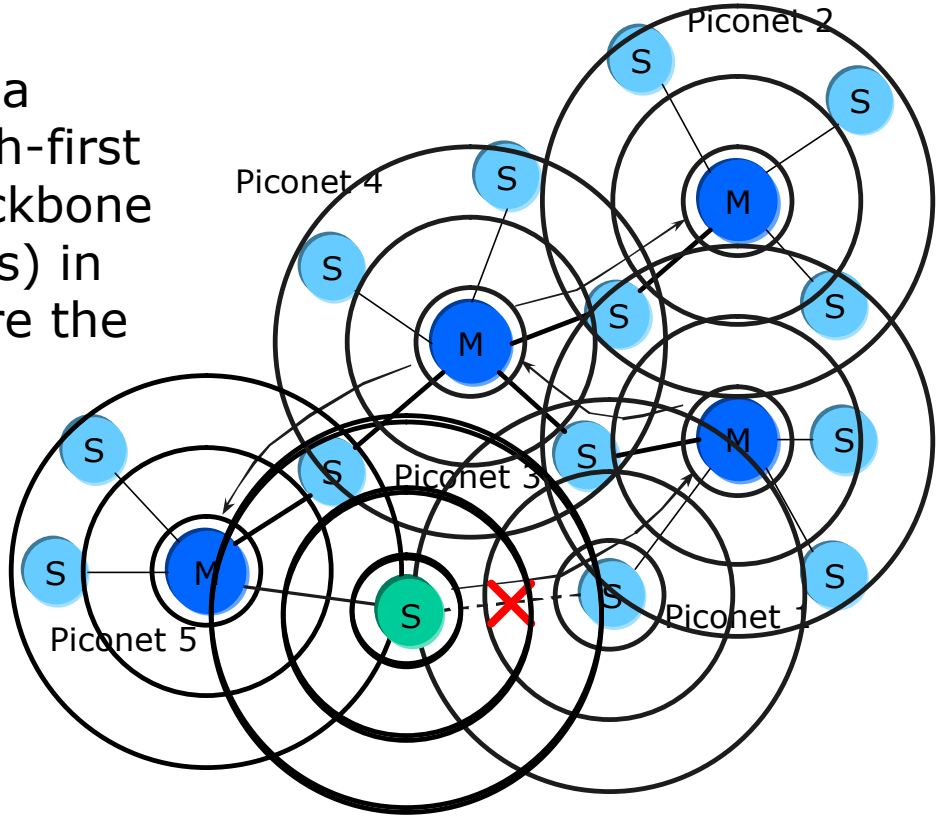
BlueScouts: On-Demand Scatternet Formation

BlueScouts in action

Case 3: Agents conduct a coordinated spatial depth-first search over a logical backbone (i.e. excluding leaf nodes) in an attempt to reconfigure the new BD's role.



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Simulation Results

Simulation parameters

- Periodic node arrivals
- Nodes are uniformly distributed
- 10, 20 & 40 square meter areas
- A Wave agent (204 bytes) fits in a single DM5 ACL packet (224 Bytes)
- 50 simulation runs per test area
- Reasonably large scatternets – 200 nodes

