Workshop on Reliable and High Performance Wireless Systems for Factory Automation

Date: June 13-14, 2019
Venue: 2019 IEEE 28th International Symposium on Industrial
Electronics (ISIE), Vancouver, Canada

Sponsored: IEEE Industrial Electronics Society (IES) Standards Committee
Technical Supports: **IEEE Instrument & Measurements Society (IMS) TC-9**
IES Committee on Cloud & Wireless Systems for
Industrial Applications
IES Committee on Industrial Agents
IES Committee on Industrial Informatics
IES Committee on Industrial Cyber-Physical Systems
National Institute of Standards and Technology

Background

Manufacturers applying factory automation systems, such as wireless sensing and control technologies in new or existing systems for monitoring and controlling equipment and processes can reap benefits by eliminating costly cabling and enabling mobility and configuration flexibility. Meanwhile, using wireless technologies can improve factory-floor operating conditions, performance, and efficiency. But before applying these technologies, companies need to determine what wireless technology is suitable and reliable for communicating measurement and control data in challenging industrial environments in such areas as robotics and mobile equipment and devices with many potential physical obstructions and sources of interference.

Purpose

The purpose of this workshop is to provide an opportunity for representatives from industry, academia, and government to work closely together to determine the best approach to develop reliable and high performance wireless systems for factory automation. The output of this workshop will help lead to the development of guidelines for wireless systems that best meet the needs of this industry. Through collaborations between industry, government and academia, high performance and reliability of factory operations can be achieved, while realizing the benefits of deploying wireless technologies in factory environments. Panelists will present their perspectives on wireless performance requirements and key use cases that will be critical to factory automation with audience participation in the discussion.

Issues to be addressed

. Wireless process monitoring and control for factory automation
. Wireless technologies and standards suitable for factory automation
. Source of interference and coexistence of wireless technologies
. Use cases and application requirements, such as robotics, mobile platforms, remote monitoring
. Systems engineering approach and processes for applying wireless technologies
. Areas of research needed to help achieve high performance and reliable wireless systems
. Areas of focus for guidelines development
. Approaches to spectrum monitoring and management in the factory
. Needs for standardization of wireless protocols and guidance

Who Should Attend/Stakeholders

Industrial wireless technology developers, system integrators, device manufacturers, end-users, and researchers are invited to speak and participate in this workshop/panel discussion for establishing guideline and research direction.

Benefits

The results of the workshop will help develop guideline, standard, and future research direction, which will help manufacturers, users, and their technology suppliers to design, assess, select, and deploy secure, wireless platforms that perform dependably in their factory settings and conditions.

Invited Speakers _____ Title of Talk _____

Invited Speakers	Title of Talk
Richard Candell, NIST	Trustworthy Wireless Systems for Factory Automation
Dr. Zhibo Pang, ABB	Last Mile Connectivity: The Bottleneck of Mission Critical Industrial IoT
Dr. Dave Cavalcanti, Intel	Wireless Time Sensitive Networking: next generation wireless for time-critical industrial systems
Marty Ryan, ATI	Shipbuilding Industry Digital Thread – What it Takes to Move the Data
Dr. Hans-Peter Bernhard, Johannes Kepler University	Secure Time Sensitive Wireless Factory Communications Networks
Dr. Iñaki Val, IK4-IKERLAN	Industrial wireless use cases and their needs concerning RF propagation environment, real-time operation, and time synchronization requirements

Dr. Nada Golmie, NIST	5G for Industrial IoT: Hype or Killer App?
Justine Shade, Phoenix Contact	Selection of Suitable Wireless Systems for Factory Automation Applications
Prof. Kim Fung Tsang Connected City Alliance City University of Hong Kong	5G and IoT Challenges and Use Cases
Penny Chen, Yokogawa	Topic to be provided

Full details on speakers' biographies and talk abstracts are given below.

