NSF Engineering Research Center (ERC) for

Reconfigurable Manufacturing Systems (RMS)

Addressing key challenges in wireless adoption

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The University of Michigan, College of Engineering

Key Challenges

1. Interoperability and coexistence of protocols

2. Mapping of existing open protocols to the requirements space

3. Handling communication jitter and packet-loss (minimize non-determinism)

4. Throughput – Developing protocols and devices (switches, routers) to handle and provide for higher throughput

5. Diagnostics – Developing tools for pre- and post-deployment diagnostics

6. Control over networks using time stamping

7. Education

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Interoperability testing:

- Radio interoperability
- Specification intra-operability

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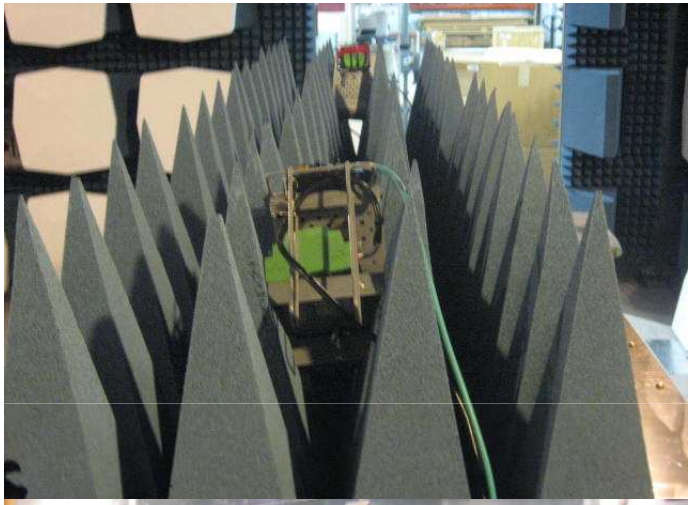
Interoperability testing:

- **Radio interoperability**
- Specification intra-operability

We found no significant Bluetooth on Bluetooth effect. The results on probabilistic BT on BT Interaction (frequency hopping)
are well documented.
Rogue routers were the only justifiable risk we spent time on. (Results in the catalog)



Interoperability between WSNs (Low speed I/O) and High speed I/O?

Key Challenges

1. Interoperability and coexistence of protocols

Interoperability testing:

- Radio interoperability
- **Specification intra-operability**

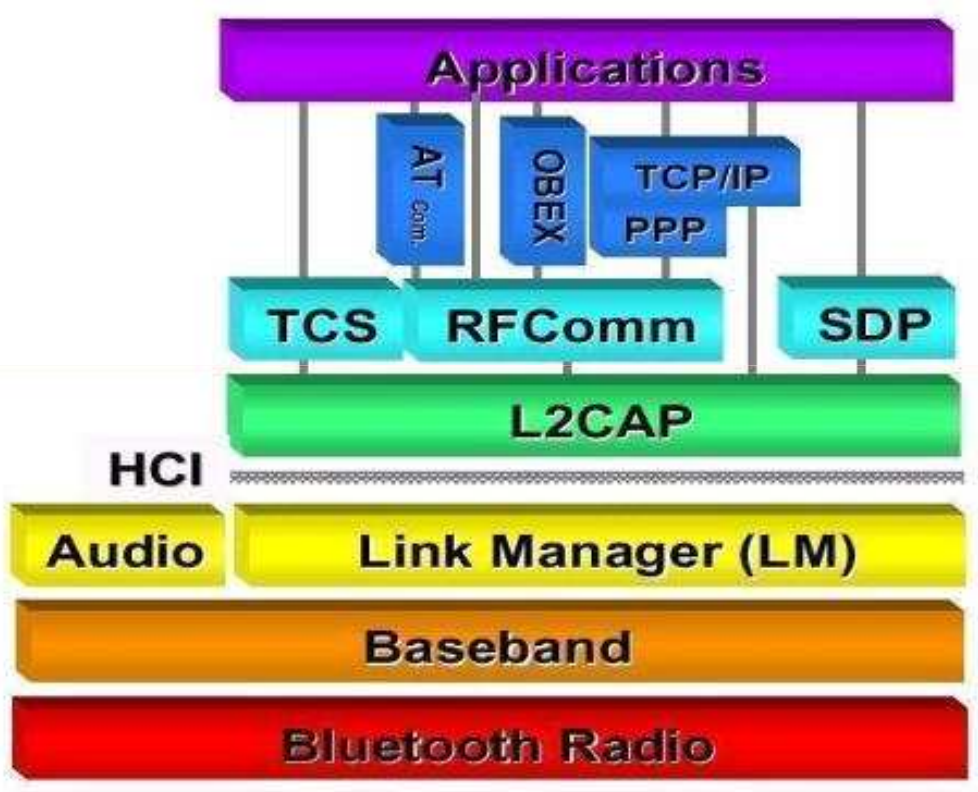
WiFi protocols work well amongst vendors and types.
We found some limitations with Layer 3 enhancements. High speed hand-off and accelerated connection times are vendor specific implementations.

Bluetooth implementations suffer some degradation with IP-based implementations. The lower level definitions in the BT stack such as L2CAP profiles are not standard and are very hard to probe.