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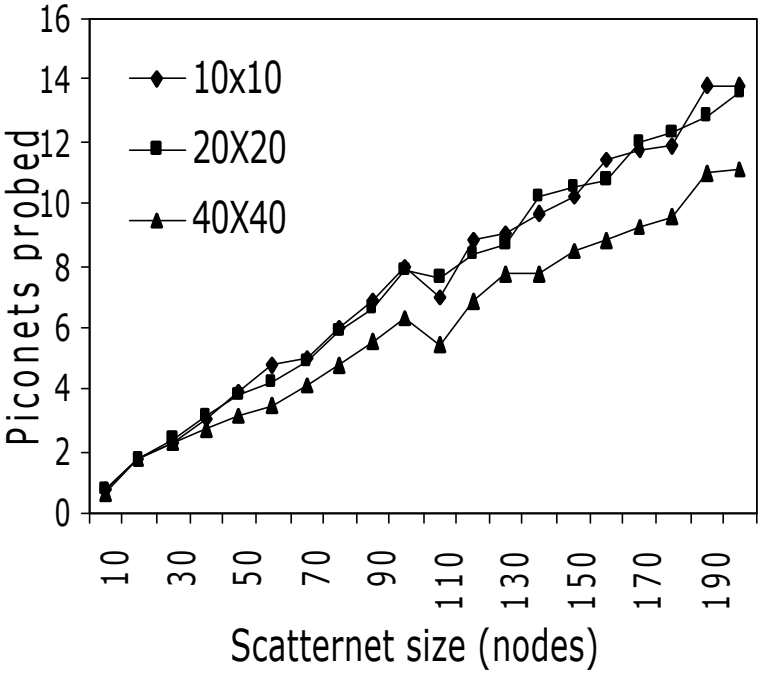
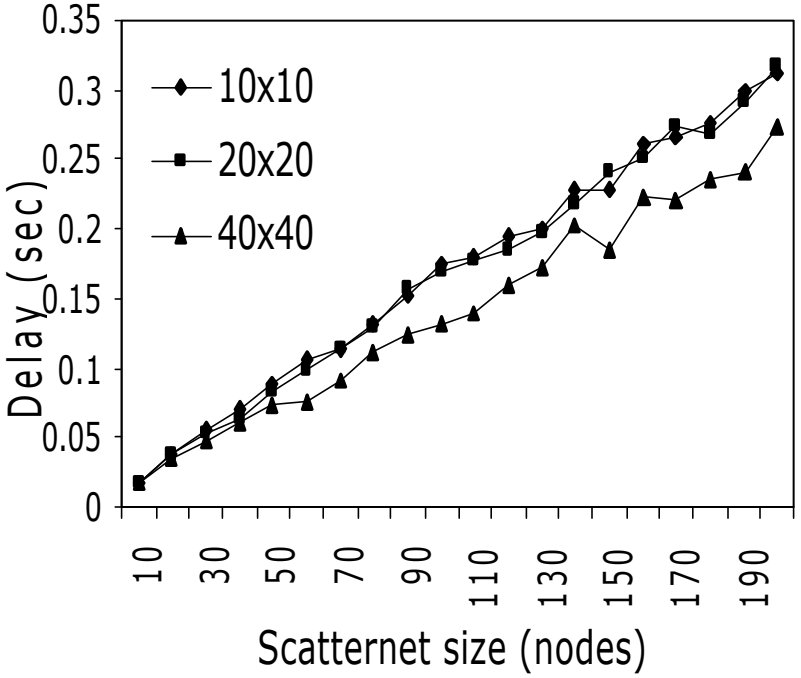
Simulation Results



Number of piconets probed



Process completion delay

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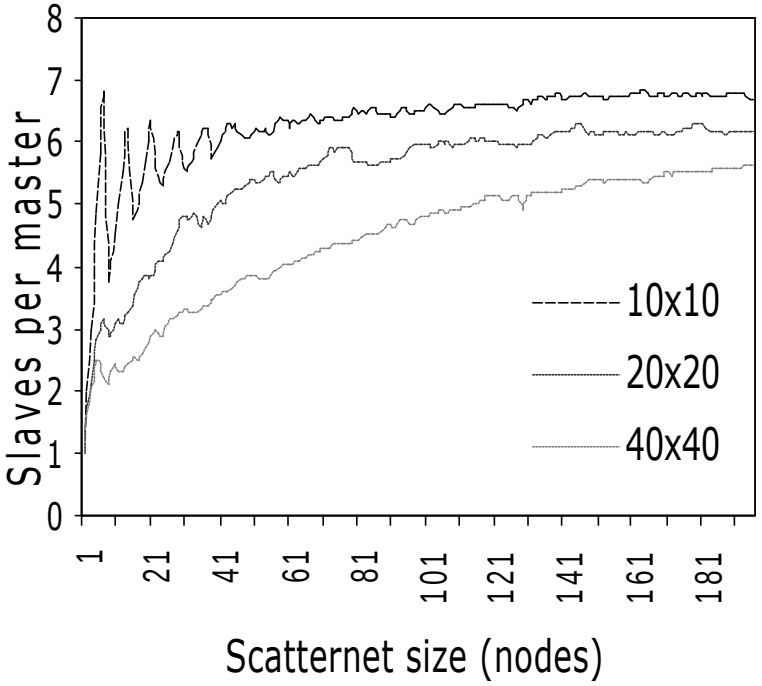
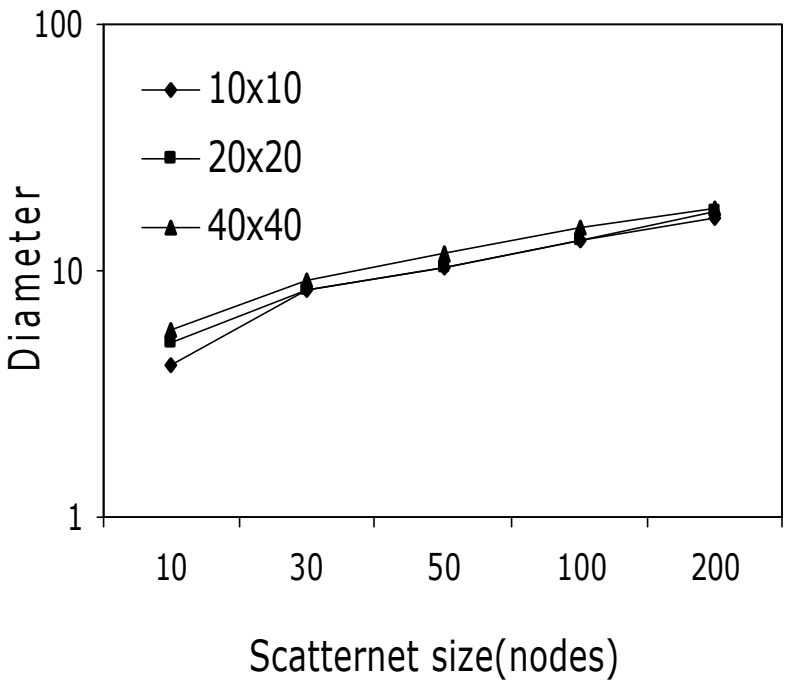
Simulation Results