Workshop Sessions (Tentative)
June 13
8:00 to 8:30 am – registration
8:30 – 10:30 am   -- presentations
10:30 – 10:45 am – coffee Break
10:45 am – 12:30 pm – presentations
12:30 – 1:30 pm – lunch break
1:30 – 3:00 pm – presentations
3:00 – 3:15 pm – coffee break
3:15 – 5 pm – Panel discussion
6:30 pm to 8:30 p.m. – Informal dinner in local restaurant
June 14
9:00 am – 10:30 am – Discussion of wireless issues and solutions
10:30 -10:15 am – coffee break
10:15 am – 12:00 pm – More discussion of wireless issues and solutions, summary & action items
12:00 pm – workshop adjournment

Fees
• Workshop ONLY – US$150
• Registered with ISIE 2019 Conference – Included in Conference Fees
• All participants will be provided with coffee breaks, lunch, workshop materials
• Register with ISIE 2019 Conference Registration

Technical contacts for information
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IES TC Chairs

Gerhard Hancke, Chair, Cloud & Wireless Systems for Industrial Applications
Stamatis Karnouskos, Chair, Industrial Agents
Valeriy Vyatkin, Chair, Industrial Informatics
Yang Shi, Chair, Industrial Cyber-Physical Systems
Victor Huang, Chair, Standards

Invited Speakers, with their respective Bio, Title of Talk, and Abstract

Speaker: Richard Candell, Project Leader, NIST, Gaithersburg, Maryland, USA

Bio: Richard Candell has over twenty years of experience in telecommunications system engineering with extensive experience in the design and evaluation of wireless communications systems. Mr. Candell spent twelve years developing, testing, and deploying secure wireless technologies for commercial and defense applications. He served as the lead systems engineer in developing spread spectrum interference cancellation and performance evaluation strategies for satellite ground stations and mobile phased array beam steering transceivers. He holds patents in successive interference cancellation and transmission burst detection applied to spread-spectrum satellite communications signals. Mr. Candell holds a BS and MS degree in Electrical Engineering from The University of Memphis. He joined the NIST in 2014. His current research interests include the performance impacts of wireless networks on industrial sensing and actuated control applications for mobile robotic, manufacturing, and safety applications. Mr. Candell was the primary contributing author of the Guide to Industrial Wireless Systems Deployments (NIST AMS 300-4) and the chair of the NIST Industrial Wireless System technical working group.

Title of Talk: Trustworthy Wireless Systems for Factory Automation

Abstract: With the emergence of the Industrial Internet of Things (IioT), Smart Manufacturing Systems provide a vision of future manufacturing that incorporate highly dynamic physical systems, robust and responsive communications systems, and computing paradigms to maximize efficiency, enable mobility, promote flexibility, and realize the promises of the digital factory. Wireless technology is a key enabler of that vision and an essential element for automation within the future factory work-cell. Several challenges to integrating wireless

systems within the factory environment include identifying robust requirements for wireless networks to support sensing and robot/machine control; managing coexistence of a variety of networks within a finite electromagnetic spectrum; realizing spectrum-aware and power-aware distributed edge computing, achieving high-reliability, low-latency, and scalability; and integrating spectrum awareness within factory automation systems. Mr. Candell will present the NIST perspective on addressing these challenges through by developing validated wireless system requirements, system models, recommended architectures, testbed activities, and guidelines for establishing trustworthy wireless systems within the mobile and collaborative work-cell.