Bluetooth Automation Profile?

Key Challenges

1. Interoperability and coexistence of protocols



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Bluetooth Automation Profile?

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2. Mapping of existing open protocols to the requirements space

- We focused on High/Medium Speed I/O.
- With 50 nodes, current Bluetooth implementations cannot meet the 100ms poll rate.
- WiFi may be able to, though the USCAR implementation strategy will have to be modified somewhat to allow some data aggregation.

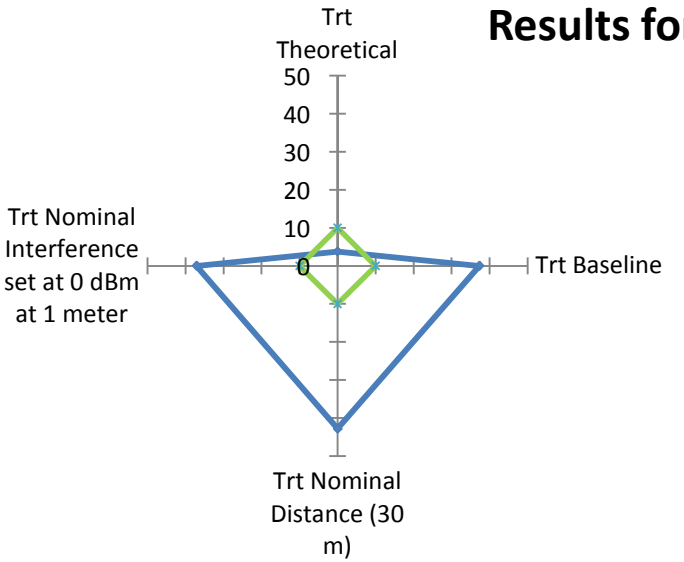
	Poll interval	# of nodes	Range
High Speed I/O	***10ms***	***50***	*10m*
Medium Speed I/O	*100ms*	*50*	***30-60m***
Low Speed I/O	*1hr*	*100+*	*100+ m*

WISA (ABB proprietary Frequency Hopping scheme) can meet the 50 device test case and the 10ms Poll Rate, but "openness" is still being worked out.

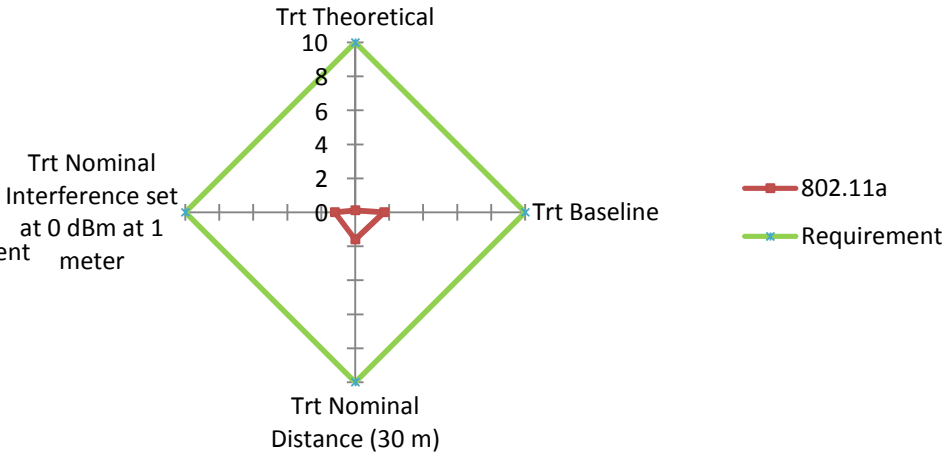
WISA IP abstraction/ bridging performance?

