

A System for Performance Measurement of PicoRadio Network Protocols

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SUPERB-IT 2002



Overview:

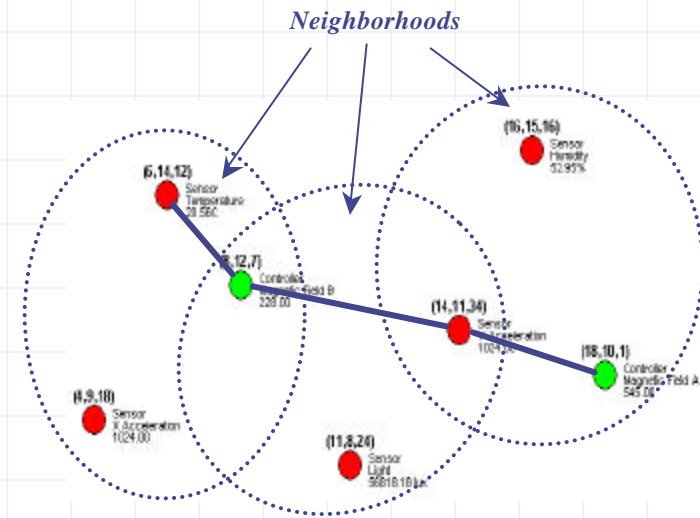
- The PicoRadio Project
 - Design Goals
 - Applications of PicoRadio
 - Communication Protocol
- The Statistics and Maintenance Service (SMS)
- Results and Conclusion





Key Characteristics:

- Low power
- Wireless
- Low cost
- Small Size
- Ad-hoc (Self-configuration)
- High Density
- Multiple Hops
- Ubiquitous



Applications

Commercial Buildings

- Monitor temperature, light, and airflow
- Maintain a comfortable work environment
- \$55 billion per year in savings
- 35 million metric tons of reduced carbon emissions in U.S.

Precision Agriculture

- Drip irrigation
- Test plots
- Orchards
- Vineyards
- Siphon and flood irrigation

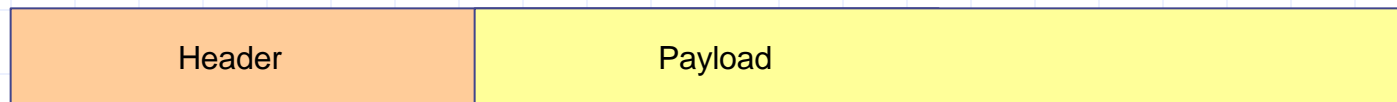


Communication

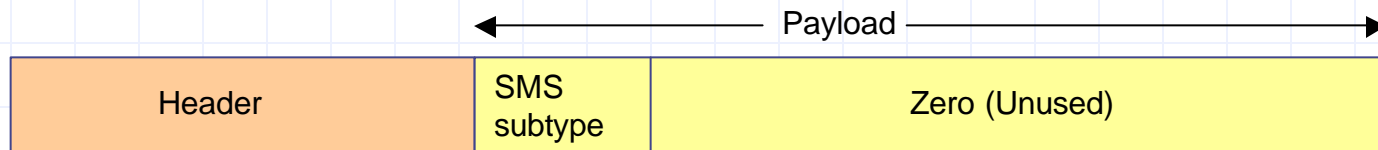
Packets:

- Request
- Response

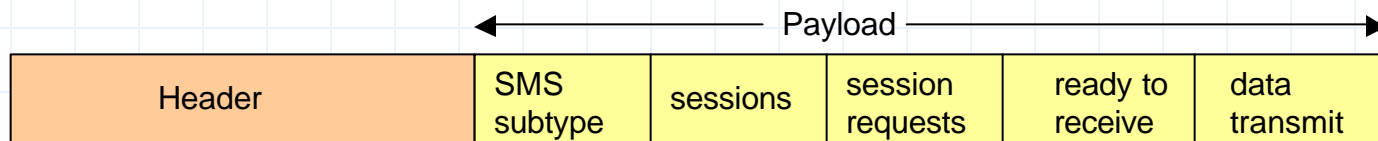
The General Packet Structure



The SMS Request Packet Structure

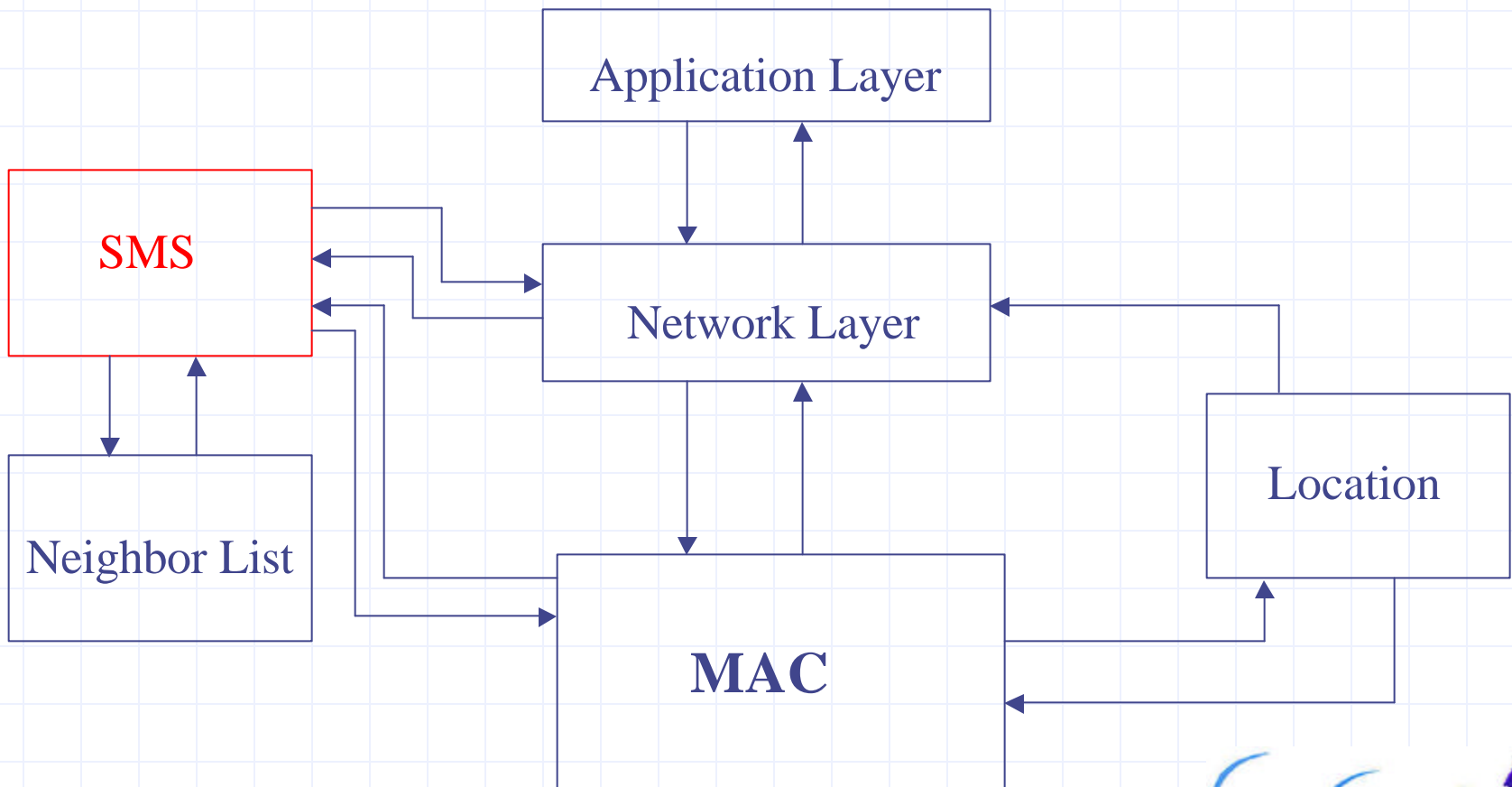


The SMS Response Packet Structure for Session Data



Communication

Intra-Node Communication

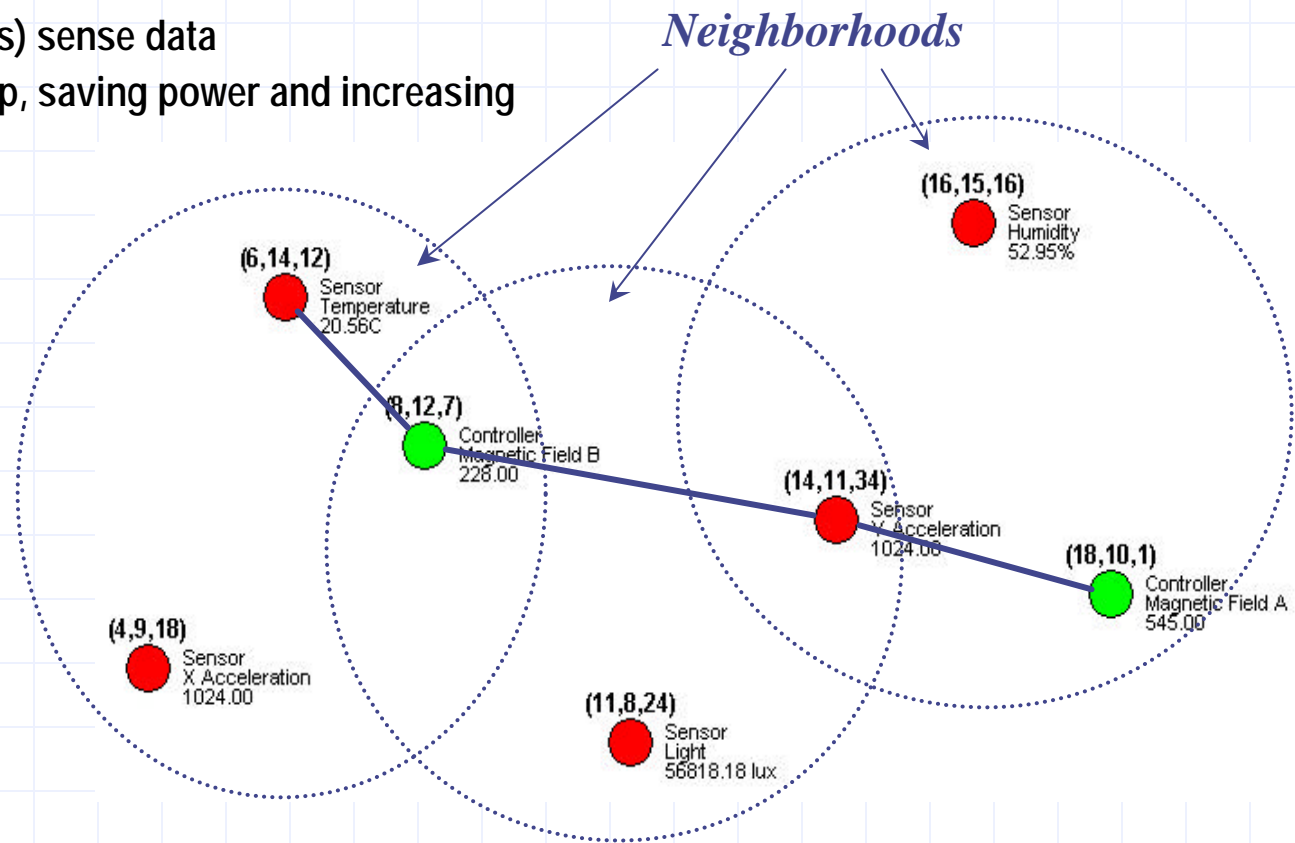


Communication

Inter-Node Communication

Example Network

- Green nodes (Controllers) generate requests and set up system
