11th IEEE World Conference on Factory Communication Systems

COMMUNICATION in AUTOMATION (WFCS 2015)

PROGRAM AND ABSTRACTS

May 27-29, 2015, Palma de Mallorca, Spain









Table of Contents

Message from the General Co-Chairs	1
Message from the Program Co-Chairs	3
Committees	5
Reviewers	7
Program at a Glance	8
Schedule	9
Papers in Sessions	10
Abstracts	15
Venue	33
Social Events	34



Message from the General Co-Chairs

It is our great pleasure to welcome you to WFCS 2015, the 11th edition of the IEEE World Conference on Factory Communication Systems. This series celebrates its 20 year anniversary and is the result of an ever increasing interest in communication technologies for automation in Europe and all over the world. Consequently, the emphasis is on "Communication in Automation", its foundations and applications in various domains. WFCS 2015 is co-sponsored by the IEEE Industrial Electronics Society and the University of the Balearic Islands.

The first WFCS was held as IEEE Workshop on Factory Communication Systems in Leysin, Switzerland, in 1995. The main goal of that workshop was to provide an open forum for researchers to both present their original results and to exchange ideas on the latest developments in factory and industrial communications. Subsequent events were held biennially and were hosted in Barcelona/Spain (1997), Västerås/Sweden (2000), Porto/Portugal (2002), Vienna/Austria (2004), Torino/Italy (2006), Dresden/Germany (2008), Nancy/France (2010), Lemgo/Germany (2012), and Toulouse/France (2014), respectively. For over a decade there has been a continuous and significant broadening of the scope of WFCS. Traditionally, industrial communication systems, building automation systems, as well as real-time systems and performance analysis are in the focus of WFCS. Over the years, challenging areas such as industrial wireless networks, dependability, fault tolerance, safety and security in industrial networks have been included. Last but not least, automation-related middleware, distributed application platforms, and application studies now complete the topics of this workshop.

Since its first edition, WFCS has always been an outstanding success. Thanks to the great efforts of a large number of volunteers we could count on during the past year of preparation, WFCS 2015 is no exception. We have done the best to design the workshop program so as to respond to your needs, irrespective of whether you are a long-standing WFCS fellow or new in this community. The goal is to discuss and advance the state of the art in communications for automation through the papers, keynote sessions, and work-in-progress presentations.

Nevertheless, WFCS 2015 introduces a number of exciting changes to tradition. First of all, from this year on, WFCS will be an annual event to suit the needs especially of young researchers for platforms to present and discuss the progress of their work. Second, we changed the name from "workshop" to "conference" to better reflect what WFCS actually is: a high-level event where top-notch research and innovation is presented. Hence, the Workshop on Factory Communication Systems has evolved into the World Conference on Factory Communication Systems. Third, based on a daring suggestion by the Program Co-Chairs and the observation that the best WFCS papers have always been of journal quality, we launched a unique experiment and made a joint call for papers together with the IEEE Transactions on Industrial Informatics to allow for a faster and tighter integration of the conference and post-conference papers published by TII within the scope of a special section.

It is obvious that the success of events like this one would not be possible without the help and commitment of a great number of people. We want to personally thank all the members of the program committee, the reviewers, and the supporting staff, who have worked for a successful WFCS 2015, for their tremendous efforts. In particular, we would like to acknowledge the contributions of the Program Co-Chairs, Paulo Pedreiras and Stefano Vitturi, for setting up a top-class scientific program, and those of the Work-



In-Progress Co-Chairs, Michael Short and Henning Trsek, for contributing to the selection of a challenging WIP technical program. Our special thanks go to Kim Man, Editor-in-Chief of TII, for venturing into the joint call for papers.

We are proud to have two attractive keynotes from Linus Thrybom (Corporate Research ABB, Industrial Communication) and from Nicola Guarino (National Research Council of Italy, Institute of Cognitive Sciences and Technologies), both focusing on completely different topics. While the first keynote presents an industrial view on the future of industrial communication systems, the second focuses on the human factor in integrated manufacturing. We would like to thank both keynote speakers for impressively underlining the width of WFCS topics.

Finally, we are also grateful to the Local Organizing Committee and to all the people backstage. Evidence of their valuable efforts can be found all around you, from the program leaflet in your hands to the proceedings and, in general, in the logistic infrastructure that has been set up to help and support you at the workshop. In particular, we like to thank Inés Álvarez, Alberto Ballesteros, Manuel Barranco, Sinisa Derasevic, and David Gessner.

Palma and Mallorca are proud to host an event like WFCS. Both are always open to their numerous visitors and even more to those that bring new knowledge and opportunities for further development. There is no need to talk about the prestige of the Balearic Islands as touristic destinations but it is probably worth mentioning the relevance of the research that is carried out in their young university. Founded in 1978 and despite its middle size with around 14,000 students, its research staff has managed to place it in the top ten positions of various and recent research rakings of Spanish universities.

Moreover, 2015 is a special year for Mallorca since it is celebrating the life of Ramon Llull (Raymond Lully) 700 years after his death. He was born in Mallorca and is considered as one of the most relevant figures of the Middle Ages in the spiritual, theological and literary fields. On the one hand, he is credited with writing the first major work of literature in Catalan Language. On the other hand, his philosophical work on the systematization of rational thinking has caused him to be pointed out as a pioneer of computation theory and, thus, he is considered sometimes as a kind of patron saint of computer scientists. For all these reasons, we chose Ramon Llull's statue in Palma as the central element of the logo for this conference, together with the beautiful cathedral, which is a fundamental landmark in Palma's coastline.

We are convinced that Palma de Mallorca as the conference location for WFCS 2015 will provide an inspiring atmosphere. For twenty years, WFCS has been the leading international forum for researches and practitioners from academia and industry to come together, share and discuss ideas, review trends and propose new research directions. We hope you will take full advantage of the upcoming next days to learn new things, meet old and new friends, extend your own knowledge, improve your experience and get inspired.

Thank you for coming to Palma and for attending IEEE WFCS 2015.