Speaker: Dr. Zhibo Pang, ABB Corporate Research, Vasteras, Sweden

Bio: Dr. Zhibo Pang, PhD & MBA received B.Eng. in Electronic Engineering from Zhejiang University, Hangzhou, China in 2002, MBA in Innovation and Growth from University of Turku, Turku, Finland in 2012, and PhD in Electronic and Computer Systems from the Royal Institute of Technology (KTH), Stockholm, Sweden in 2013. He is currently a Principal Scientist on Wireless Communications at ABB Corporate Research, Västerås, Sweden, leading projects in digitalization solutions for smart buildings and homes, robotics and factories, healthcare and logistics, power electronics and power systems. He is also Affiliated Faculty and PhD Supervisor at Royal Institute of Technology (KTH). Before joined ABB, he was co-founder and CTO of startups such as Ambigua Medito AB. He is a Senior Member of IEEE and Co-Chair of the Technical Committee on Industrial Informatics. He is Associate Editor of IEEE Transactions on Industrial Informatics and IEEE Journal of Biomedical and Health Informatics, Guest Editor of Proceedings of the IEEE, IEEE Internet of Things Journal, and IEEE Reviews in Biomedical Engineering, etc. He was awarded the "2016 Inventor of the Year Award" by ABB Corporate Research Sweden. He has 60+ patents and 50+ refereed journal papers and 40+ conference papers in these areas.

Title of Talk: Last Mile Connectivity: The Bottleneck of Mission Critical Industrial IoT

Abstract: As important fuel of the fourth revolution of industries (Industry 4.0), Industrial IoT especially the industrial wireless connectivity has become the new driver of research in communications. To deliver the big values promised by the Industrial IoT, closing the control and optimization loops is the first step. Despite continuous efforts in the recent decades by telecom and industries, last mile connectivity is still the bottleneck for closed loop control and optimization in mission critical applications. There are significant differences between the two different worlds, consumer connectivity vs. industrial connectivity. Noticeable mistakes have been made when previous industrial connectivity technologies were developed such as the WirelessHART. To fully address the requirements of critical Industrial IoT applications (such as mining automation, autonomous robotics, power systems, factory of future, etc.), much higher

performances are required including multi-gigabit-per-second data rate, sub-microsecond latency, and ultra-high reliability. Basic feasibility has been proven by the latest work on Wireless HP (high performance) at ABB based on FPGA-based SDR (software defined radio) which has outperformed the 5G URLLC by x 10 times in terms of latency. As highlighted in future research agenda, new fundamental design, standards, and chips are demanded.

Speaker: Dave Cavalcanti, PhD, Intel Corporation

Bio: Dave Cavalcanti received his PhD in computer science and engineering in 2006 from the University of Cincinnati. He is currently Sr. Research Scientist at Intel Labs where he develops next generation wireless connectivity and networking technologies and their applications in autonomous, time-sensitive systems. Before joining Intel Corporation in 2015, he was with Philips Research North America, where he developed several WLAN, WPAN and cognitive radio technologies. He has contributed to IEEE 802.11 and 802.22 working groups. He is Senior Member of the IEEE and served as the chair of the IEEE computer society technical committee on simulation (TCSIM) from 2008 to 2014. He leads a team who received the IEEE INFOCOM 2018 Best Demo Award for a demonstration of time-critical applications over next generation 802.11 networks.

Title of Talk: Wireless Time Sensitive Networking: next generation wireless for time-critical industrial systems

Abstract: Emerging applications are demanding more than high throughput and average low latency from wireless networks. A growing number of time-sensitive applications, such as mobile robots, autonomous vehicles, industrial automation, real-time analytics, mobile gaming and AR/VR, need worst-case low latency guarantees and extremely high reliability. Given the inherently unreliable, varying capacity and latency prone characteristics associated with wireless communications, enabling "time-critical" performance is major challenge, but it is also opportunity for next generation wireless technologies. This talk will provide an overview of emerging applications, requirements and unique challenges to enable time-critical performance over wireless. The presentation will review the background work by the IEEE 802.1 Time Sensitive Networking (TSN) family of standards dive into existing and upcoming features extend TSN capabilities over Wi-Fi/802.11 (e.g. 802.11ax Trigger-based OFDMA and multi-AP coordination) and 5G (flexible NR frame structure and URLLC) standards. Last, but not least, the presentation will highlight implementation challenges that need to be considered beyond standards development, such as interference management, network configuration, cross-device coordination, latency-reliability optimized scheduling, and co-design of time-critical applications and networks. The presentation will conclude with an outlook on evaluation

methodologies, tools and testbeds required for validation of wireless technologies and industry adoption for time-critical applications.