Mapping to the requirement space

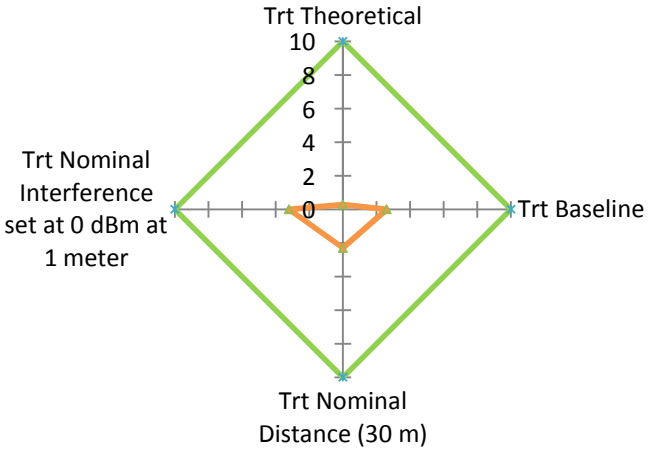
Results for Bluetooth



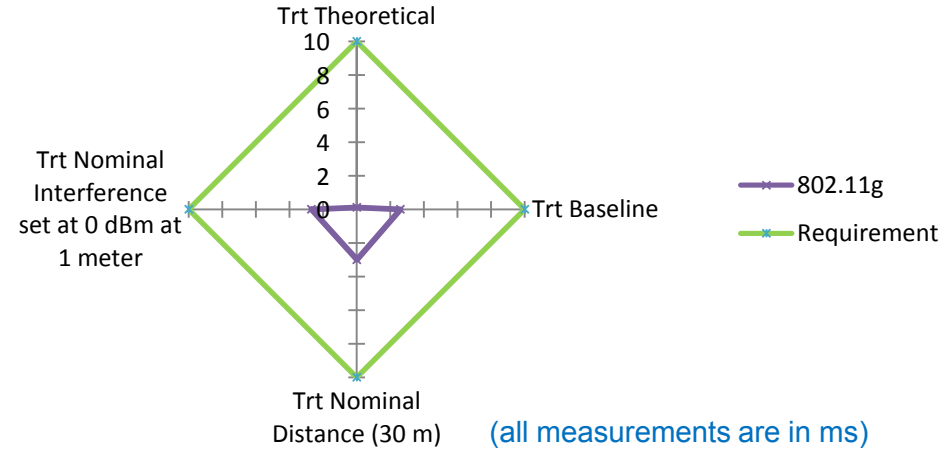
Results for 802.11a



Results for 802.11b



Results for 802.11g