- Red nodes (Sensors) sense data
- Routing is multi-hop, saving power and increasing coverage



The Statistics and Maintenance Service (SMS)

- Motivation

- Function:

Monitor and Record Performance of the PicoRadio Network

- Structure:

SMS Controller Module

SMS Sensor Module

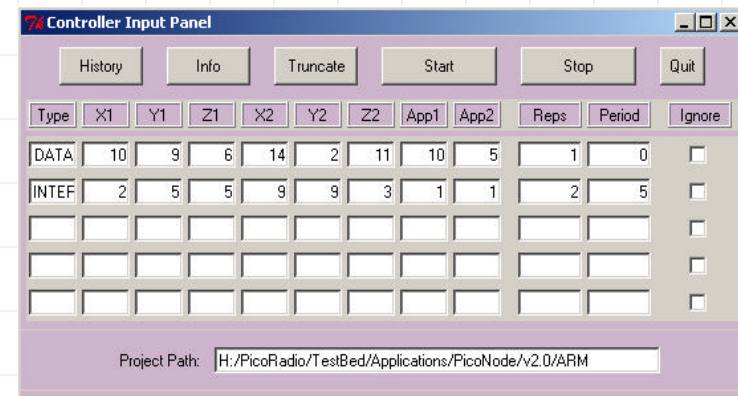
- Implementation:

Software

Hardware

- Using the SMS:

User Input Graphical User Interface (GUI)