Slave/Master ratio



Scatternet diameter

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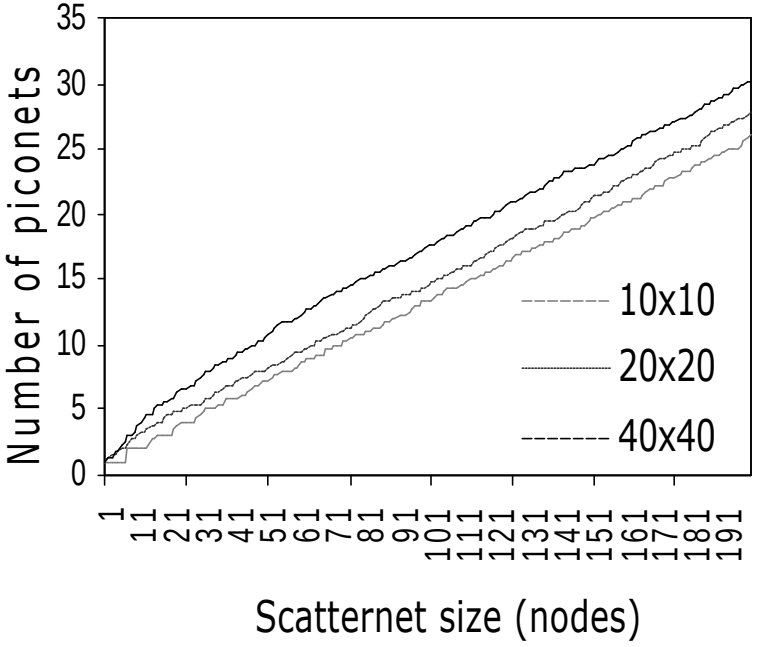
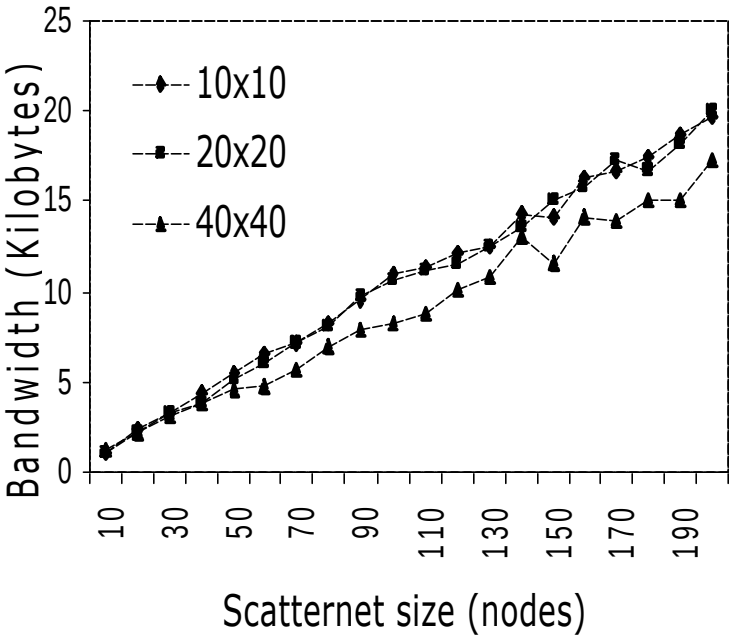
Simulation Results



Total number of piconets



Consumed bandwidth

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Simulation Results

Discussion

- Changes to the Baseband specification are transparent to our scheme: agents employ APIs available at the nodes
- Existing schemes greatly emphasize on results at the Baseband layer: incompatible performance metrics deem a direct comparison mostly impractical
- Topology optimality not degraded as scatternets grow: slaves/master ratio performance is comparable or better
- Bandwidth consumption very low and linear
- Security issues attributed to mobile agents are less of a concern here: the interpreter lives around L3, not L7

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Conclusions

- First mobile agent-based scatternet formation protocol (to our knowledge)
- Agent approach helps decouple scatternet formation from device discovery, which greatly facilitates the topology reconfiguration process
- Agent approach enables fully asynchronous protocol operation and helps to eliminate constraints observed in existing schemes
- 'Programmable' approach introduces unmatched flexibility by allowing context-aware topology formation

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Acknowledgements

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Thank you!