UM-ERC/RMS 3rd Annual Network Performance Workshop Report
Wireless Network Deployment on the Factory Floor: Challenges and Opportunities
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Executive Summary

The Engineering Research Center for Reconfigurable Manufacturing Systems at the University of Michigan held the 3rd annual network performance workshop to *explore the challenges associated with deployment of wireless systems on the manufacturing floor, to discuss possible causes of these barriers and finally to identify areas where the University of Michigan could contribute through research to overcome the barriers.*

Dr. James Moyne from the University of Michigan introduced the scope and goals for the workshop and the highlighted the background and results of a few of the past and current projects undertaken by ERC in collaboration with industry leaders. *The presentation summarized the successes in research in wireless industrial automation at U of M to date and stressed the need to identify and address obstacles in the deployment of wireless systems on the factory floor so that future milestones could be achieved.* Mike Read from Ford Motor Company represented USCAR and gave an overview of the USCAR efforts in the area as well as characteristics of wireless requirements for a variety of applications. *The key takeaway from the presentation was to realize the advantages of wireless controlled network systems in applications operating at high, medium and low speeds and to get a glimpse of the test criteria and methodology for wireless products at Ford.* Richard Kluth from Siemens explained why Profinet was chosen as a wireless solution for an ASRS deployment and analyzed the results of tests before and after security considerations were enforced. *The purpose of this presentation was to demonstrate the effectiveness of adopting Profinet and to highlight the necessity of taking adequate measures to secure the wireless network channel.*

Finally a target milestone of *factories becoming completely wireless where wireless made sense* was noted; however there was no consensus among the attendees as to when this goal might be achieved.

Table 1. Barriers to deployment of wireless network systems

1. Lack of education
2. Need for tools to facilitate visualization of the environment
3. Problem in determining best practices for redundancy – cost issues
4. Sorting logistics of ownership and planning between Controls and IT
5. Lack of tools for translating IT to plant floor
6. Security considerations – Deliberate and inadvertent intrusion
7. Need for an independent look at tools – different environments may need a separate set of diagnostic tools

Table 2. Contributions from universities to overcome barriers

1. Education in basic and advanced use of wireless technologies
2. Verification and testing of the product performance
3. Education about adopting best practices
4. Repeatable measurables – Repetitive testing for accuracy and consistency in results
5. Network control systems design and modeling
6. Developing software/hardware for visualization of the communication environment for trouble shooting and maintenance
7. Emphasize the benefits of migrating from wired to wireless control systems
8. Combat fear, uncertainty and doubt

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I. Purpose of the Workshop

The purpose of the 3rd Network Performance Workshop was to bring together experts from the manufacturing industry, network suppliers and university researchers to discuss the advantages of migrating from wired networked control systems to wireless technology, to explore the challenges and opportunities of introducing wireless on the factory floor and, lastly, to identify how the University of Michigan could contribute to facilitate the adoption of wireless systems.

II. Workshop format

The workshop was structured to explore challenges and opportunities from both user and supplier perspectives. After an introduction to the research U of M has been conducting in networks and wireless technology, industry partners involved with development and deployment of industrial control networks were requested to give presentations outlining the requirements for wireless solutions on the factory floor and to point out barriers faced in testing and in migrating.

A panel discussion towards the end was designed to reach a consensus on the most significant barriers of moving to wireless and to analyze the possible causes for these hurdles. The feedback was then used to set key milestones for the next few years and identify how U of M could contribute in terms of research and education so that future research efforts in network controlled systems can be directed effectively and efficiently to areas that deserve immediate attention.

III. Presentations

This section contains the summary of the various presentations made by wireless practitioners. The presentation slides can be viewed at the website:
http://erc.engin.umich.edu/research/TA2.html

1. University of Michigan: Overview

Dr. James Moyne – University of Michigan, ERC/RMS

Dr. Moyne compared the advantages and disadvantages of switching to wireless and briefly discussed the characteristics (range, data rate, redundancy, data size) of the three main wireless technologies: ZigBee, Bluetooth and 802.11. He gave a synopsis of the ERC TA2 networking projects from 2001 through the present which involve collaboration with industry partners. The results of previous Network Performance Workshops were summarized, and the purpose for the 2008 workshop was defined as *determining best practices for deploying wireless on the manufacturing floor and addressing concerns about performance, security and reliability.*

The remainder of the presentation was dedicated to examining the results of recent tests involving the variables of distance and interference applied to Bluetooth technology. The tests confirmed that *further work is needed to determine to what extent wireless can be applied to time critical communications (e.g., control). Spectral recording of signals in the field and recreation of these signals in the laboratory in "record/playback" fashion can provide a mechanism for analysis to improve wireless testing. The ERC is collaborating with USCAR on standardized testing to further these efforts.* Dr. Moyne concluded his presentation with a timeline displaying previous accomplishments and a roadmap for university research and collaboration to further the state of the art of wireless applied to diagnostics, control and safety networking.

