

UM-ERC/RMS 2nd Annual Network Performance Workshop Report:
The Move to Ethernet and Wireless Technology
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I. Introduction and Executive Summary

The 2nd Annual Network Performance Workshop brought together experts from the manufacturing industry and industrial network suppliers to discuss the future of Ethernet and wireless systems as part of a process as part of a comprehensive plan to determine strategies and best practices for the deployment of these technologies on the factory floor.

Major players in the industrial Ethernet Community discussed *considerations in moving to Industrial Ethernet in three presentations*:

1. Time synchronization: Leveraging Ethernet Everywhere - Time Synchronization was discussed as a major tool for improving Ethernet communication and utilization in industrial environments.
2. Testing and Network Considerations - Various topological and prioritization issues in Ethernet were discussed.
3. Ethernet for Control Determinism and System Response Time: Myths vs. Reality - Considerations for an approach to Ethernet based control were presented.

A better understanding of the *state-of-the-art of wireless Ethernet in Automation* was provided in two presentations:

1. Wireless Testing in the Factory Environment - Various test results of wireless functionality in factory tests were presented.
2. Wireless for Automation - A broad overview of the implementation of wireless technologies was give and implementation and operation issues identified.

A set of *industrial wireless research needs and requirements* were determined in a roundtable discussion; these requirements will be utilized to help guide wireless research at the ERC-RMS. As the discussion also raised several technical questions that should be answered before the wide scale implementation of wireless technologies in industrial applications, it is believed that the output of the discussion could also be utilized as the first step in determining wireless deployment best practices for the factory floor.

II. Presentations

This section provides a general outline of each of the presentations along with issues of discussion based on those presentations. The full presentations can be viewed on the TA2 website (http://erc.engin.umich.edu/news/network_workshop.html).

1. Time synchronization: Leveraging Ethernet Everywhere

Ya-shian Li – National Institute of Standards and Technology (NIST)

Ya-shian Li presented her group's work with time synchronization and Ethernet technology (a portion of this work is being conducted in partnership with the University of Michigan, focused on factory-wide simulation of synchronization (see http://erc.engin.umich.edu/research/TA2_docs/Network_Time_Sync.pdf.) One of the main issues her group has seen with high data collection rates is the synchronization of time data. Fault diagnostics can also be derived from time stamping and is a very useful tool. Finally, an experimental correlation between data and events can be built from time synchronization.

It was expressed, by those in attendance, that information on the effect that routers and switches have on the robustness of the network and time synchronization is of interest. Finally, it was suggested that a future topic of research could be the effect of latency with Ethernet and time synchronization, if it causes increased network load or packet loss.

2. Testing and Network Considerations

Jonathan Parrott – Open DeviceNet Vendors Association (ODVA)

Jonathan Parrot gave a high-level presentation on various considerations that ODVA has been investigating to determine the best configuration and layout of a network. One main point of research is how to implement prioritization in networks and to increase functionality. Also, the best topology for Ethernet in a factory was presented with various pluses and minuses.

3. Ethernet for Control Determinism and System Response Time: Myths vs. Reality

Fred Cohn – Modbus-IDA

Fred Cohn presented an approach for utilizing Ethernet for control and some issues involved with the implementation of this approach. First, he discussed Ethernet determinism and various factors, like topology and bandwidth, which can cause adverse or positive effects. He discussed some common practical misconceptions about Ethernet and the reality of these issues. He finished with a discussion of tests that were conducted to evaluate the impact of common Ethernet related issues. He concluded that the end devices on a network have a large effect on network system timing and performance. Additionally, there was

some discussion on the effect of operating systems on performance. System stacks and real time operating systems (RTOS) have a significant effect on the end device performance. He also discussed, when prompted by audience questions, the fitness of Ethernet, which is optimized for wide bandwidth communication if properly configured and implemented.

4. Wireless Testing in the Factory Environment

Les Lee – Ford Motor Company

Les Lee discussed various testing that his research group has, and is, conducting on wireless technology used in the factory environment and some conclusions. His tests used dual channels for communication and hopped between the two based on signal strength, which was marked as the variable to determine network quality. He found that the length of antenna or mast didn't significantly affect network quality. However, mast rotation had a 5-10% effect on signal quality.

