NSF Engineering Research Center for
Reconfigurable Manufacturing Systems
University of Michigan

Wireless Networks for Industrial Automation

MOTIVATION AND CHALLENGE

Wireless technology, which has boomed in the IT sector over the past years, can be suitable for industrial control networks as well, providing solutions with high ROI for diagnostics, control and safety. In managing the move to wireless, it is clear that common wireless protocols such as WiFi and BlueTooth can be utilized on the factory floor. *The challenge is understanding how to utilize wireless solutions, developed for IT applications, as replacements for wired systems in time-critical scenarios typical of factory floor domains*. To-date, most wireless systems in production systems are focused on applications that require polling frequencies on the order of seconds or longer. However, the fundamental capabilities of these protocols allow support of much higher-speed applications such as motion control and closed loop distributed logic. To address this challenge, the following issues must be addressed in wireless technology for manufacturing :

- *Determining the performance of wireless technology (data rate, transmission, jitter and link reliability)*
- Developing best practices for wireless solution deployment and maintenance
- Implementing standardized device testing across industries, including automated performance benchmarking.

BENEFITS

- ✓ Profile the performance of wireless devices and systems as it relates to metrics important for production system applications (e.g., speed, determinism and jitter)
- ✓ Provide best practices for migrating to and maintaining wireless systems in manufacturing domains
- ✓ Give a plant engineer a prior knowledge of performance limitations and tools to identify potential liabilities
- ✓ Provide a platform for industry standardized testing and benchmarking of wireless devices and systems
- ✓ Provide an understanding of the implementation areas for wireless that will provide the highest Return on Investment.

OVERVIEW OF THE WORK

Device Testing:

- Standardize device and network testing and develop performance specifications that represent application requirements of an industrial control system
- Develop a test plan in partnership with industry that parameterizes wireless devices and networks; test plan drives university research and achieves conformity among industry partners
- Develop Best Practices for implementation of wireless control, diagnostics and safety systems

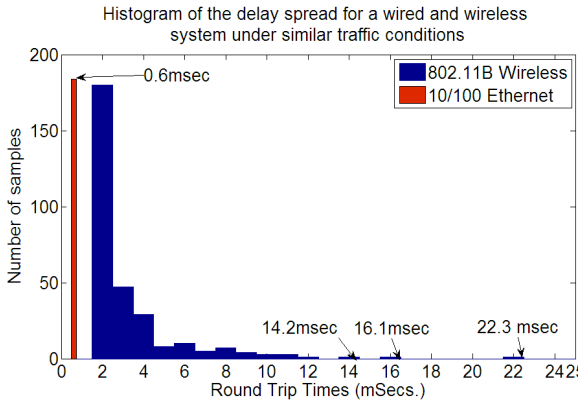
Wireless Network Control Simulator:

- A system-scale simulator is currently being developed capable of simulating network performance when wireless interfaces are used. The solution includes simulation of:
  - *Protocol stack and data processing related delays*
  - *Multi-node access and arbitration related delays*
  - *Interference and error recovery related delays*
- Further, this simulator can be extended to include the performance of the Wireless Control System in terms of Sampling Rate, System Bandwidth, Failure Modes, Fault Tolerance and Robustness. It can also incorporate experimental analysis into the model.

Tools for wireless cell layout planning:

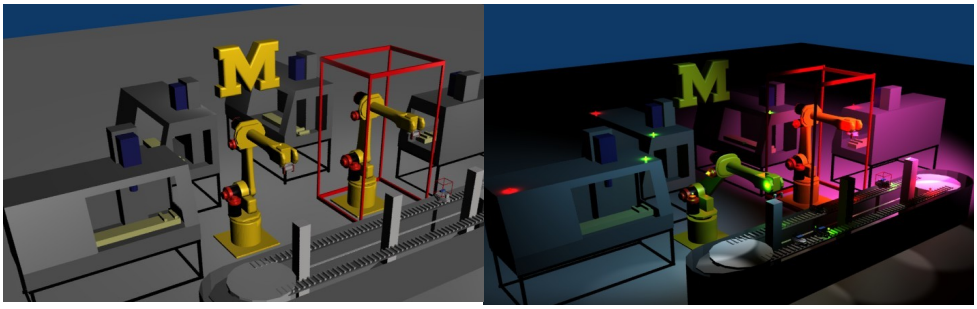
- With the use of radio there is an additional dimension to the design of the cell layout. The radio coverage area or beam footprint of the base station antennae and all the sensors has to be considered.
- A simulation tool capable of predicting radio coverage of non-conventional radio feeders like the leaky coax is currently being developed.
- The simulation tool can overlay existing cell geometry to look for trouble spots in the form of weak fields, shadow zones, scattering interference and leakage outside the cell.

A wireless supervisory controller replacing an Ethernet based controller, such as for a Robotic Weld Station pictured above, will have to tolerate much larger packet transmission delay and delay variation. An example of this is seen below, where wired and wireless systems are compared in a typical industrial setting with interfering radio transmissions and network traffic.



PRELIMINARY RESULTS

- Most control and safety systems with millisecond response requirements CANNOT be replaced one-for-one with wireless systems without some level of redesign
- The common technique of *increasing transmission power in wireless systems to improve reliability does not always work* and can, in fact, be detrimental to performance.
- With microwave transmissions in closed spaces, *multi-path propagation effects dominate system performance*, resulting in lower performance. External environment geometries must be considered.
- Network algorithm changes that can easily be applied to existing WiFi and Bluetooth systems have shown appreciable performance improvement in simulations.
- When designing wireless infrastructures for control orthogonal band allocation, collaborative power management and optimal packet sizing greatly improve system performance.



A simulation showing predicted radio coverage inside a machining cell

GOALS

- Develop methodologies and best practices for using wireless in diagnostics, control and safety applications.
- Provide a standardized testing mechanism and test plan for making effective wireless reconfiguration decisions.
- Provide a capability for “record / playback” style investigation / re-creation in lab / analysis and reporting, for wireless troubleshooting.
- Provide design tools for the planning stage of a wireless setup.
- Report on technology trends in wireless systems for control.

CURRENT STATUS

- Device and technology testing is ongoing, leveraging partnerships with Underwriters Laboratories for testing expertise and USCAR for technology application inputs.
- Radio interference in the plant floor environment is being captured and analyzed.
- Vendor concepts for the next generation of wireless solutions are being evaluated.
- A real time data analysis tool for wireless network performance was designed and made available online to ERC members.

DELIVERABLES

- An industry-standardized software solution for automated testing and reporting on performance of wireless devices
- A software wireless control system design and analysis tool
- A software tool for “multi-feeder” wireless system that simulates radio coverage over existing cell geometry that looks for trouble spots in the form of weak fields, shadow zones, scattering interference and leakage outside the cell.

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FUTURE MILESTONES

- Release the Wireless Network Simulator for control system design and analysis (Summer ’09)
- Comprehensive wireless protocol profiling guide for application of wireless to manufacturing (Summer’ 09)
- Release a set of best practices for both deployment and management of wireless networked control (Fall ’09)