At the end of the presentation, a representative from Chrysler indicated that further attention needs to be paid to the interference of wireless networks with devices such as hearing aids and pacemakers.

2. Wireless Requirements for Automotive Manufacturing

Mike Read – Ford Motor Company

Mike Read presented an overview of the work being done by USCAR in this area. He indicated the need for wireless I/O for setups where wired options might be expensive or require high maintenance. He identified three types of I/O (high speed, low speed and medium speed) and discussed the requirements of each category in terms of power supply, performance, form factor and PLC interface. *The need for securing wireless systems against unauthorized access and intrusion was emphasized and the advantages of network segmentation to improve the quality of the setup were also realized.* Read described testing 'off the shelf' wireless devices for their performance and their level of interference by using a PLC as a test instrument for the device throughput.

3. Wireless Industrial Ethernet used in an Automotive AS/RS

Richard Kluth - Siemens

Richard Kluth explained how Siemens was pursuing various options to improve the existing AS/RS that was initially connected to a 19.2 KBaud I/O network. Using an example shop floor implementation he described how after a thorough analysis of the capabilities of the current optical technology relative to the wireless industrial Ethernet, their team decided to opt in favor of a wireless solution using Profinet. Initial results seemed inconsistent because, due to a lack of security mechanisms, employees had logged on the network. However, later observations of tests revealed that there was *no downtime* due to failure of wireless Profinet since commissioning and that the *safety I/O on Profinet was ensured* due to independent monitoring by PLC devices. Kluth recommended that for future projects, it would be beneficial to *engage the IT department early* in the planning process. He also noted that *adding security configurations* (as long as they were cost effective) was a useful preemptive measure to protect against deliberate intrusions.

IV. Opportunities for wireless technology

Some of the highest expenses incurred in the instrumentation and control of a manufacturing plant have been caused by the installation and long term maintenance requirements of wires. Hence there is a very strong interest in replacing wired with wireless systems on the factory floor.

1. *Wireless increases physical flexibility and allows more room for reconfiguration:* In his presentation, Mike Read pointed out how wiring tight radius joints in a robot end effector could be tedious and may lead to higher maintenance costs because the wires will be constantly flexed in a tight configuration.
2. *Variety of power sources available for wireless:* Local AC or DC power is commonly available and batteries could be used to power wireless in low speed applications. Alternative energy sources, such as solar energy, could also be harnessed in areas with adequate sunlight.
3. *Reliability:* Mesh networks have proven to be reliable and fault tolerant because of their 'self healing' characteristic. ZigBee wireless sensor networks employ this topology to function in areas of high interference and traffic.
4. *Safety:* Since there is no fear of cable break, wireless transmission is particularly conducive to areas on the factory floor which involve chemicals or fluids. Richard Kluth highlighted the positive results of testing after implementing safety features such as encryption and changing network key on a regular basis. Also, if each node had its own safety time out, it would ensure continuity of the entire system.

V. Barriers to wireless technology

The panel discussion highlighted the challenges in migrating from wired to wireless technology with a particular focus on issues of interference, security and the determination of best practices. All the barriers noted by the panelists and participants can be classified into broad categories of *knowledge, standards, best practices, tools and diagnostics and testing.*

Mark Woudenberg from ABB listed the *lack of knowledge of applications for wireless* as one of the top three barriers to wireless deployment. He emphasized how there was a lack of understanding of the benefits of wireless systems relative to wired ones and how the misconceptions about wireless contributed towards a dearth of interest from the industry to make modernization of their factory floor a priority. Woudenberg also identified the *lack of adequate standards* as an important factor contributing to a limited demand for wireless devices and consequently leading to high prices of products. He also pointed out how the presence of many proprietary standards instead of a single standardized version of wireless added to the difficulty in devising accurate standards. Lastly, Woudenberg noted the difficulty of *defining the Radio Frequency use in manufacturing* and how this resulted in the problem of determining whether the IT or the Controls department deserved more control of the 'air'.

Another panelist, Jason McLees from Phoenix Contact, highlighted the *lack of tools for translating IT to the factory floor* as a barrier to the advancement of wireless. He explained that successful coordination between the two departments could lead to on-floor personnel being better equipped with trouble shooting tools/knowledge to combat security situations such as deliberate or inadvertent intrusion. McLees also stressed on the need for monitoring the interaction of the wireless environment with routers and firewalls because they might not necessarily coexist.