Speaker: Marty Ryan, Vice President for Naval Technologies, ATI

Bio: Mr. Ryan is a Vice President of ATI, Naval Technologies Division Lead, and the Executive Director of ATI's three Navy ManTech Centers of Excellence. He is responsible for five major Naval programs including; the Naval Shipbuilding Research Program (NSRP), the Composites Manufacturing Technology Center (CMTC), The Naval Shipbuilding and Advanced Manufacturing Center (NSAM), the Center for Naval Metalworking (CNM) and the Demonstration & Assessment Team. These five programs leverage and coordinate their activities to maximize technology development at shipyards, airframers and vehicle manufacturers. Mr. Ryan is a thirty-five year veteran of the Naval R&D community ranging from laser research, to manufacturing technologies, to national and international technology assessments.

Title of Talk: Shipbuilding Industry Digital Thread—What it Takes to Move the Data

Abstract: A shipyard environment is a very challenging environment for expansion of wireless technologies. In addition to the traditional transceivers (nodes/routers) grid/network functionality, there are concerns of data security, latency, range and interoperability. The US shipyards' 'speed of relevant data access' must first overcome the pitfalls of wireless technology for shipyard implementation. The proposed uses and interoperability will be presented, grasping the need to understand whether or not current technologies are able to meet production data demand and where current standards provide enough guidance to enable wirelessly distributed data use optimization. Key issues for presentation include:

- Completed and Active Navy ManTech Digital Thread/Wireless Projects
- Wide-scale 'IOT' hurdles:
  - The various wireless data standards: Bluetooth, RFID, 802.11 wireless standards (WiFi), various cell standards (CDMA, GSM, LTE, 3G, 4G and 5G)

  - The ability of wireless to operate ship hull, ability to penetrate steel enclosures
  - Latency issues what is the best transmission for moving large amounts of data if we have a smart manufacturing environment and data security.
  - The power limitation of the technology is regulated; are there other regulations?
  - Potential frequency/bandwidth interferences

- Easily discernible state-of-the-art technologies: What multi-mode systems are out there that could bring the various technologies together and minimize cost and provide hardware efficiencies?
  - The IT framework hardware/software compatibilities to tie a diverse mixture of technologies.
- Futuristic Vision

Speaker: Dr. Hans-Peter Bernhard, Head of Research Unit Wireless Communication of Silicon Austria Labs GmbH, Linz Austria and Senior Scientist Institute for Communication and RF-Systems, Johannes Kepler University, Linz Austria

Bio: Dr. Hans-Peter Bernhard received the Dipl.-Ing. (M.Sc.) degree in communication engineering and the Dr. techn. (Ph.D.) degree with distinction from Vienna Technical University in 1991 and 1997, respectively. From 1985 to 1992 he worked for different companies in the area of database and organizational programming. From 1992 to 1998 he was with the INTHFT of Technical University Vienna as a research assistant and became in 1994 assistant professor at this institute. 1999 he joined the Institute for Communications Engineering and RF-Systems, Johannes Kepler University Linz, as a lecturer and senior scientist. He was guest researcher with the Academy of Sciences Prague and the University of Cambridge UK. Starting in 2004 he served as consultant for several companies as there are Infineon, DICE, and others. In 2007 he founded a scientific consulting company with focus on assisting handicapped persons and nonprofit health care organizations. He is holding patents in the field of computer science and computer assisting systems for handicapped persons. He has contributed to and led several university, European and industrial research projects. His research interests include algorithm design for wireless communications with a special focus on synchronization and energy efficient protocols. Since 2018 he is Head of Research Unit Wireless Communication of Silicon Austria Labs GmbH, Linz Austria.