(all measurements are in ms)

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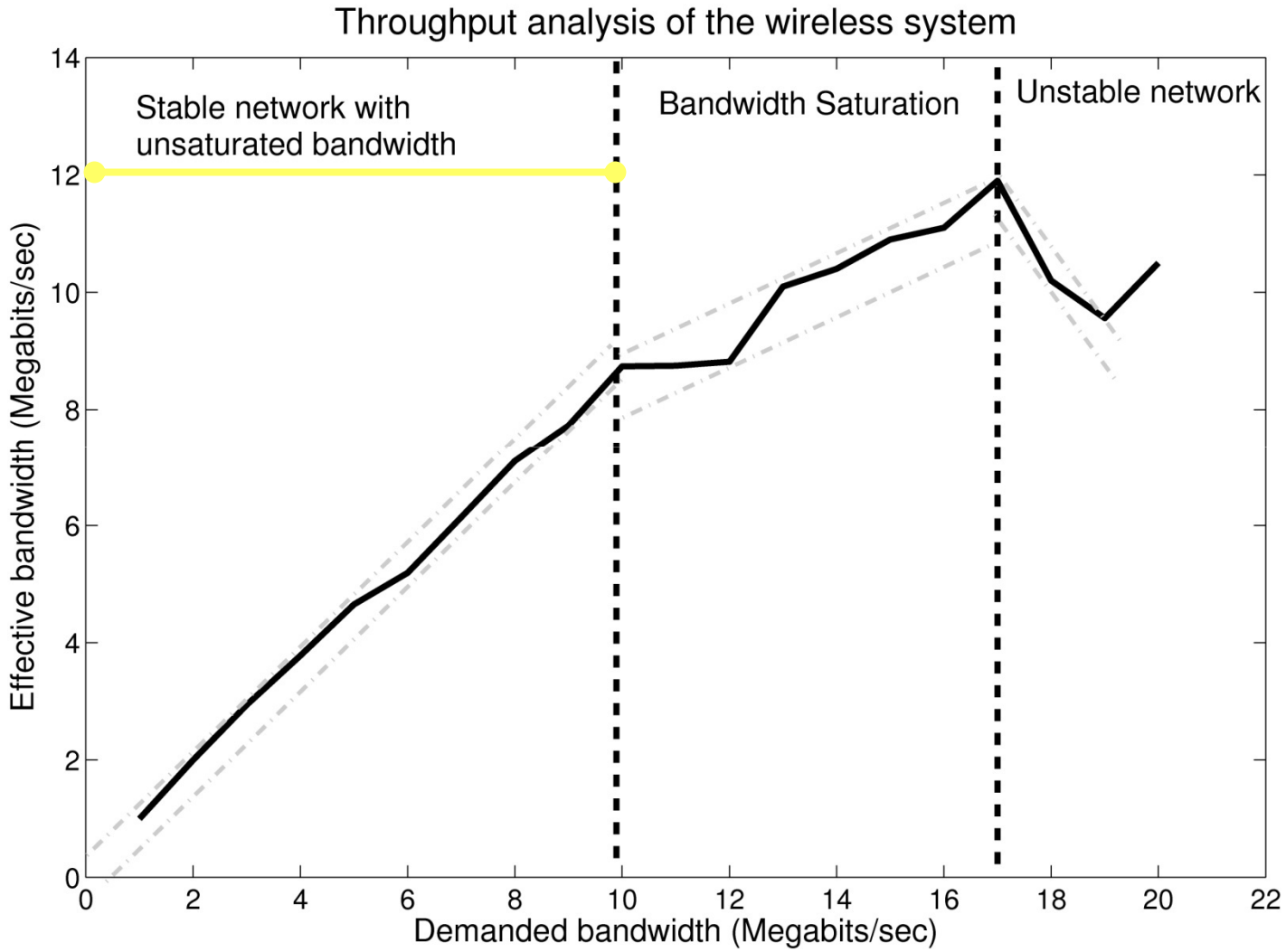
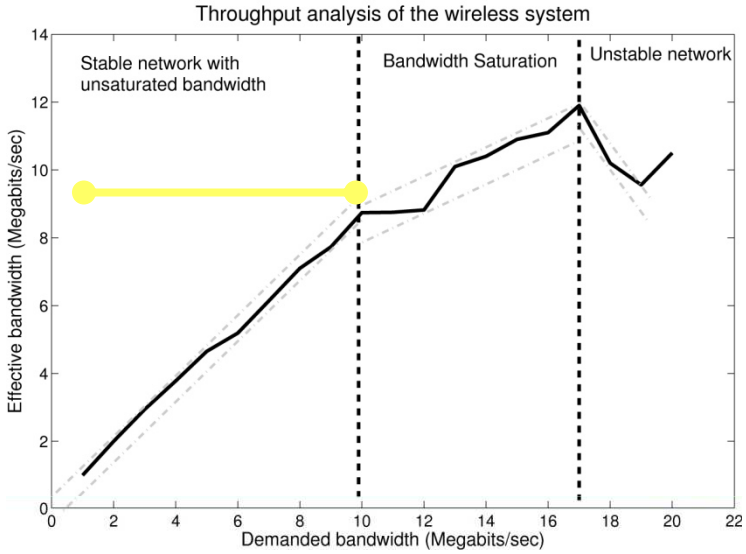
Jitter and Throughput