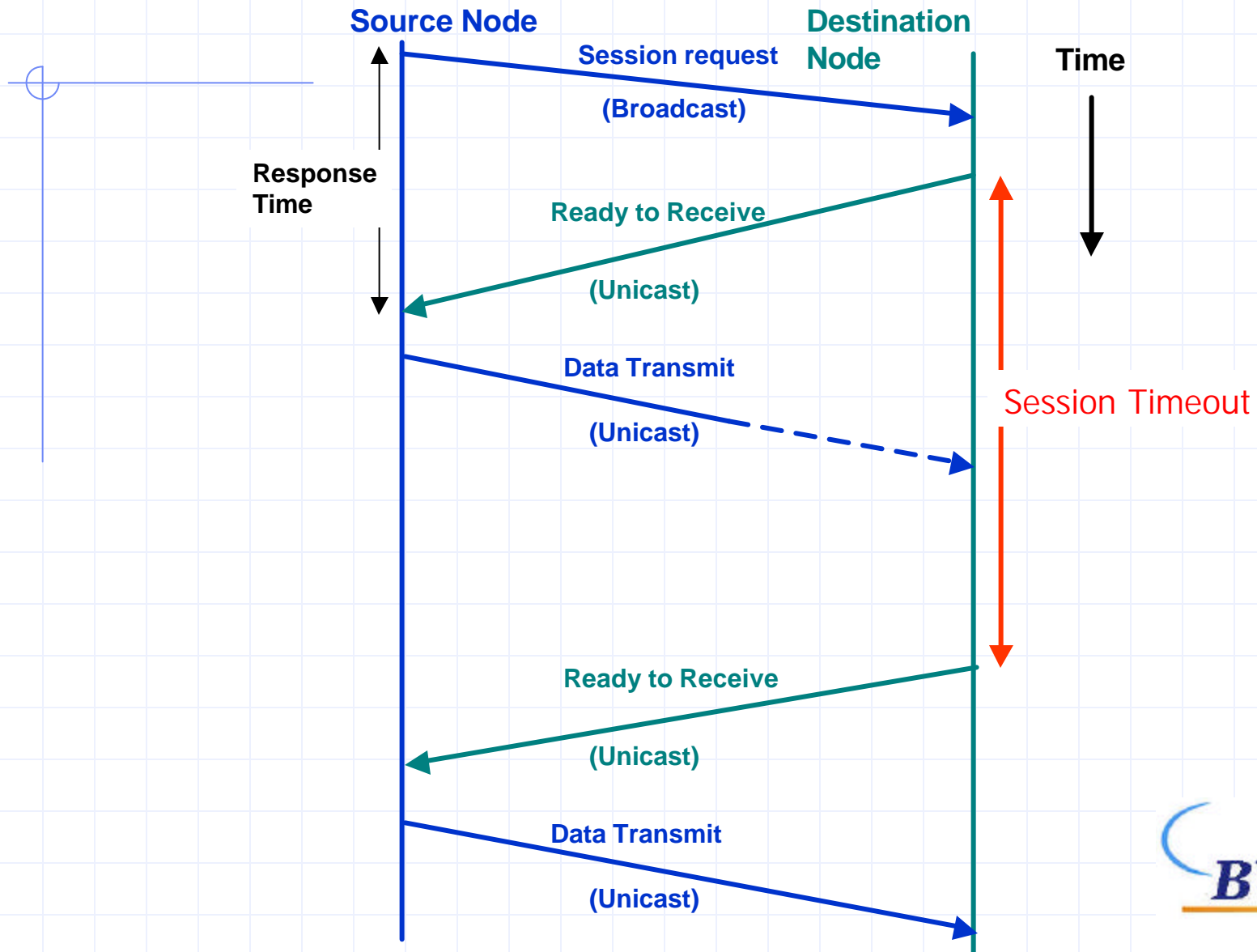
SMS Information Groups

- Neighbor List
 - Number of neighbors
 - Contents of the neighbor list
- Network
- Session
 - Number of sessions
 - Number of session requests
 - Number of ready-to-receives
 - Number of data transmits

- Maintenance
- Physical
 - Number of CRC (Cyclic Redundancy Check) failures
 - Total number of packets
 - Bit Error Rate (BER)



MAC/Datalink Protocol



How do we measure the performance of the MAC/Datalink Protocol?