Julián Proenza and Thilo Sauter WFCS 2015 General Co-Chairs



Message from the Program Co-Chairs

It is our great pleasure to welcome you to Palma de Mallorca and to announce the technical program of the 11th IEEE World conference on Factory Communication Systems (WFCS 2015). This is the largest IEEE technical event specially devoted to industrial communication systems. Over the years it became a privileged forum for presenting research results and practical experiences in industrial communications and automation, as well as to discuss new ideas and research directions. Continuing the tradition, WFCS attracts researchers and practitioners from both industry and academia, covering a vast range of topics, including Industrial Wireless Communications, Real-Time Ethernet networks, Cyber-Physical Systems and Software-Defined Networks, to name just a few.

For the first time, this year the WFCS Call for Papers was jointly issued with the Special Section on "Communication in Automation" by the IEEE Transactions on Industrial Informatics. Thus, some papers submitted to WFCS have been immediately selected as possible candidates for the Special Section.

This implied an even more selective and comprehensive review process. As far as regular papers are concerned, we have received 52 submissions, 27 of which have been accepted for oral presentation. Among them, 9 papers were selected as Special Section candidates (the actually selected papers were 11, but the authors of two of them declined the invitation for the Special Section and, consequently, those papers have been just included in the WFCS Proceedings).

The 9 selected papers will be presented in three dedicated WFCS sessions and short versions of these papers have been published on the WFCS Proceedings The WFCS WiP track received altogether 38 submissions (out of which one was subsequently withdrawn by the authors) and 18 of them have been accepted for publication in the proceedings, combined with a short oral presentation and a poster display.

All papers (both regular and WiP ones) have been reviewed by the members of the WFCS technical program committee, possibly with the help of some carefully selected sub-reviewers, involving 87 people in total. In case of conflicting reviews about a paper, TPC members were further invited to engage in discussions, and the final decisions were made by taking both the reviews and the discussion results into account.

We would like to truly thank all the people involved in making this workshop a success. First, we wish to thank the members of the technical program committee and the additional reviewers for their hard work and their constructive, thoughtful and timely reviews. It is thanks to their effort that the review process of WFCS has achieved such a high quality.

Secondly, we thank the Co-Chairs of the WFCS WiP track, Michael Short and Henning Trsek, for the exemplary way in which they managed all the aspects of the WiP track and for the valuable help they provide in many other aspects related with the conference organization.

Thirdly, our great appreciation and gratitude go to the General Chairs of WFCS 2015, Julián Proenza and Thilo Sauter, for the outstanding support and cooperation they provided.

Finally, we would like to thank the authors and the participants of the 11th IEEE World conference on Factory Communication Systems. We hope you will enjoy a stimulating



technical program and delightful social events, and we trust your staying in Palma de Mallorca will be pleasant and memorable.

Paulo Pedreiras and Stefano Vitturi WFCS 2015 Program Co-Chairs



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Family	First	Family	First	Family	First
Name	Name	Name	Name	Name	Name
Agirre	Aitor	Gaj	Piotr	Pozo	Francisco
Alam	Muhammad	Garibay- Martinez	Ricardo	Proenza	Julian
Almeida	Luis	George	Laurent	Re	Andrea
Amer	Hassanein	Girs	Svetlana	Saadatmand	Mehrdad
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de Sousa	Mario	Lo Bello	Lucia	Sisinni	Emiliano
Decotignie	Jean- Dominique	Luvisotto	Michele	Song	Ye-Qiong
Di Natale	Marco	Mahmood	Aneeq	Tovar	Eduardo
Dzung	Dacfey	Mangharam	Rahul	Tramarin	Federico
Elmenreich	Wilfried	Marau	Ricardo	Treytl	Abert
Estevez	Elisabet	Marcos	Marga	Trsek	Henning
Exel	Lukas	Medina	Julio	Uhlemann	Elisabeth
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Fonseca	Jose	Pedreiras	Paulo	Wollschlaeger	Martin
Frey	Georg	Pérez	Federico	Yakoh	Takahiro
Frühwirth	Thomas	Petersen	Stig	Zug	Sebastian
Gaddour	Olfa	Portugal	Paulo	Zunino	Claudio



Program at a Glance

Start	Wednesday, May 27	Thursday, May 28	Friday, May 29
08:00			
08:15			
08:45	Registration		
09:00	Opening Session and		
09:15	presentation on TII by		
09:30	Kim F. Man.	TII-SS-3: Industrial	
09:45		Wireless	Session 3:
10:00	Session 1: Wireless	Systems	Architectural issues
10:30	Networks	ey sienie	
10:45			
11:00	Coffee break	Coffee break	Coffee break
11:15			
11:30			Session A. Building
12.00	Keynote 1	Keynote 2	Automation
12:15			Automation
12:30			
12:45			
13:00	Lunch break	Lunch break	Lunch break
13:15			
13:45			
14:00			WiP-S2: Wireless
14:15	TIL-SS-1: Reliability	WIP-ST: Industrial	Networks,
14:30	and Architectures	Desian, Analysis and	Applications and
14:45		Performance	Virtualized environments
15:00		Coffee break and	Coffee break and
15:15	Coffee break	Poster discussion	Poster discussion
15:30			
15:45	TII-SS-2: Schedulina		
16:00	and Performance	Session 2: Real-Time	Session 5: Reliability
16:30	Analysis	and Industrial	and salely
16:45		Ethernet	
17:00			Closing Session
17:15			Closing session
17:30			
1/:45			
18:30			
19:00	Guided Walk and		
19:30	welcome Reception		
20:00			



Schedule

Start	End	Wednesday, May 27th
08:30	09:00	Registration
09:00	09:45	Opening Session and presentation on IEEE TII by Kim F. Man
09:45	11:00	Session 1: Wireless Networks
11:00	11:30	Coffee break
11:30	12:30	Keynote 1: Industrial Communication and Networking in Automation Systems – today and tomorrow
12:30	14:00	Lunch break
14:00	15:00	TII-SS-1: Reliability and Architectures
15:00	15:30	Coffee break
15:30	17:00	TII-SS-2: Scheduling and Performance Analysis
18:30	22:00	Guided Walk and Welcome Reception

Start	End	Thursday, May 28th
09:00	11:00	TII-SS-3: Industrial Wireless Communication Systems
11:00	11:30	Coffee break
11:30	12:30	Keynote 2: Helping people (besides machines) understand each other in integrated manufacturing
12:30	14:00	Lunch break
14:00	15:00	WiP Session 1: Industrial Communication Networks: Design, Analysis and Performance
15:00	15:30	Coffee break and poster session 1
15:30	17:30	Session 2: Real-Time and Industrial Ethernet
18:00	00:00	Conference Dinner