Title of Talk: Secure Time Sensitive Wireless Factory Communication Networks

Abstract: Time-sensitive communication is essential for industrial communication and has already established itself strongly in wired factory automation, which is widely visible through ongoing TSN efforts. Although there are many applications where a lack of flexibility and reliability exists with wires, but wired solutions are chosen because of the traditionally high trust in copper. It is precisely this trust we need in wireless communication to increasingly establish these systems in factory communications. We discuss the core topics of research and technology such as time awareness, flexibility, service quality and holistic security from the PHY layer to the system level. Therefore, we address the planned flexibility as an integral part of the answer leading to channel access methods and the use of different technologies. We will ask

whether LTE and 5G will be able to open factory communications applications for wireless communications more widely or not. The use of private frequencies and the promised characteristics of 5G will be discussed in combination with existing wireless networks to pave the way for Wireless Time Sensitive Networks (WTSN) as a real part of future factory communications.

Speaker: Dr. Iñaki Val, Communication Systems group Team Leader at IK4-IKERLAN

Bio: Iñaki Val received B.S. and M.S. degrees from the Department of Electronics Engineering at Mondragon University (Spain) in 1998 and 2001, respectively, and a Ph.D. degree from the Department of Signals, Systems and Radiocommunication at Polytechnic University of Madrid in 2011. Since 2001, he has been with the Communications department of IK4-IKERLAN, and in the past he has been with Fraunhofer IIS of Erlangen (Germany) as invited researcher (2005-2006). Currently, he is the Team Leader of Communication Systems group. His research activities include the design and implementation of digital wireless communications systems, industrial real-time requirements, time synchronization, communications for distributed control systems, vehicular communications, wireless channel propagation/characterization and digital signal processing. He is currently focused on industrial communication applications.

Title of the Talk: Industrial wireless use cases and their needs concerning RF propagation environment, real-time operation, and time synchronization requirements

Abstract: Industrial applications impose strong requirements to the underlying communication systems in order to guarantee high levels of time synchronization and real-time operation. The use of wireless communications implies additionally that the specific characteristics of the RF propagation medium need to be taken into account. In this talk the requirements of several industrial wireless use cases will be presented, providing examples of both industrial and research projects. Additionally, the technology solutions adopted in each case for the wireless communication system will be described. These solutions will be focused on standard approaches, such as the initiatives adopted towards a wireless Time-Sensitive Networking (TSN) technology, as well as custom solutions, such as the in-house developed Synchronous and Hybrid Architecture for Real-time Performance in IWSAN (SHARP) protocol.

Speaker: Nada Golmie, PhD, NIST, Gaithersburg, Maryland, USA

Bio: NADA GOLMIE received her Ph.D. in computer science from the University of Maryland at College Park. Since 1993, she has been a research engineer at the National Institute of Standards and Technology. She is currently the chief of the wireless networks division in the Communications Technology Laboratory. Her research in media access control and protocols for wireless networks led to over 200 technical papers presented at professional conferences, journals, and contributed to international standard organizations and industry led consortia. She is the author of "Coexistence in Wireless Networks: Challenges and System-level Solutions in the Unlicensed Bands," published by Cambridge University Press (2006). She leads several projects related to the modeling and evaluation of future generation wireless systems and protocols and serves as a co-chair for the 5G mmWave Channel Model Alliance.

Title: 5G for Industrial IoT: Hype or Killer App?

Abstract: Providing adequate connectivity continues to play a key role in achieving the desired advances in IIoT*.* The need for reliable and adaptive communication infrastructures to address the scalability, agility, fault-tolerance, bandwidth, latency, spectrum efficiency challenges has never been greater. At the same time, exploiting the many features provided by advanced infrastructures such as 5G and IEEE 802.11ax/ac/ad/ay remains challenging. This presentation will provide a quick overview of the IIoT needs and discuss the challenges and opportunities provided by the latest advances in communications systems.