- Session Requests
- Data Transmits
- Failed Sessions
- Robustness

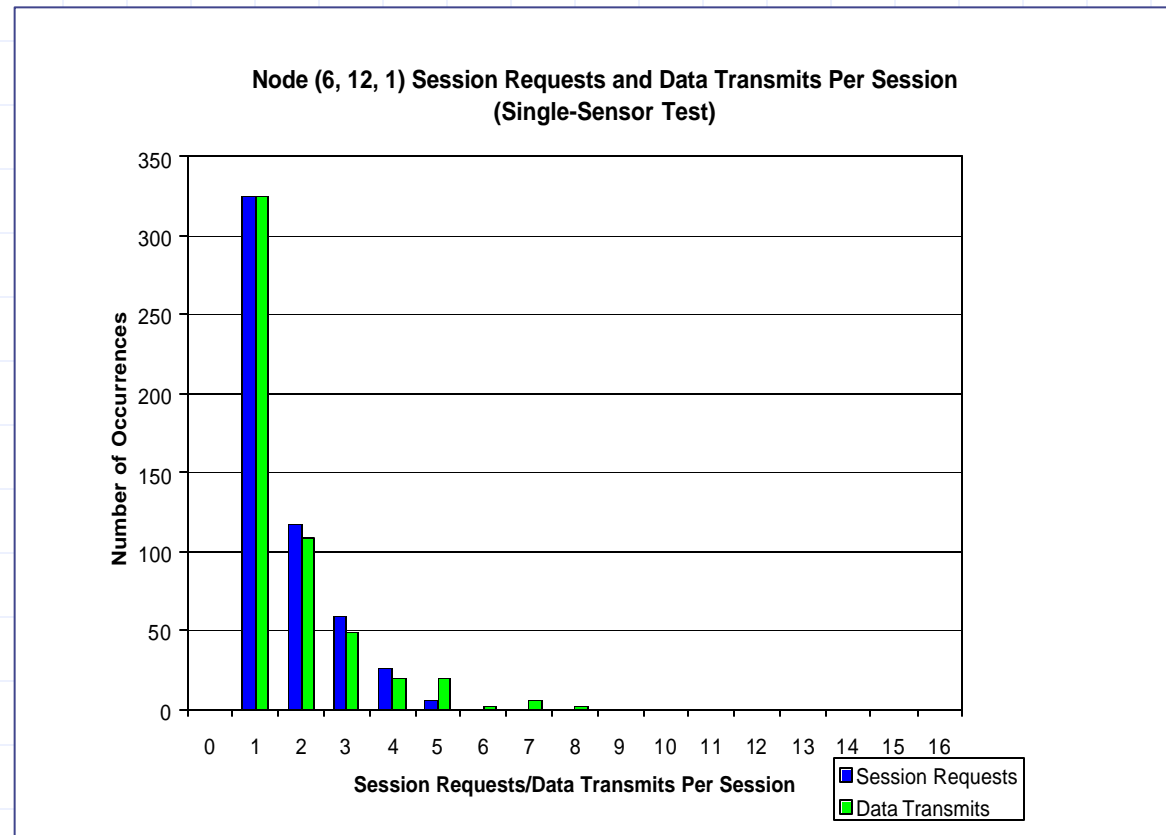


Field Testing: Acquiring Data

- Single-Sensor Scenario
- Multi-Sensor Scenario

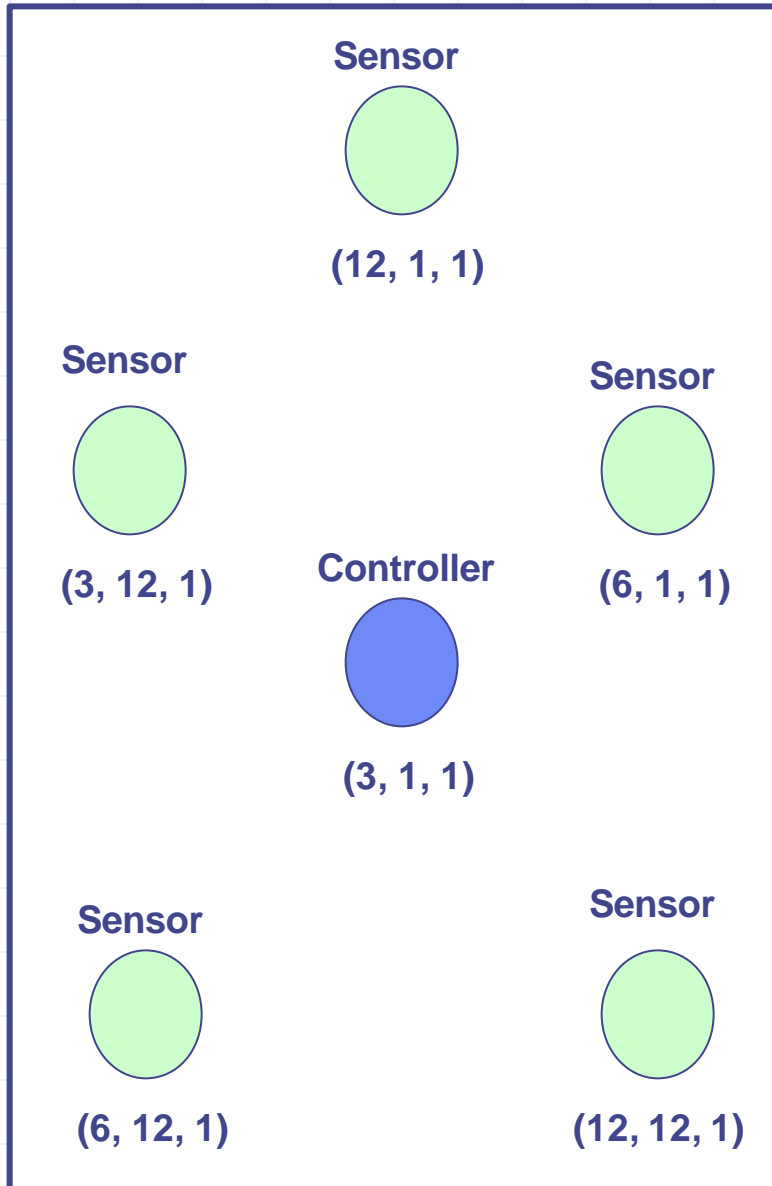


The Single-Sensor Test



Conclusion: The broadcast channel and the unicast channel had comparable performance in the single-sensor test.