Start	End	Friday, May 29 th
09:00	11:00	Session 3: Architectural Issues
11:00	11:30	Coffee break
11:30	12:30	Session 4: Building Automation
12:30	14:00	Lunch break
14:00	15:00	WiP Session 2: Wireless Networks, Applications and Virtualized environments
15:00	15:30	Coffee break and poster session 2
15:30	17:00	Session 5: Reliability and Safety
17:00	17:30	Closing Session



Wednesday, May 27th

Start	End	Topic/Title
08:30	09:00	Registration
09:00	09:45	Opening Session & Publishing Opportunities in IES Journals. Kim F. Man
09:45	11:00	Session 1: Wireless Networks. Chair: Ricardo Moraes
		Using LTE as an Access Network for Internet-Based Cyber-Physical Systems
		Monammaa Elattar ana Jurgen Jasperneire
		Extracting Markov Chain Models from Protocol Execution Traces for End to End Delay Evaluation in Wireless Sensor Networks François Despaux, Ye-Qiong Song and Abdelkader Lahmadi
		Multi-hop routing within TDMA slots for teams of cooperating robots Luís Oliveira, Luis Almeida and Pedro Lima
11:00	11:30	Coffee break
11:30	12:30	Keynote 1. Chair: Stefano Vitturi
		Industrial Communication and Networking in Automation Systems – today and tomorrow Linus Thrybom (ABB Corporate Research, Sweden)
12:30	14:00	Lunch break
14:00	15:00	TII-SS-1: Reliability and Architectures Chair: Martin Wollschlaeger
		iPRP: Parallel Redundancy Protocol for IP Networks Miroslav Popovic, Maaz Mohiuddin, Dan-Cristian Tomozei and Jean- Yves Le Boudec
		A RESTful Extension of OPC UA Sten Grüner, Julius Pfrommer and Florian Palm
15:00	15:30	Coffee break
15:30	17:00	TII-SS-2: Scheduling and Performance Analysis Chair: Jürgen Jasperneite
		FlexRay Static Segment Scheduling on Two Independent Channels with Gateway Jan Dvořák and Zden <i>ě</i> k Hanzálek
		Improving Profinet IRT Frame Packing Using Ethernet Control Characters Ralf Schlesinger, Thilo Sauter and Andreas Springer
		Holistic Analysis for Fork-Join Distributed Tasks supported by the FTT-SE Protocol Ricardo Garibay-Martinez, Geoffrey Nelissen, Luis Lino Ferreira, Paulo
		Pedreiras and Luis Miguel Pinho
18:30	22:00	Guided Walk and Welcome Reception



Thursday, May 28th

Start	End	Topic/Title
09:00	11:00	TII-SS-3: Industrial Wireless Communication Systems Chair: Lucia Lo Bello
		A WSN Data Retransmission Mechanism Based on Network Coding and Cooperative Relayers Odilson Valle, Carlos Montez, Gustavo Araujo, Ricardo Moraes and Francisco Vasques
		The IEEE 802.11n wireless LAN for real-time industrial communication Federico Tramarin, Stefano Vitturi, Michele Luvisotto and Andrea Zanella
		A Simulation-based Comparison of IEEE 802.11's Timing Advertisement and SyncTSF for Clock Synchronization Aneeq Mahmood, Reinhard Exel and Thilo Sauter
		Scheduling Transmissions in Industrial Networks Using Source Relaying and Packet Aggregation Svetlana Girs, Andreas Willig, Elisabeth Uhlemann and Mats Björkman
11:00	11:30	Coffee break
11:30	12:30	Keynote 2 Chair: Paulo Pedreiras
		Helping people (besides machines) understand each other in integrated manufacturing Nicola Guarino (National Research Council of Italy)
12:30	14:00	Lunch break
14:00	15:00	WiP Session 1: Industrial Communication Networks: Design, Analysis and Performance Chair: Henning Tsrek
		Less Wires - a Novel Approach on Combined Power and Ethernet Transmission on a Single, Unshielded Twisted Pair Cable Derk Wesemann, Jens Dünnermann, Marian Schaller, Norman Banick and Stefan Witte
		Software Defined Networking Applied to the Heterogeneous Infrastructure of Smart Grid Stefano Rinaldi, Paolo Ferrari, Dennis Brandao and Sara Sulis
		Performance Analysis of the Ethernet Powerlink Poll Response Chaining Mechanism Mladen Knezic, Branko Dokic and Zeljko Ivanovic
		A Configuration Agent based on the Time-Triggered Paradigm for Real-Time Networks Marina Gutiérrez, Wilfried Steiner, Radu Dobrin and Sasikumar Punnekkat



Experimental Evaluation of Network Component Crashes and Trigger Message Omissions in the Flexible Time-Triggered Replicated Star for Ethernet

David Gessner, Alberto Ballesteros, Andreu Adrover and Julian Proenza

Seamless reconfiguration of Time Triggered Ethernet based protocols Lukasz Wisniewski, Satendrasingh Chahar and Juergen Jasperneite

Applying End-to-end Path Delay Analysis to Multi-rate Automotive Systems Developed using Legacy Tools Saad Mubeen and Thomas Nolte

Analytical Approach to Multiple Memoryless Backoff Contention Analysis

Marek Miśkowicz, Jakub Szyduczyński and Dariusz Kościelnik

Modeling Burst Errors in Industrial Networks Andreas Platschek, Bernd Thiemann and Heimo Zeilinger

15:00 15:30 Coffee break and Poster session 1

15:30 17:30 Session 2: Real-Time and Industrial Ethernet Chair: Luis Lino Ferreira

An Analysis of Real-Time Ethernets With Regard to Their Automatic Configuration

Lars Dürkop, Jürgen Jasperneite and Alexander Fay

Optimising Non-Real Time Frame Handling in Real Time Ethernet Nodes Lukas Itin and Hans Dermot Doran

Improving EtherCAT Master-Slave Synchronisation Precision using PTCP Embedded in EtherCAT Frames: A Proof-of-Concept David Ganz, Serafin Leschke and Hans Dermot Doran

IoT integration on Industrial Environments Miguel Díaz-Cacho Medina, Emma Delgado, Pablo Falcón and Antonio Barreiro