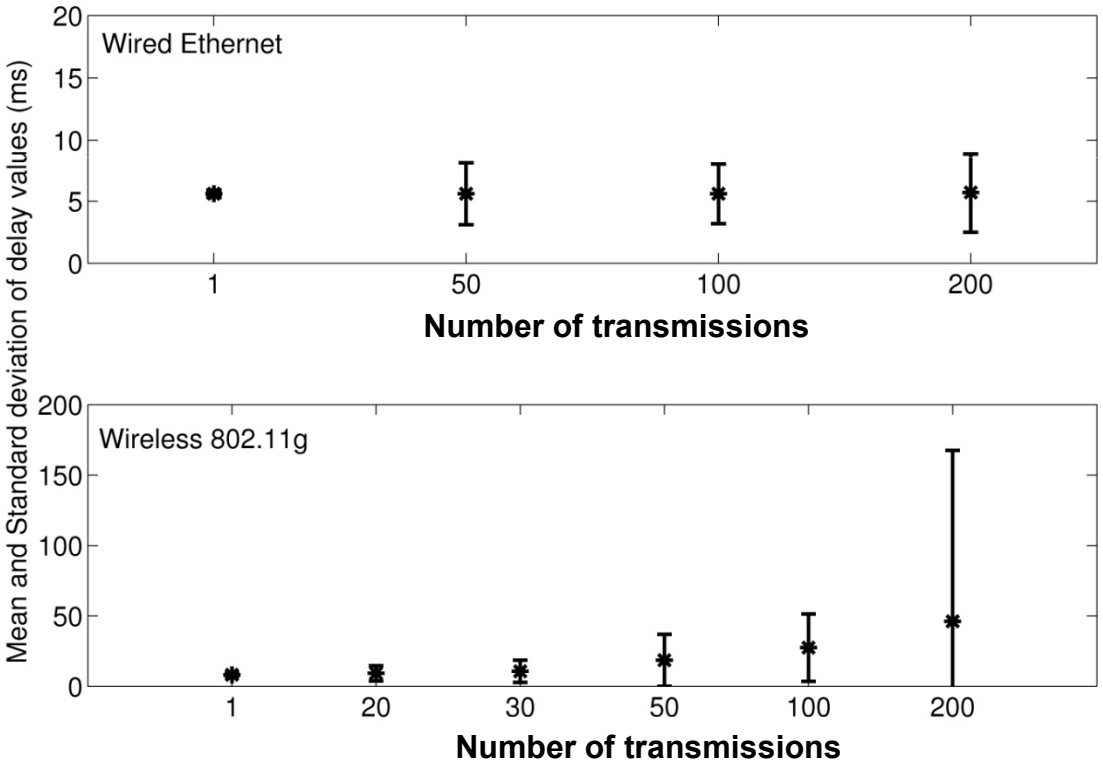
Jitter and Throughput



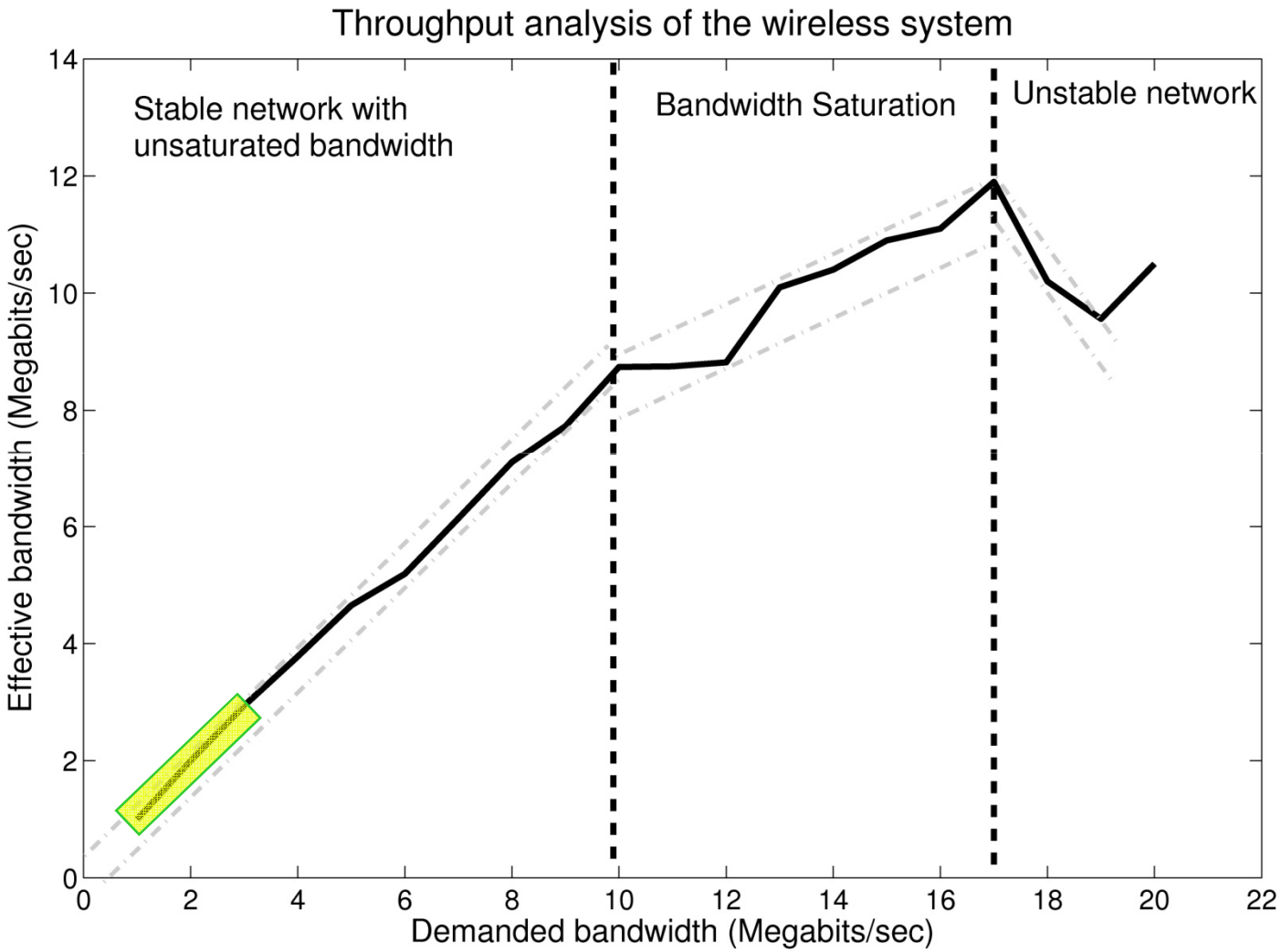
$$10Mb/s \rightarrow 200\,packets$$

$$\frac{10\times10^{6}\,bits/\sec}{8bits/byte\times200\,packets\times60bytes}=104.16\,packets/\sec/node$$