Multi-Sensor Test

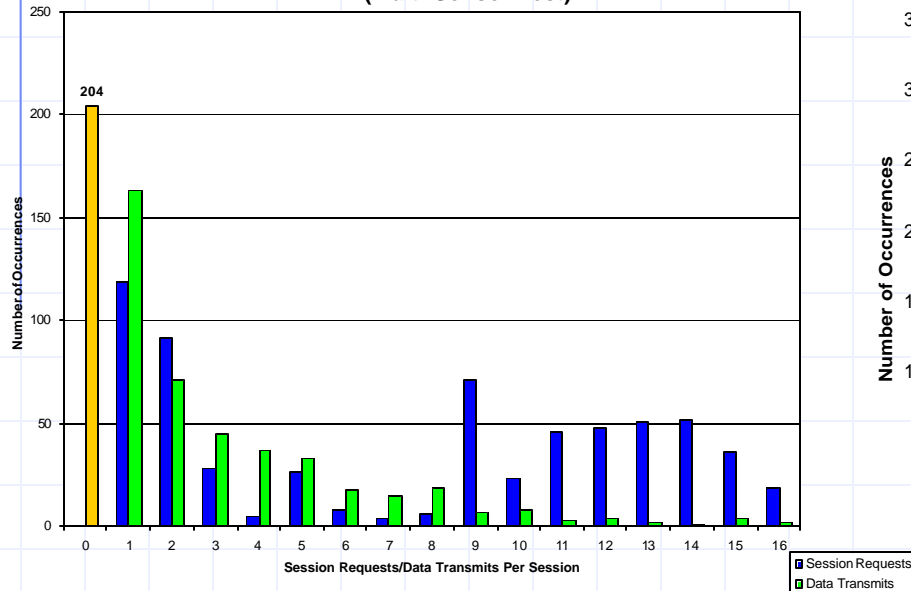


- Total Request Packets Sent: 1500
- Total Response Packets Received: 4450
- Total Routed Packets: 502
- Total Failed Sessions: 1160

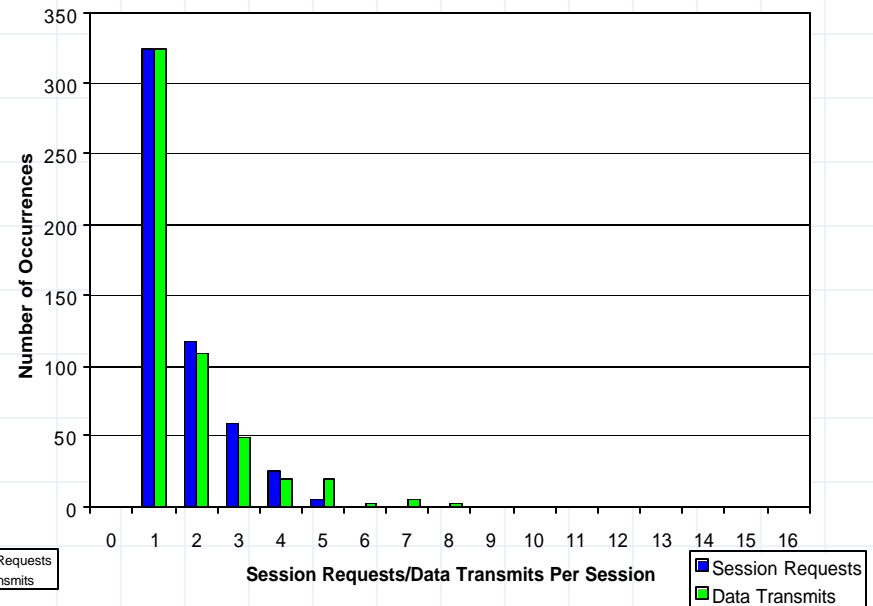


Multi-Sensor Test

Node (6, 12, 1) Session Requests and Data Transmits Per Session
(Multi-Sensor Test)



Node (6, 12, 1) Session Requests and Data Transmits Per Session
(Single-Sensor Test)



Conclusions:

- The broadcast channel is experiencing collisions in the multiple-sensor network
- The unicast channel is unaffected.