Speaker: Justin Shade, Product Marketing Lead Specialist – Wireless at Phoenix Contact USA

Bio: Justin Shade is the Lead Product Marketing Specialist for Wireless Products at Phoenix Contact. He received a Bachelor's of Engineering in Computer Engineering from Elizabethtown College in 2006.   In 2006, he started his career with Phoenix Contact as an Apprentice before moving into the Technical Service department in 2007. In 2011, he transitioned to the Marketing department taking over responsibility for the sales, marketing, and support for the complete wireless portfolio from Phoenix Contact. Product technologies include Proprietary FHSS, industrial WLAN, industrial Bluetooth, WirelessHART and cellular technologies. During this time, he has led four successful product launches, one with the second highest first-year revenue in company history. In 2015, Justin obtained his Certified Wireless Network Administrator (CWNA) certification, in 2016 his

Certified Wireless Analysis Professional (CWAP) certification, and in 2017 his Certified Wireless Design Professional (CWDP) certification from the Certified Wireless Network Professional (CWNP). Justin is also an Ekahau Certified Survey Engineer (ECSE). Over the course of his tenure in the marketing department Justin has published six technical articles focused on implementing wireless technologies into industrial applications.

Title: Selection of Suitable Wireless Systems for Factory Automation Applications

Abstract: Over the past 20 years, wireless technologies have evolved and become more commonplace in everyday life. Everything from office equipment to phones to household appliances is now linked through a wireless connection. However, in an industrial factory setting, application requirements vary from mission critical, time sensitive data, where every packet is important, to the 'it would be nice to have' data. Not only is it important to verify that wireless technology is a good fit for the application, it is important that all parties that have assets on the factory floor are in good communication so all wireless technologies in use can coexist with one another. With the inevitable merge of IT and OT, selection and design process or wireless technologies and systems in the factory automation space becomes ever more important.

Speaker: Prof. Kim Fung Tsang, Founding Chair, Connected City Alliance; Faculty of City University of Hong Kong

Bio: Dr KF Tsang is the Founding Chairman of Connected Cities Alliance. KF is also on the Faculty in the City University of Hong Kong. He has been dedicated to Internet of Things (IoT) development in particular to smart lamp pole, 5G harmonization and modelling, IoT LPWAN (LoRa, SigFox and NB IoT) development and applications. In 2016, KF was awarded the IoT Heros Award by GS1 IoT Council (nominated by Cisco). Currently, KF contributes to key IoT standards and IoT performance evaluation, and is advising the Hong Kong government and a provincial government in the deployment of IoT infrastructure. KF is the Chairman of IEEE Standard P2668 "IoT Maturity Index"; Chairman of LP Wan Work Group for IEEE P1451.5 smart sensors; a member of the IEEE1932.1 standard for License/Unlicensed Spectrum Interoperability in Wireless Mobile Networks Working Group; Membership Champion of IEEE Industrial Electronics Society; Associate Editor of IEEE Transactions on Industrial Electronics; Associate Editor of IEEE Transactions on Industrial informatics; Associate Editor of IEEE Industrial Electronics Magazine; Associate Editor of IEEE ITeN.

Title: 5G and IoT Challenges and Use Cases

Abstract: The large number of deployed Internet-of-things (IoT) devices will enhance the quality-of-life in various disciplines including industrial environments, transportation, healthcare, environment, smart grids, …..etc. The ubiquitous connectivity between the things facilitates data flow which are essential for establishing smart operations and thus providing efficiency and reliability. This presentation will discuss the road map and general challenges in IoT rollouts. Attention is drawn to the use of IoT for industrial or critical grade services. Challenges in particular applications, say 5G and NB IoT development in Hong Kong, will also be briefed. The use of 5G, NB IoT, LoRa etc. for numerous use cases in Hong Kong and Greater Bay Area China will be discussed.

Speaker: Ms. Penny Chen, Yokogawa

Topic, Abstract and Biography to be provided