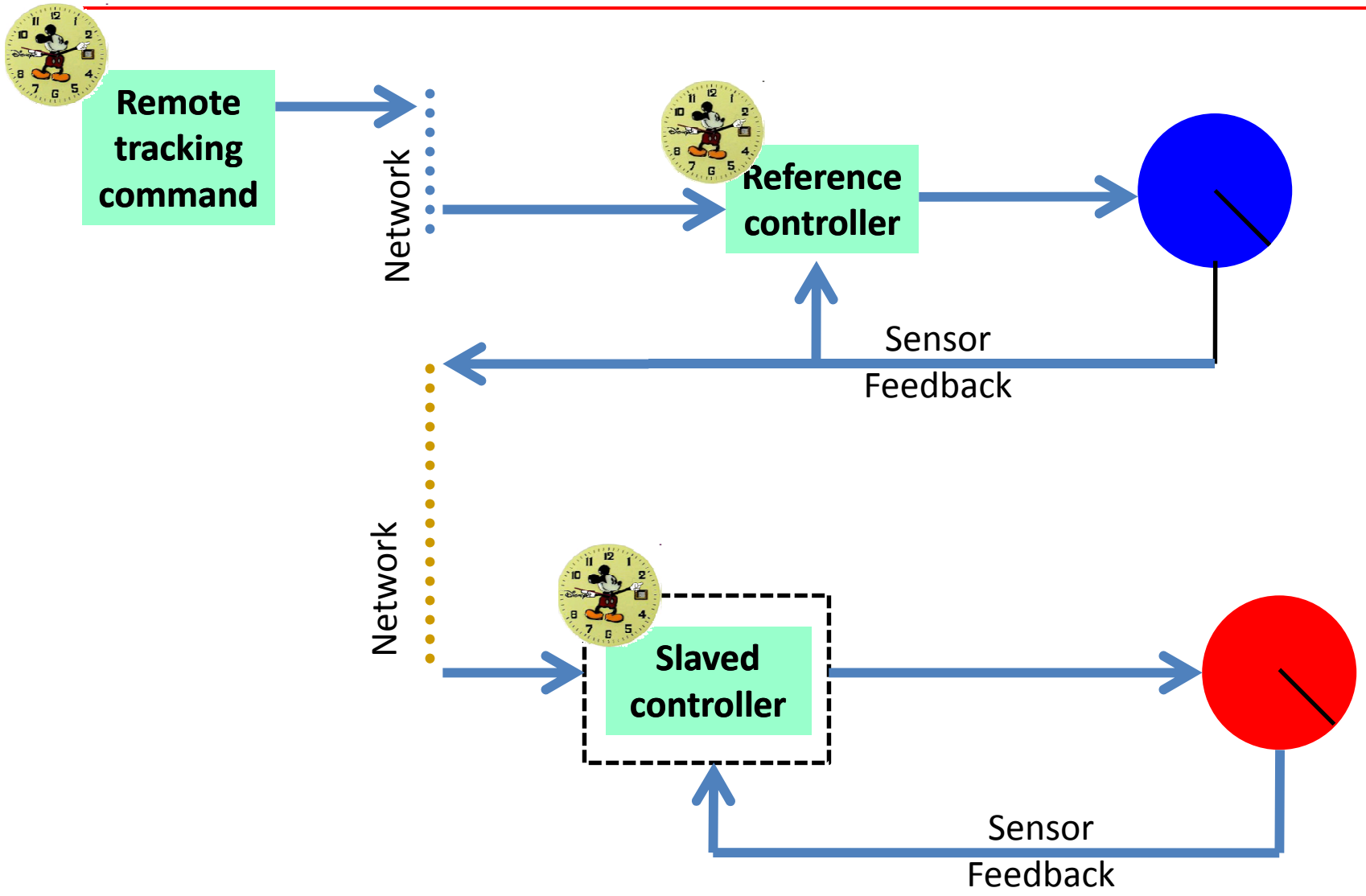
$$Freq.=1/(9.6ms)$$



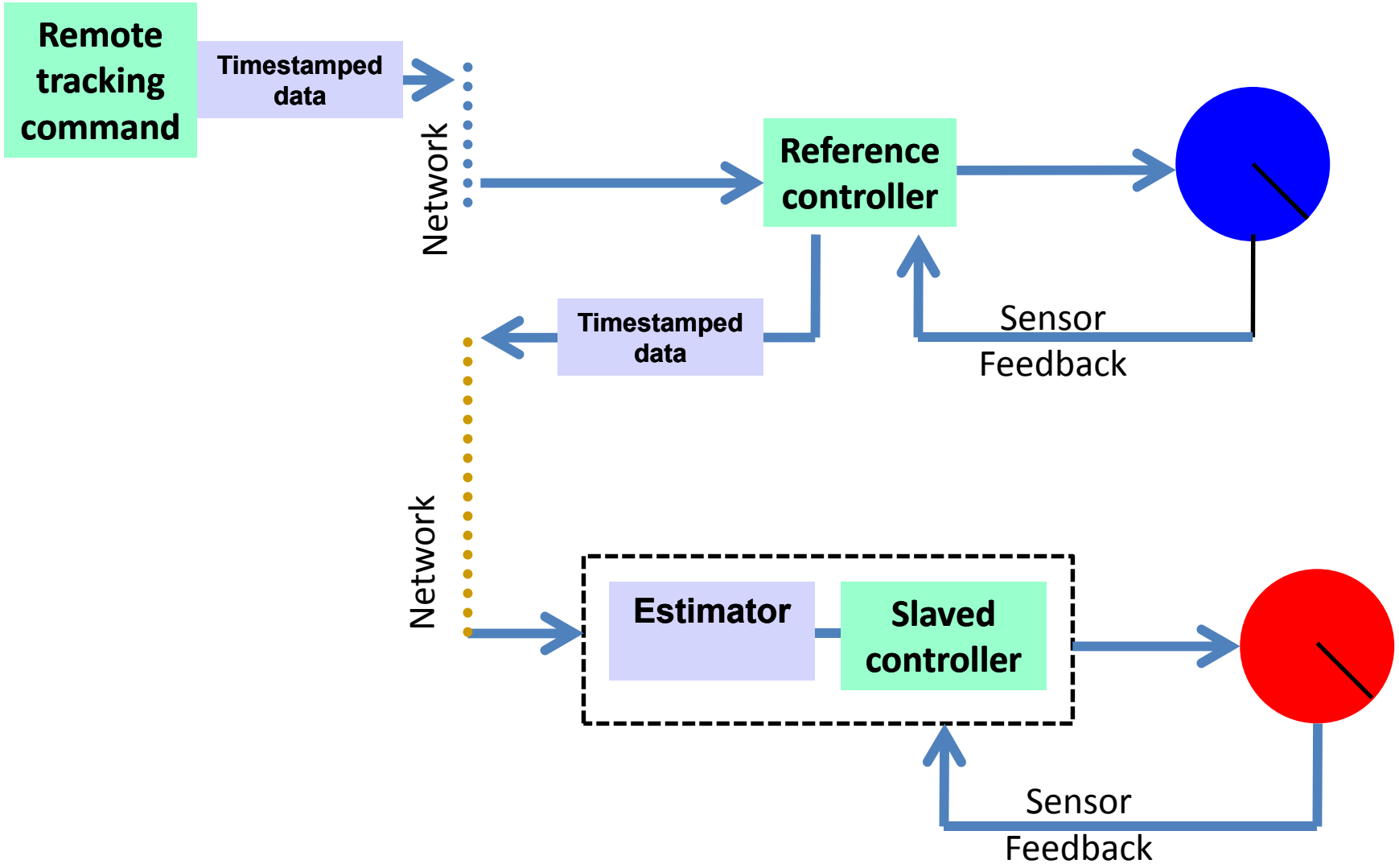
Jitter and Throughput



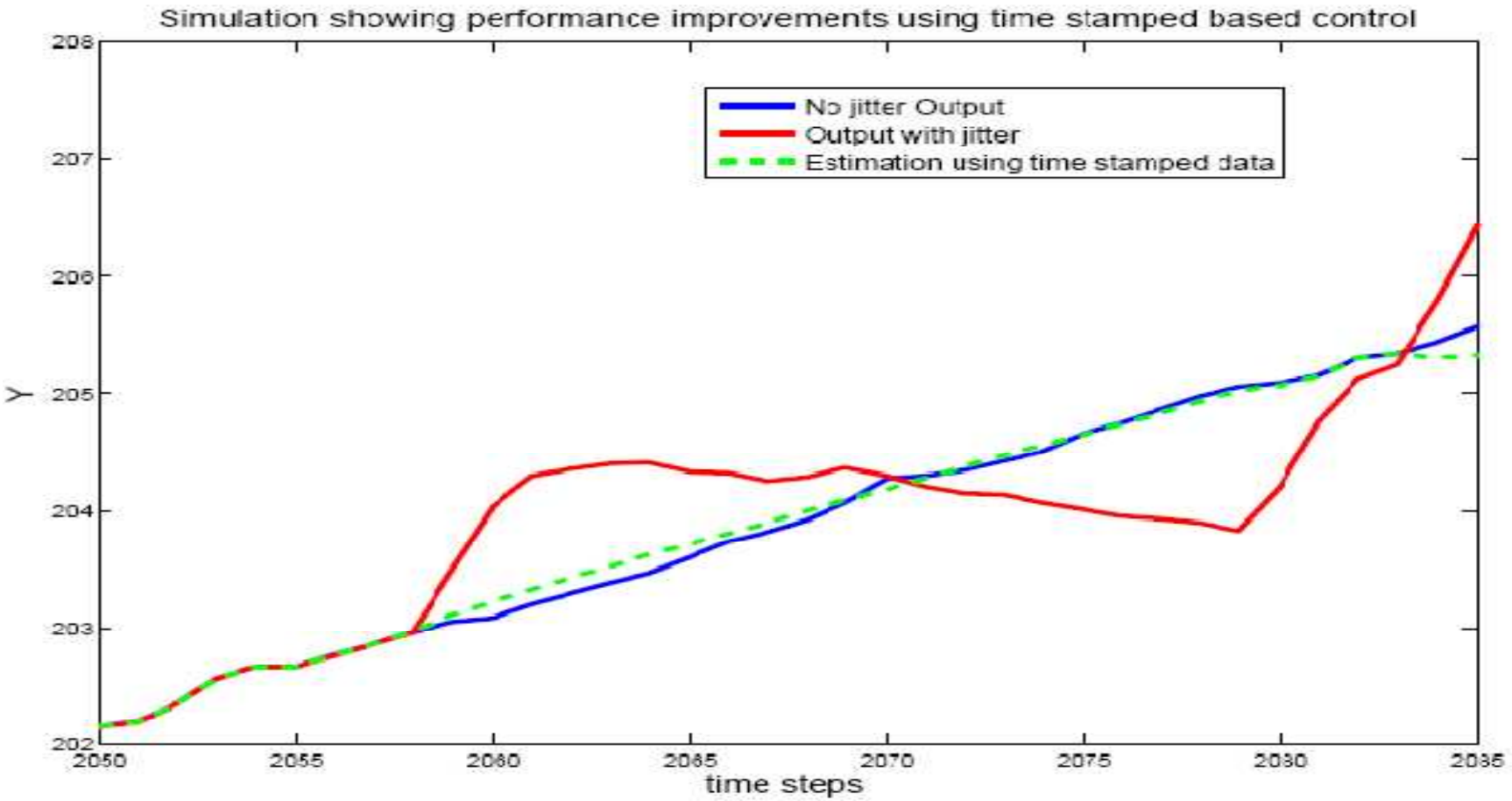
Synchronized nodes



Time augmented control



Simulation results



D. Sharma, D. Anand, Y. Li-Baboud and J. Moyne; A Time Synchronization Testbed to Define and Standardize Real-Time Model-Based Control Capabilities in Semiconductor Manufacturing; AEC/APC '09

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Improving control using time sync./stamping for manufacturing cells?

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Real-time Ethernet over Wireless?

For some details on wireless extensions to "Powerlink", please look at Lucia Seno's presentation[1].
Explore standards including EtherCAT and Profinet IRT?
Groups working on Substation automation for power-grid are also showing interest in the real-time "*High availability redundant ring protocol.*"
For details on our work with NIST on grid automation, please look at Jeffery Fletcher's presentation[2].