Data supply chain in Industrial Internet Andrea Buda, Kary Främling, Sylvain Kubler, Manik Madhikermi, Saeed Mirzaeifar and Jukka Borgman

18:00 00:00 Conference Dinner



Friday, May 29th

Start	End	Topic/Title
09:00	11:00	Session 3: Architectural Issues Chair: Marek Miśkowicz
		A Resource Oriented Architecture for Web-Integrated SCADA Applications
		Pablo Valério Polônia, Luiz F. Bier Melgarejo and Max Hering De Queiroz
		On the Use of Multiple MAC Registration Protocol in Industrial Networks Paolo Ferrari, Alessandra Flammini, Stefano Rinaldi, Mattia Rizzi, Emiliano Sisinni and Gunnar Prytz
		Sensor Based Transaction Temporal Database Architecture Michal Kvet, Karol Matiaško and Monika Vajsová
		Time-Synchronized Wireless Sensor Network for Structural Health Monitoring Applications in Railway Environments Iñaki Val, Aitor Arriola, Cristina Cruces, Raul Torrego, Eduardo Gomez and Xabier Arizkorreta
		A Reference Architecture for Condition Monitoring Martin Wollschlaeger, Stefan Theurich, Albrecht Winter, Frank Lubnau and Christoph Paulitsch
11:00	11:30	Coffee break
11:30	12:30	Session 4: Building Automation Chair: Paolo Ferrari
		Distribution of control functionality in energy-aware industrial building environment Aleksey Bratukhin, Aneeq Mahmood and Anetta Nagy
		Model-Driven Integration of Building Automation Systems into Web Service Gateways Daniel Schachinaer and Wolfgang Kastner
12:30	14:00	Lunch break
		WiP Session 2: Wireless Networks, Applications and Virtualized
14:00	15:00	environments Chair: Aleksey Bratukhin
		Exploiting Voting Strategies in Partially Replicated IEC 61499 Applications
		Mario de Sousa, Christos Chrysoulas and Aydin Homay
		ZigBee Cluster Tree Formation For Time-Bounded Data Flows in One Collision Domain Aasem Ahmad and Zdenek Hanzalek
		Developing CPPS within IEC-61499 based on Low Cost Devices Marcelo Garcia, Federico Pérez, Isidro Calvo and Guadalupe Moran



Control of Robots and Machine Tools with an Extended Factory Cloud Axel Vick, Christian Horn, Martin Rudorfer and Jörg Krüge

Evaluation of Cognitive Radio for Mission-Critical and Time-Critical WSAN in Industrial Environments under Interference Pedro M. Rodríguez, Iñaki Val, Aitor Lizeaga and Mikel Mendicute

Evaluation of Open Source SIEM for Situation Awareness Platform in the Smart Grid Environment Rafal Leszczyna and Michał Ryszard Wróbel

A Sleep-Scheduling Scheme for Enhancing QoS and Network Coverage in IEEE 802.15.4 WSN Tiago Semprebom, Carlos Montez, Gustavo Araújo and Paulo Portugal

Enhancing the Real-Time behavior of IEEE 802.11n Federico Tramarin, Stefano Vitturi and Michele Luvisotto

Towards Low-datarate Communications for Cooperative Mobile Robots

Gaetano Patti, Giovanni Muscato, Nunzio Abbate and Lucia Lo Bello

15:00 15:30 Coffee break and Poster session 2

15:30 17:00 Session 5: Reliability and Safety Chair: Radu Dobrin

Minimizing Revalidation and Recertification in Evolutionary Embedded Systems

Waled Almakhawi and Roman Obermaisser

Improving Safety Message Delivery through RSU's Coordination in Vehicular Networks Nuno Ferreira and José Fonseca

Scheduling feedback for scalability and reliability in a streaming multicast protocol Julio Cano, Ana Pereira, Luis Oliveira and Luis Almeida

17:00 17:30 Closing Session



ABSTRACTS

Wednesday, May 27th

09:00 - 09:45: Opening Session & "Publishing Opportunities in IES Journals" *Kim F. Man* 09:45 - 11:00: Session 1: Wireless Networks

Using LTE as an Access Network for Internet-Based Cyber-Physical Systems Mohammad Elattar and Jürgen Jasperneite

ABSTRACT:

Cyber-physical systems (CPSs) represent a new generation of control systems where distributed local control systems are connected not only physically, but also computationally by means of communication networks. CPSs target introducing intelligence beside traditional monitoring and control functionalities in a way that optimize the performance of the overall system. However, the realization of many CPS applications requires reliable communication systems that provide quality of service (QoS) control. In this domain, Long Term Evolution (LTE) standard offers a comprehensive QoS frame work. Nevertheless, commercial implementations of the standard provide only best effort type of service. In this paper, we demonstrated the benefits of using LTE networks with QoS support for CPSs by comparing the performance of a CPS application over LTE network with and without QoS support. The results clearly indicate the benefit to enable the QoS features in commercial implementations of LTE in order to realize reliable CPS applications.

Extracting Markov Chain Models from Protocol Execution Traces for End to End Delay Evaluation in Wireless Sensor Networks

François Despaux, Ye-Qiong Song and Abdelkader Lahmadi

ABSTRACT:

Many WSN industrial applications impose requirements in terms of end to end delay. However, the end to end delay estimation in WSNs is not a simple task because of the high dynamic of networks, the use of duty-cycled MAC protocols as well as the impact of the routing protocols. Markov-based modelling is an interesting approach to deal with this problem aiming to provide an analytical model useful for understanding protocol's behavior and to estimate the end to end delay, among other performance parameters. However, existing Markov-based analytic models abstract the reality simplifying the analysis and thus resulting models are not accurate enough for estimating the end to end delay. Furthermore, establishing an accurate Markov model using classic approaches is very difficult considering the highly dynamic behavior of the sensor nodes. In this paper, we propose a novel approach to obtain the Markov chain model of sensor nodes by means of Process Mining techniques through the code execution trace. End to end delay is then computed based on this Markov chain. Experimentations were done using IoT-LAB testbed platform. Comparisons in terms of delay are presented for two different metrics of the RPL protocol (hop count and ETX).