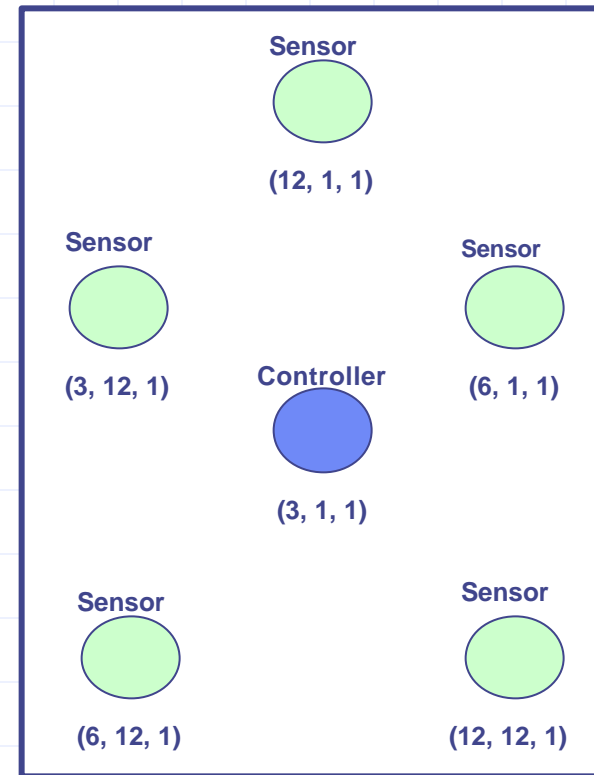
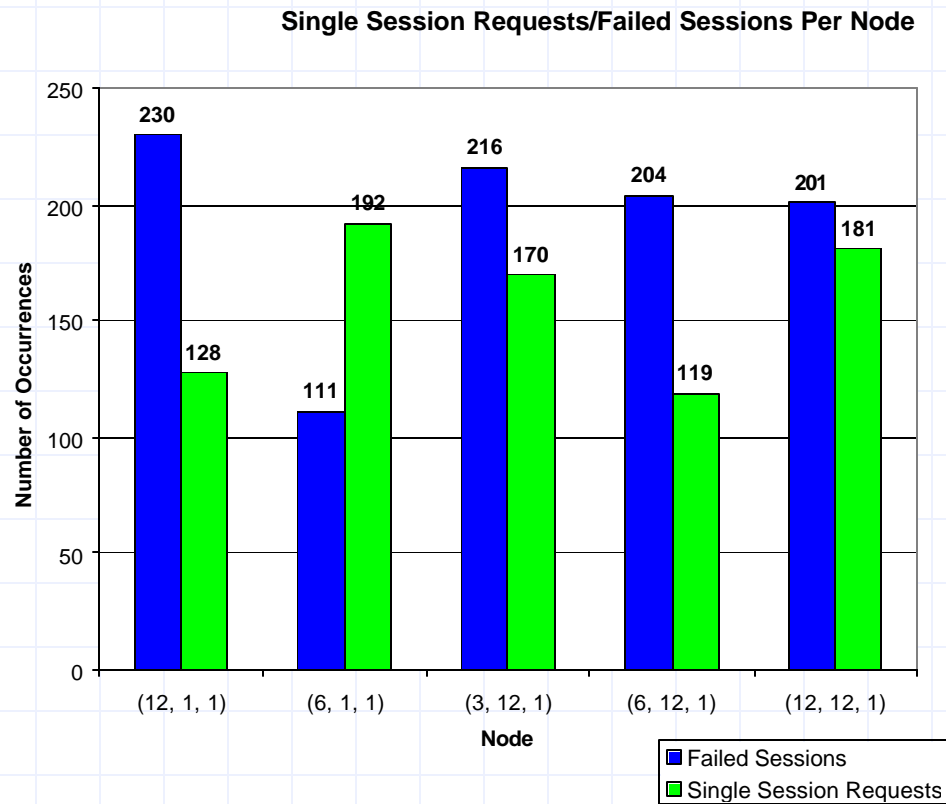
The Impact of Packet Forwarding

Single-Sensor Test			
Node	Number of Request Packets	Number of Response Packets	Percent Responded (%)
(6, 12, 1)	1500	534	35.60

Multi-Sensor Test			
Node	Number of Request Packets	Number of Response Packets	Percent Responded (%)
(6, 1, 1)	1500	956	63.73
(12, 12, 1)	1500	944	62.93
(3, 12, 1)	1500	885	59.00
(6, 12, 1)	1500	865	57.67
(12, 1, 1)	1500	799	53.27

Conclusion: Packet Forwarding increases the reliability of broadcast transmissions

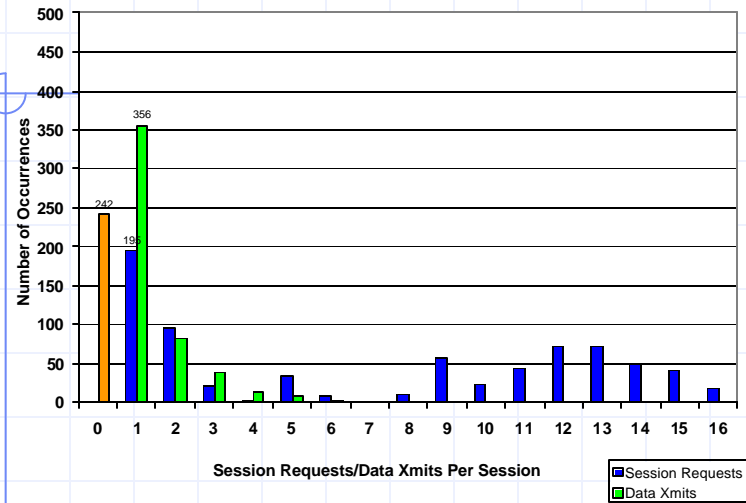
Relative Ability of Nodes to Communicate