During the discussion, the attendees pointed out that the *absence of visualization software/tools/simulations as well as the lack of shop floor tools* for trouble shooting, configuration and diagnostics was also a hurdle in swift error detection and treatment. Participants unanimously agreed that coupling the controls and wireless industries would be beneficial in *searching for integrated diagnostics solutions.* The need for determining *best practices for redundancy* was also established because redundancy increases costs. Lastly, everyone acknowledged the necessity to dispel any *fears, uncertainties and doubts* about wireless technology.

VI. University research directions

One of the main goals of the annual Network Performance Workshops is to pinpoint areas of industry concern and identify how University of Michigan can respond positively and effectively to them. The following is a prioritized list of ways in which the university can make an impact through research in an effort to combat the barriers mentioned in Section IV:

1. *Education in basic and advanced use of wireless technologies:* If students are made aware of the advantages and potential of wireless technology, the knowledge gained in university will be useful in industry when the students graduate.
2. *Verification and testing:* U of M could develop testing procedures for compliance and performance of wireless devices. Such testing procedures are beneficial because they can help identify vital information, such as the advantages and disadvantages of the characteristics of a particular wireless technology in a lab environment. A lab also acts as an excellent control environment to independently recreate, verify and trouble shoot real situations and to analyze how results could differ if certain variables were altered. Hence by developing a standardized format of pros and cons of a system to compare new results against, the university would also be imparting knowledge about best practices. The results could then be communicated back to standard making bodies, thereby enabling them to devise effective standards.
3. *Networked control system (NCS) design and modeling:* Networked control systems are very attractive because their common bus architecture offers several advantages such as a small volume of wiring and distributed processing. The university could conduct research on case studies and determine whether segmented or integrated configurations should be favored. The university could also contribute to extract data from legacy systems and search for means and methods to leverage data 'floating in air'.
4. *Repeatable Measurables:* By repetitive testing, the university could assist in identifying consistent patterns to understand phenomena such as interference and hence be able to suggest remedies to mitigate its effects. Identification of a pattern could lead researchers to predict possible outcomes and visualization tools/software can be developed (such as merging Autocad with simulations) to help identify errors and trouble shoot them.
5. *Develop software/hardware for visualization of the communication environment, trouble shooting and maintenance:* The challenge with this aspect of research is to ensure that the wireless systems are dynamic and responsive to environmental changes. For example the existing wireless network should have the capabilities to automatically detect new nodes or new networks and respond accordingly. The software and tools for trouble shooting should be accessible and easy to navigate for on floor personnel. There is also the need for tools to translate open connectivity via open standards to the simple network management protocol so that IT and the plant floor are better connected.
6. *Combat fear, uncertainty, doubt:* The misconceptions about wireless technology can be purged if the university focuses on promoting the advantages of wireless relative to wired systems. One method of convincing skeptics is to conduct several case studies to demonstrate the capabilities of wireless in terms of its performance and reliability. Results can be validated further by using a cost benefit analysis and a return on investment (ROI) analysis.

VII. Other Contributions

University research and efforts by industry to raise awareness interact to play a crucial role in the acceleration of the adoption of wireless technology. However, it is also important to acknowledge other factors such as the *role of standard making bodies* in contributing largely to the extent of wireless in the automation industry.

The definition of wireless standards is important because one wireless standard may not necessarily work for every application. The main barrier is the presence of a multitude of wireless standards and therefore, it becomes a tedious and time consuming process to deliberate which standard to use for what application.

To address the issue of too many standards, the university and industry should communicate the results of any testing back to the standard making bodies so that they can coordinate and 'funnel' through the variety of standards to obtain a more focused solution.

VIII. Conclusion

Based on the discussion of challenges and possible solutions for the migration to wireless technology on the factory floor, two milestones were noted and an effort was made to define tentative time durations for each goal. The first milestone noted was *factories will become completely wireless* and the second milestone identified was *controls and wireless will become one problem that could be solved together.*

However *no consensus* was reached because the counterargument was that wireless and wired systems will coexist with each other. In the upcoming years, with rapid technological advancement, data volume rates and traffic wireless networks could perhaps be managed more efficiently; nonetheless it was concluded that Ethernet and wireless networks would continue to cohabit together.

IX. Acknowledgements

The UM-ERC/RMS would like to thank all the participants of the 3rd annual Network Performance Workshop. A special thanks to participants who gave presentations and motivated discussions about the various issues regarding wireless networks. Those attendees are:

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- Richard Kluth (Siemens)
- Jason McLees (Phoenix Contact)
- Mark Woudenberg (ABB)

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Appendix A: Attendees

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