Additionally, he mentioned a few issues that should be addressed before widespread implementation of wireless technology. For instance, the importance of channel partitioning to maintain network health and security measures to eliminate illegal access points.

5. Wireless for Automation

Hunter Harrington – PROFIBUS Trade Organization (PTO)

Hunter Harrington gave a broad overview of major wireless technologies and their implementation and major issues. Specifically, he reviewed the different versions of the 802.11 standard with a focus on strengths and weaknesses in implementation. Additionally, to this information, he discussed some real world issues with the Wireless Ethernet and some industry led solutions. The issues he discussed include: design considerations, bandwidth reservation, and wireless infrastructure. Finally, he explained the implementation of wireless technologies in several real world factory and plant scenarios. His discussion was very informative for high-level design considerations when planning an implementation of wireless technology on any level.

III. Round Table Discussion

The purpose of the round table discussion was to bring together engineers, suppliers, and experts in the field of networks and operation to discuss Ethernet and (especially) wireless technology on the factory floor. One goal of the discussion was to provide input and guidance for development of a best practices document for wireless communication. A second goal was to identify what focus points for ERC wireless networked control system research that would aid the implementation of these best practices.

Best Practices Document

There is a need for a working document with a set of best practices for wireless communications with the following major categories and that answers the following questions:

General

1. Tasks and common usages should be developed such that they don't impact safety or the operation of a system
2. Address access concerns and a perceived lack of security
 - Possibly incorporate existing solutions for security that use model number for connection security

Performance

1. What are the main sources of noise and what is the impact on wireless
 - How immune are different networks to noise, mechanical structures, etc.
2. How is the location of wireless devices and networks affected by directionality and proximity issues
3. Mesh architectures vs. P2P
4. There is a need to evaluate the level of determinism of wireless; is it enough to meet current control application
5. Can the performance metrics for industrial Ethernet be applied to wireless?

Changeover

1. The market needs to be advised of the possibility of integration
 - Wired and wireless
 - Wireless type 1 and wireless type 2
 - Will they seamlessly work together?
2. A wireless changeover model should be developed for it would be beneficial in planning a wireless solution
3. What is the ROI of moving to wireless

Questions

These questions were raised about the fitness and configuration of implementing wireless and Ethernet solutions with current technology.

1. Are there going to be issues with in-vehicle wireless systems and plant wireless co-existence?
2. There are a significant number of different technologies with numerous scopes of applicability.
 - A method of simplifying this situation is the use of dedicated access by secured bandwidth
 - Can we provide exclusivity with respect to bandwidth for an application?
 - Backbone traffic handling vs. cell traffic
3. There is a real need to implement a wired solution in wireless, i.e., seamless transition with replication of functionality and performance
 - Is it possible?
 - What technologies recommend?
 - Could a change in the configuration of current devices and protocols accomplish this need?
4. Getting power to the device to preserve wireless benefits
 - Is the zigbee solution viable?
 - Communications over existing power lines?
 - Same issue with industrial Ethernet which is a step back from powered bus solutions
 - Running wireless devices on existing power lines
5. How do we migrate conventional controls to networked to wireless controls?
 - What are the weak links in current network technology

Other Technical Issues Discussed

1. Troubleshooting tools for wireless devices and networks should be developed. Software and hardware tools that are easy to use and to train maintenance workers in their use were mentioned as possible solutions to this issue.
2. How to integrate controls in the IT organization
 - “I own % of the bandwidth”
3. New access techniques will take too long to create and implement (silicon change) then the adaptation of current technologies.

IV. Workshop Attendance

Name	Affiliation	Email Address
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Fred Cohn	Schneider Electric	fred.cohn@schneider-electric.com
Les Lee	Ford	llee1@ford.com

V. References

- Acton, K., Antolovic, M., Kalappa, N., Luntz, J., Moyne, J., Tilbury, D., April 2006, "Practical Metrics for Evaluating Network System Performance," UM-ERC/RMS Network Performance Workshop, Ann Arbor, MI.
- "Manufacturing Information and Control", ERC Thrust Area 2 (TA-2) website <http://erc.engin.umich.edu/research/TA2.html>
- All presentations that have been released by the presenters will be available at: (URL)