Multi-hop routing within TDMA slots for teams of cooperating robots

Luís Oliveira, Luis Almeida and Pedro Lima



ABSTRACT:

Small teams of cooperating robots have been shown to benefit from the increased reliability of synchronised message exchanges provided by TDMA-based schemes. However, such schemes may also impose a long propagation delay to communications between non neighbour robots. Such negative impact is further increased by long TDMA rounds, which favour reduced medium utilisation and energy consumption, and by decentralised mesh topologies, which increase the team coverage and layout flexibility. For small size teams, say up to 10 units, it is feasible to setup a global TDMA framework as well as tracking the instantaneous network topology, making it available to each robot. In this work we use this knowledge to forward packets along their path within the TDMA slot to allow them to reach other robots beyond their one-hop neighbourhood, in a multi-hop fashion. To that end, we present a novel communication protocol that combines global TDMA and multi-hop routing. It maintains the reliability benefits of the TDMA schemes while strongly reducing the end-to-end propagation delay of interactions between non neighbour robots when compared to a typical protocol that forwards the packets to the immediate one-hop neighbours in each TDMA slot, only, and also when compared to a common token-passing approach. We conclude the paper with experimental results that validate our claims, namely when compared to a traditional TDMA implementation, our proposal has a measured end-to-end delay that can be as low as 35% that of a traditional TDMA implementation. Finally, when compared with an audio streaming application implemented using a token passing protocol, our proposal is shown to match its requirements with less management bandwidth.

11:00 - 11:30: Coffee break

11:30 - 12:30: Keynote 1

Industrial Communication and Networking in Automation Systems – today and tomorrow

Linus Thrybom (ABB Corporate Research, Sweden)

ABSTRACT:

Industrial automation systems depend highly on deterministic and reliable communication and networking. Additionally, most automation systems can already be seen as a kind of an "Internet of Things, Services and People", since an automation plant network connects the sensors, actuators, control algorithm, data store and operators with each other. The introduction of Ethernet into the industrial communication domain is a recent change which has impacted most of us, but what is the next phase in industrial communication and networking? This talk will present some of the communication and networking solutions which are used in industrial products and systems, as well as an outlook into future trends of industrial communication and networking in automation systems.

12:30 - 14:00: Lunch break

14:00 - 15:00: TII-SS-1: Reliability and Architectures

iPRP: Parallel Redundancy Protocol for IP Networks

Miroslav Popovic, Maaz Mohiuddin, Dan-Cristian Tomozei and Jean-Yves Le Boudec

ABSTRACT:

Reliable packet delivery within stringent delay constraints is of primal importance to industrial processes with hard real-time constraints, such as electrical grid monitoring.



Because retransmission and coding techniques counteract the delay requirements, reliability is achieved through replication over multiple fail-independent paths. Existing solutions such as parallel redundancy protocol (PRP) replicate all packets at the MAC layer over parallel paths. PRP works best in local area networks, e.g., sub-station networks. However, it is not viable for IP layer wide area networks, a key element of emerging smart grids. Such a limitation on scalability, coupled with lack of security, and diagnostic inability, renders it unsuitable for reliable data delivery in smart grids. To address this issue, we present a transport-layer design: IP parallel redundancy protocol (iPRP). Designing iPRP poses non-trivial challenges in the form of selective packet replication, soft-state and multicast support. Besides unicast, iPRP supports multicast, which is widely using in smart grid networks. It duplicates only time-critical UDP traffic. iPRP only requires a simple software installation on the end-devices. No other modification to the existing monitoring application, end-device operating system or intermediate network devices is needed. iPRP has a set of diagnostic tools for network debugging. With our implementation of iPRP in Linux, we show that iPRP supports multiple flows with minimal processing and delay overhead. It is being installed in our campus smart grid network and is publicly available.

A RESTful Extension of OPC UA

Sten Grüner, Julius Pfrommer and Florian Palm

ABSTRACT:

RESTful interfaces are a wide-spread architecture style for webservice implementations and are built upon the resource-oriented approach to decentralized architectures (ROA). REST postulates a set of requirements, e.g., stateless requests, that are not covered by the OPC Unified Architecture (OPC UA) communication protocol. We propose a set of extensions to the OPC UA binary protocol that enable RESTful communication. The evaluation shows an order of magnitude improvement in the use of communication resources for sporadic service requests. Additionally, RESTful OPC UA allows applications to profit from the advantages of the resource-oriented architecture style, such as increased scalability and loose application coupling

15:00 - 15:30: Coffee break

15:30 - 17:00: TII-SS-2: Scheduling and Performance Analysis

FlexRay Static Segment Scheduling on Two Independent Channels with Gateway Jan Dvořák and Zdeněk Hanzálek

ABSTRACT:

The FlexRay bus is a modern standard used in the automotive industry. It offers deterministic message transmission with zero jitter while using time-triggered scheduling in the static segment. Even if its bandwidth is ten times higher than the bandwidth of CAN, its throughput limits are going to be reached in high-class car models soon. The solution that could postpone this problem is to use an efficient scheduling algorithm that exploits all the FlexRay features. The significant and often neglected feature that can theoretically double the bandwidth is the possibility to use two independent communication channels that can intercommunicate through the gateway node. In this paper, we propose a heuristic algorithm that decomposes the problem to the channel assignment subproblem which decides which channel and node should be connected and the channel scheduling subproblem which creates static segment communication schedules for both channels. Finally, the



algorithm is evaluated on real-data and synthesized instances and the difference between single channel and dual channel scheduling is presented.

Improving Profinet IRT Frame Packing Using Ethernet Control Characters

Ralf Schlesinger, Thilo Sauter and Andreas Springer

ABSTRACT:

Profinet IRT makes use of dynamic frame packing (DFP) in order to support very short cycle times. The applied packing order is highly dependent on the network topology, and thus the scheduling must be recalculated offline every time the network structure is changed. This study presents a proposal for an automatic packing mechanism (APM) that is based on subframes with delimiters using control characters. As a consequence the subframe positions can be recognized by each device, which makes a scheduling dispensable. Furthermore, APM achieves better performance than DFP, especially in star or tree topology. The paper also presents experimental validation results.