[1] //TAC_Lucia Seno_Wireless extension to Powerlink.pdf
[2] //TAC_Jeff Fletcher_Smart grid and beyond.pdf

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Wireless device class extension for Ethernet/IP (and/or Profinet) ?

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Report generator

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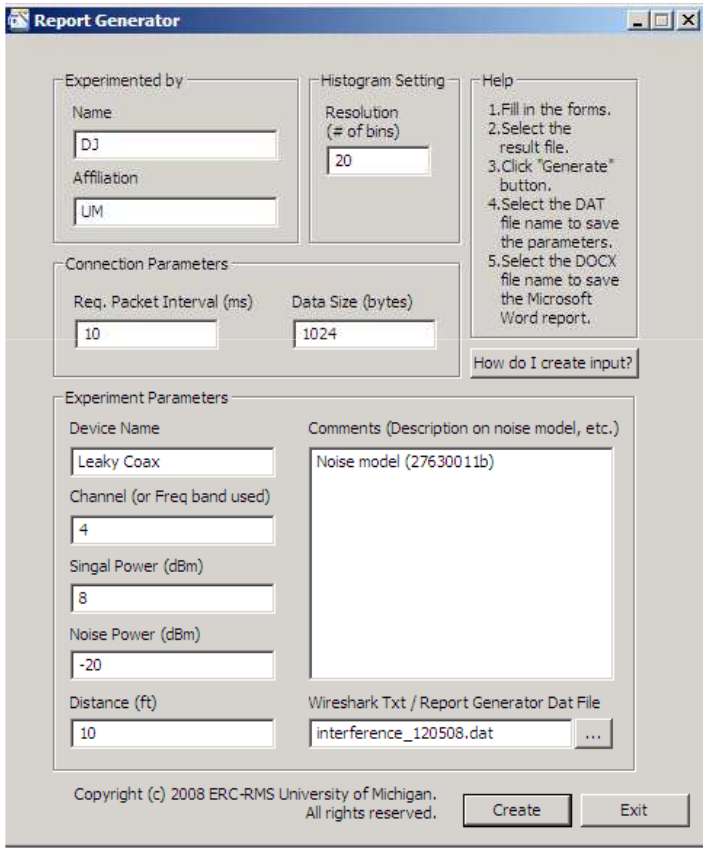
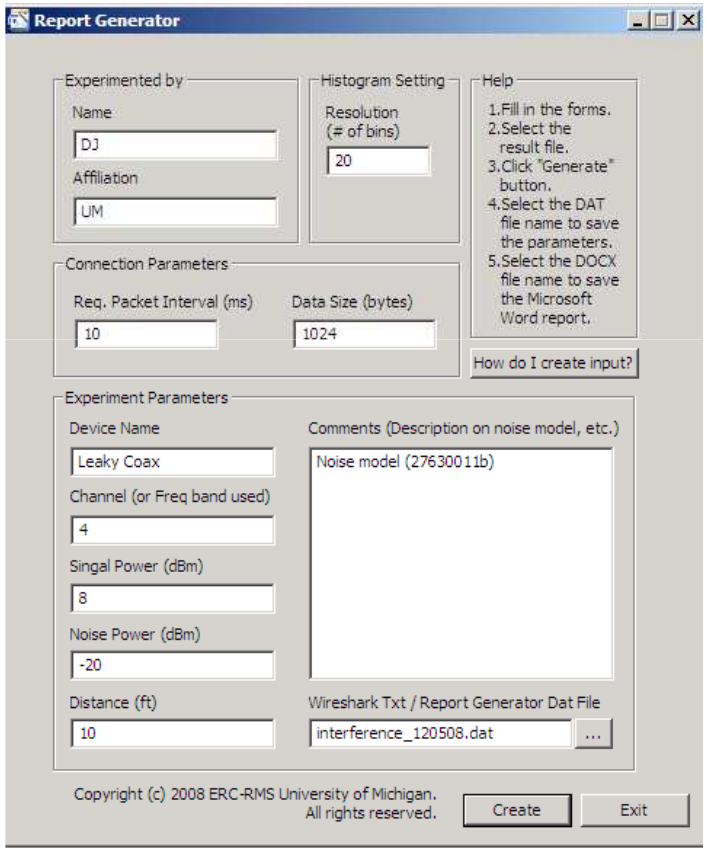


+ Simulation profiles for wireless interference

Report generator

5. Diagnostics – Developing tools for pre- and post-deployment diagnostics



+ Simulation profiles for wireless interference

Revive wireless layout tool?

Expanded functionality with E/IP+ Profinet App. Layer support ?

Future steps

- Interoperability between WSNs (Low speed I/O) and High speed I/O?
- Bluetooth Automation Profile?
- WISA IP abstraction/ bridging performance?
- Real-time Ethernet over Wireless?
- Revive wireless layout tool?
- Improving control using time sync./stamping for manufacturing cells?
- Wireless device class extension for Ethernet/IP (and/or Profinet) ?
- Expanded functionality for the report generator with E/IP+ Profinet App. Layer support ?

Thank You

Questions?