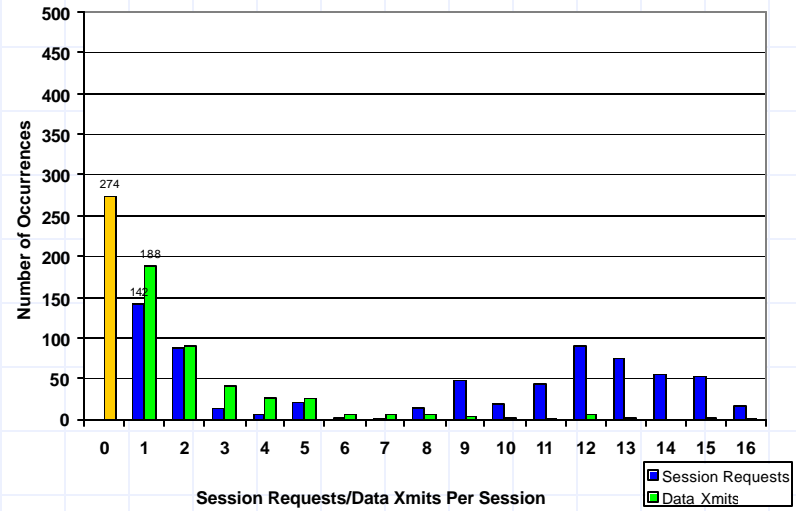
Conclusion: Some nodes communicate better than others

Analysis by Sensor

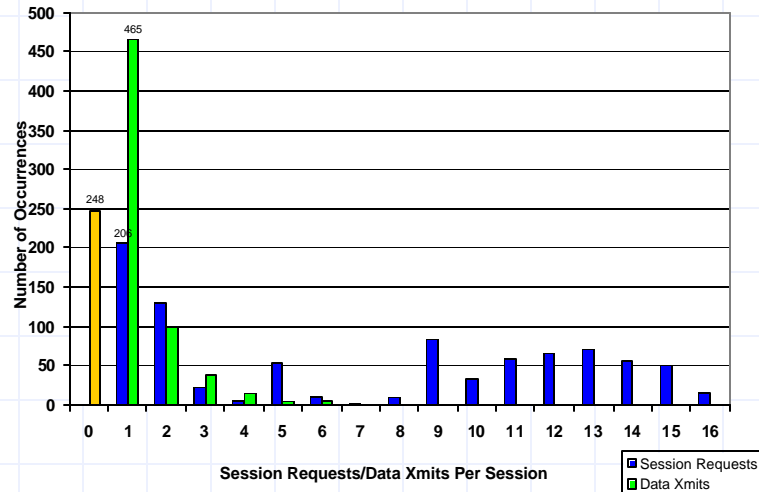
Node (3, 12, 1) Session Requests and Data Xmits Per Session



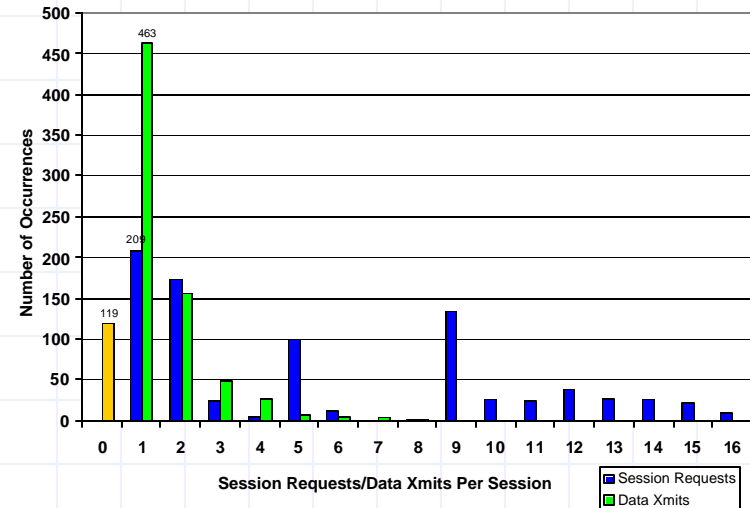
Node (12, 1, 1) Session Requests and Data Xmits Per Session



Node (12, 12, 1) Session Requests and Data Xmits Per Session



Node (6, 1, 1) Session Requests and Data Xmits Per Session



Conclusion: Best performing node: (6,1,1), worst performing node: (12,1,1)

Conclusion

- There is a mechanism for acquiring information
- Meaningful information has been gathered
 - Multiple nodes increase network performance
 - Unicast is more reliable than broadcast
 - Nodes differ in capabilities
- Work on the SMS module is continuing
 - Session information is completed
 - Bit Error Rate (BER) is in 'C' code



Acknowledgements

- SUPERB Staff
- BWRC Staff
- Fellow SUBERBites



THANK YOU!