Holistic Analysis for Fork-Join Distributed Tasks supported by the FTT-SE Protocol

Ricardo Garibay-Martinez, Geoffrey Nelissen, Luis Lino Ferreira, Paulo Pedreiras and Luis Miguel Pinho

ABSTRACT:

Modern distributed real-time embedded applications have high processing requirements associated with strict deadlines. Such constraints cannot be fulfilled by existing single-core embedded platforms. A solution is to parallelise the execution of the applications, by allowing networked nodes to distribute their workload to remote nodes with spare capacity in the system. In this context, this paper presents a holistic timing analysis for fixed-priority fork-join parallel distributed tasks (P/D tasks). Furthermore, we extend the holistic approach to consider the interaction between parallel threads and messages interchanged through a Flexible Time Triggered -Switched Ethernet (FTTSE) network, and we show how the pessimism on the Worst-Case Response Time (WCRT) computation of such tasks can be improved by considering a pipeline effect in such distributed systems.

18:30 - 22:00: Guided Walk and Welcome Reception



Thursday, May 28th

09:00 - 11:00: TII-SS-3: Industrial Wireless Communication Systems

A WSN Data Retransmission Mechanism Based on Network Coding and Cooperative Relayers

Odilson Valle, Carlos Montez, Gustavo Araujo, Ricardo Moraes and Francisco Vasques

ABSTRACT:

The use of cooperative diversity techniques and network coding concepts are promising solutions to improve the communication reliability in industrial Wireless Sensor Networks (WSNs). In this paper, it is proposed the NetCoDer scheme to address this problem, whose design is based on these concepts. The effectiveness of the NetCoDer scheme is evaluated through both an experimental setup with real WSN nodes and a simulation assessment, comparing its performance against state-of-theart TDMA-based retransmission techniques.

The IEEE 802.11n wireless LAN for real-time industrial communication

Federico Tramarin, Stefano Vitturi, Michele Luvisotto and Andrea Zanella

ABSTRACT:

In the last years, IEEE 802.11 Wireless LANs (WLANs) have proved their effectiveness for a wide range of real-time industrial communication applications. Nonetheless, the enhancements at the PHY and MAC layers introduced by the IEEE 802.11n amendment have not yet been adequately addressed in the context of industrial communication. In this paper we investigate the impact of some IEEE 802.11n new features on some important performance figures for industrial applications, such as timeliness and reliability.

A Simulation-based Comparison of IEEE 802.11's Timing Advertisement and SyncTSF for Clock Synchronization

Aneeq Mahmood, Reinhard Exel and Thilo Sauter

ABSTRACT:

The lack of provisioning of synchronized timing support from known timing standards in IEEE 802.11 wireless networks has been overcome in IEEE 802.11-2012, through the timing advertisement (TA) mechanism. The scheme, however, presents a synchronization architecture of a cascade of four clocks. It provides no information how the external time will be synchronized with the built-in clock of the access point. Moreover, there exists a lack of clarity about when the timestamping is performed for synchronization between the access point and wireless stations, which can lead to a loss in synchronization accuracy. To this end, this work analyses the quantitative performance of the TA mechanism with another scheme SyncTSF, and compares the performance with the help of simulations. Both schemes perform similarly if synchronization in the cascade is performed properly, but SyncTSF is more flexible as it can be easily implemented using commercial off-the-shelf hardware using only software support. For the TA scheme, the IEEE 802.11 standard needs to provide additional guidelines to guarantee accurate and precise wireless synchronization.



Scheduling Transmissions in Industrial Networks Using Source Relaying and Packet Aggregation

Svetlana Girs, Andreas Willig, Elisabeth Uhlemann and Mats Björkman

ABSTRACT:

Wireless networks present a promising alternative to the currently used wired systems as they are more flexible, easier to install and maintain. However, requirements on reliability and timeliness which at present are met by wired networks, also need be fulfilled by wireless solutions. Relaying and packet aggregation have been recognised as viable tools to do this. However, introducing additional relay nodes into an industrial network is costly. Hence, in this paper we propose to use a combination of relaying and packet aggregation performed by the source nodes them-selves. The results show that our proposal improves performance considerably, but also that the transmission schedule plays a crucial role. A schedule adapting to the varying channel conditions, improves the performance substantially. By carefully choosing which packet to aggregate, even further improvements can be achieved.

11:00 - 11:30: Coffee break

11:30 - 12:30: Keynote 2

Helping people (besides machines) understand each other in integrated manufacturing

Nicola Guarino (National Research Council of Italy)

ABSTRACT:

In integrated manufacturing, Product Lifecycle Management (PLM) systems aim at handling the whole spectrum of information processed during all phases of product development, from conceptual and detailed design, to process planning, cost analysis, marketing, and possibly recycling. In this scenario, product information interoperability plays of course a key role, and several standards have been introduced for this purpose to let different computer systems communicate. We are still far away, however, from semantic interoperability, whose ultimate purpose is to facilitate mutual agreement among people on the relevant business terms, especially in large multinational contexts where designers, technicians, marketing persons and administrators speak different languages and are scattered across the world. Yet the costs of human misunderstandings in these contexts may be huge, especially for critical applications. The technique being used nowadays to address these problems is based on computational ontologies. In this talk I will briefly explain what computational ontologies are, what is the role they can play in integrated manufacturing, and what is the status of research in this promising field..

12:30 - 14:00: Lunch break

14:00 - 15:00: WiP Session 1: Industrial Communication Networks: Design, Analysis and Performance

Less Wires - a Novel Approach on Combined Power and Ethernet Transmission on a Single, Unshielded Twisted Pair Cable

Derk Wesemann, Jens Dünnermann, Marian Schaller, Norman Banick and Stefan Witte

ABSTRACT: This paper discusses an alternative to common Powerline oder Power-over-Ethernet



applications, combining a 100BASE-TX-equivalent full duplex communication and simultaneous DC power transmission on one single twisted pair wire. The reduction of wires and connections can potentially ease the modularity and reconfigurability of industrial production installations, if the data communication offers a sufficiently high robustness against influences from the DC power transmission. This part of our research focuses on the necessary electrical adaptations between data and power circuitry and evaluates interference scenarios that are common for industrial fieldbus installations.

Software Defined Networking Applied to the Heterogeneous Infrastructure of Smart Grid

Stefano Rinaldi, Paolo Ferrari, Dennis Brandao and Sara Sulis

ABSTRACT:

The increased need for power quality monitoring and active control of distribution grid necessitates the introduction of the Smart Grid (SG) approach, requiring an efficient ICT system for the monitoring and control of distribution grid state. The main obstacle to deployment of SG in real system is the lack of an efficient communication infrastructure. The use a heterogeneous network, which employs various technologies, appears to be the most promising solution. Nevertheless, the management of these communication systems has proven to be hard and error prone. In the following paper, the Software Defined Networking (SDN) approach has been proposed to manage SG communication system applied to grid monitoring/supervision. The preliminary feasibility analysis is promising, although a more detailed modeling and analysis of the system is required due to the extreme heterogeneity of the network.

Performance Analysis of the Ethernet Powerlink Poll Response Chaining Mechanism

Mladen Knezic, Branko Dokic and Zeljko Ivanovic

ABSTRACT:

Ethernet Powerlink (EPL) is an industrial Ethernet networking solution that enables hard real-time communication in distributed control and automation systems. The PollResponse Chaining (PRC) mechanism is an extension of the EPL protocol aimed at increasing the network performance when nodes exchange small amount of data, especially if they are connected in line topology. In this paper, we conduct performance assessment of the PRC mechanism for two basic network configurations (line and star topology). In addition, we provide some experimental results obtained by measuring relevant timing parameters of the real EPL network prototype operating in the PRC mode.

A Configuration Agent based on the Time-Triggered Paradigm for Real-Time Networks

Marina Gutiérrez, Wilfried Steiner, Radu Dobrin and Sasikumar Punnekkat

ABSTRACT:

Distributed cyber-physical systems are growing in size and functionality and deterministic communication is an important requirement for those systems. The existing solutions based on the time-triggered paradigm pose certain limitations in regards to the configuration. Usually configuration is seen as a one-time event during the installation of the network. Future real-time networks need to be able to adapt



more easily to changes in the network. Thus, the configuration becomes an ongoing service, e.g., as for network maintenance and re-configuration to add and remove new, respectively old, equipment. We postulate that configuration will emerge to a continued service that accompanies a real-time network throughout its different lifecycle phases. In this context of evolving and dynamic networks, we introduce the concept of a configuration agent for real-time networks and demonstrate the concept by a realization based on the time triggered paradigm.

Experimental Evaluation of Network Component Crashes and Trigger Message Omissions in the Flexible Time-Triggered Replicated Star for Ethernet

David Gessner, Alberto Ballesteros, Andreu Adrover and Julian Proenza

ABSTRACT:

A distributed embedded system (DES) is made up of a set of computing nodes interconnected by a network. If we want the DES to continue to operate even if a subset of its network elements fail, the network must be fault-tolerant. In particular, this requires that the architecture of the network provides redundant paths between nodes and that any elements critical for the operation of the network are replicated. In the context of DES that must not only be highly reliable, but also provide sufficient flexibility to adapt to unpredictable requirement changes, the Flexible Time-Triggered Replicated Star for Ethernet (FTTRS) has been proposed. One of the core features of FTTRS is precisely its fault-tolerant network architecture. In this paper we present a proof-of-concept prototype of FTTRS and a series of fault-injection experiments. These experiments show that FTTRS can tolerate the crash of any single network element, as well as the crash of various combinations of multiple network elements. A variety of omission failures affecting the most critical FTTRS message (called the trigger message) are also tolerated.

Seamless reconfiguration of Time Triggered Ethernet based protocols

Lukasz Wisniewski, Satendrasingh Chahar and Juergen Jasperneite

ABSTRACT:

One of the key aspects to consider increasing flexibility of production plants is the industrial communication sys- tem. In case of time triggered Ethernet (TTE) systems, the flexibility is typically limited. In this paper an approach for seamless reconfiguration of TTE system is proposed. It has been shown that the reconfiguration can be performed without influencing currently running system.

Applying End-to-end Path Delay Analysis to Multi-rate Automotive Systems Developed using Legacy Tools

Saad Mubeen and Thomas Nolte

ABSTRACT:

The end-to-end path delay analysis is used to predict timing behavior of multi-rate automotive embedded systems. Some of the assumptions used by the existing analysis may not be strictly followed by some legacy tools due to optimizations applied during the development of these systems. As a result, the existing analysis may not be applicable in some cases. In this paper we identify one such case. That is, the case in which all the tasks in a multi-rate task chain have equal priorities despite the fact that they have different periods. Furthermore, the chain contains at least one



single-rate sub-chain. We also propose a preliminary solution that makes the existing analysis applicable to this case. However, the proposed solution is pessimistic. Currently, we are working on minimizing the pessimism.

Analytical Approach to Multiple Memoryless Backoff Contention Analysis

Marek Miśkowicz, Jakub Szyduczyński and Dariusz Kościelnik

ABSTRACT:

The paper addresses the performance analysis of the multiple memoryless backoff contention in slotted-CSMA protocols. By multiple memoryless backoff (MMB) system we define a heterogeneous random access protocol when the contending stations sample from different numbers of contention slots, and the sampled backoff times are cancelled when the transmission is detected in the channel. The MMB contention occurs in practice in many random access networks usually due to different history of collisions experienced by particular stations (e.g. in binary exponential backoff in CSMA/CD IEEE 802.3, or in linear backoff used in predictive p-CSMA in LonTalk (ISO/IEC 14908). The MMB provides unequal allocation of bandwidth among the stations, and thus introduces unfairness in channel access. The paper contains derivations of analytical formulae for probabilities of successful and successful transmissions needed to determine throughput and mean access delay. Finally, sample numerical results for multiple memoryless backoff network are presented.

Modeling Burst Errors in Industrial Networks

Andreas Platschek, Bernd Thiemann and Heimo Zeilinger

ABSTRACT:

When argumenting the safety of an industrial system, the validity of the calculation of the residual error rate depends on multiple factors. Examples are a correct and thorough analysis of hazards, a correct estimation of occurrence and on the risk the identified hazards pose. These properties of the analysis have then to be compiled into a sound error model that reflects reality, and can then be used as basis for calculating the residual error rate of the system. One error model for industrial communication networks is given in IEC 61784-3 [1, B.3]. In this paper, this commonly used error model for industrial communication networks is analyzed and its shortcomings are pin-pointed, leading to the question, whether the current model should be scrutinized, not only its parameters. Based on this analysis a new approach on an error model is proposed. This new model has the advantages of more accurately modelling burst errors, and using input parameters that give less reason for discussion as they are widely used in electro magnetic compatibility (EMC) tests for hardware.

15:00 - 15:30: Coffee break and Poster session 1

15:30 - 17:30: Session 2: Real-Time and Industrial Ethernet

An Analysis of Real-Time Ethernets With Regard to Their Automatic Configuration

Lars Dürkop, Jürgen Jasperneite and Alexander Fay

ABSTRACT:

Future market conditions require production systems which can be easily adapted to changing demands. However, the engineering process of industrial automation



systems is characterized by high manual configuration efforts. Thus, the reconfiguration of such system leads to time-intensive and expensive downtimes. Therefore, this paper will present a concept on reducing the engineering effort - at least on the lower layers of the automation pyramid. Due to the real-time requirements on these layers, specific communication technologies must be used there - for example Real-Time Ethernets (RTEs) which are increasingly applied in industrial automation. However, their real-time capability is contrasted by an additional configuration effort in comparison to standard networks from the information technology domain. This paper will show an approach for the automatic configuration of RTEs and will check its applicability on the most widely-used RTE variants.

Optimising Non-Real Time Frame Handling in Real Time Ethernet Nodes

Lukas Itin and Hans Dermot Doran

ABSTRACT:

Modern Real Time Ethernet technologies rely on well-described hardware acceleration techniques to ensure that hard real-time deadlines are met. Real Time Ethernet is also often used in situations where appreciable non real-time bandwidth is used and where throughput is important. In this paper, using the example of PROFINET, we examine the performance of various communication controller architectures in non-real-time data handling. Finding the performance not up to industry requirements we propose a multiprocessor architecture and describe an implementation and measurement results. This architecture allows better partitioning of communication and application processing whilst supporting maximum bandwidth utilization for non-real-time traffic.

Improving EtherCAT Master-Slave Synchronisation Precision using PTCP Embedded in EtherCAT Frames: A Proof-of-Concept

David Ganz, Serafin Leschke and Hans Dermot Doran

ABSTRACT:

Designed for efficient real time traffic at low cycle times, EtherCAT is known to display several inefficiencies which include high quality master-slave synchronization. In this paper we examine a prototype circuit that allows us to achieve high quality time synchronization between master and slave device using PTCP embedded in EtherCAT frames. This circuit is backward compatible to existing EtherCAT networks. We provide measurement data and make proposals for future work.

IoT integration on Industrial Environments

Miguel Díaz-Cacho Medina, Emma Delgado, Pablo Falcón and Antonio Barreiro

ABSTRACT:

Internet of Things (IoT) devices in industrial environments can be a significant increase in the network load of the local IP backbone, involving the network performance. To deal with the important amount of network traffic generated by the IoT devices, this paper proposes the use of IoT gateways in industrial environments (but not limited to) that unifies the data structures improving the size efficiency, and filters the data to be send across the shared IP backbone. To implement this solution some data structures and a multidimensional deadband scheme are presented. Simulations are performed



using Networked Control Systems as IoT devices to show the feasibility of the proposed solution.

Data supply chain in Industrial Internet

Andrea Buda, Kary Främling, Sylvain Kubler, Manik Madhikermi, Saeed Mirzaeifar and Jukka Borgman

ABSTRACT:

The Industrial Internet promise to radically change and improve many industries daily businesses operations. Data collected from machines is analyzed and used to adjust the behavior of a given equipment. This paper first presents the architecture of a typical industrial internet application. Then it highlights one fundamental arising contradiction: "Who owns the data is often not capable of analyze it". This statement is explained by imaging a visionary data supply chain that would realize some of the industrial internet promises. To concretely implement such system, a recently published standard is described, highlighting the characteristics that make it particularly suited for the task. Finally that paper discuss comparable solutions and conclude with possible scenarios evolution.

18:00 - 00:00: Conference Dinner



Friday, May 29th

09:00 - 11:00: Session 3: Architectural Issues

A Resource Oriented Architecture for Web-Integrated SCADA Applications

Pablo Valério Polônia, Luiz F. Bier Melgarejo and Max Hering De Queiroz

ABSTRACT:

Supervisory Control and Data Acquisition (SCADA) systems are widely used on industry and public utility services to gather information from field devices and to control and monitor processes. The adoption of Internet technologies in automation have brought new opportunities and challenges for industries, establishing the need to integrate information from various sources on the Web. This paper exposes the design and implementation of a Resource Oriented Architecture for the integration of typical SCADA applications based on the Web architectural principles of the Representational state transfer (REST) architectural style. The application to a didactic Flexible Manufacturing Cell illustrates how SCADA can take advantage of the interoperability afforded by open Web technologies, interact with a wide range of systems and leverage from the existing Web infrastructure, such as proxies and caches.

On the Use of Multiple MAC Registration Protocol in Industrial Networks

Paolo Ferrari, Alessandra Flammini, Stefano Rinaldi, Mattia Rizzi, Emiliano Sisinni and Gunnar Prytz

ABSTRACT:

Large industrial automation networks based on Real-Time Ethernet protocols may need efficient multicast management and filtering in order to control traffic load and to guarantee the desired quality of service. Very often industrial network are required to be highly available, implying the use of redundancy protocols, and thus, the use of dynamic (layer 2) multicast reconfiguration may be effective. This paper evaluates the application of standard IEEE Multiple MAC registration Protocol (MMRP) to industrial automation scenarios. Two main application fields are considered: large (and slow) process automation plants; and fast factory automation networks inside electric substations for measuring and protection. Following analytical and simulation approaches complete model of MMRP has been developed. Last, a new set of protocol parameters is proposed to maximize effectiveness of MMRP in industrial scenarios: a great network load reduction and a multicast reconfiguration time of 40 ms after a fault can be obtained in networks with complex topology.

Sensor Based Transaction Temporal Database Architecture

Michal Kvet, Karol Matiaško and Monika Vajsová

ABSTRACT:

Sensor data processing and managing is a fundamental requirement of industrial systems. Validity of these data is time bordered and should be stored in database. However, existing database solutions are dinadequate in terms of performance – effectiveness of the whole system which is manifested using the size of the managed data and processing time. This paper deals with the principles of extended temporal data modelling based on the attribute level, which is very useful for time-various sensor data processing. It deals with the transaction management problems and



describes solutions. However, each sensor has defined measurement precision, thus only reliable data based on significant change are stored. This solution is mostly designed for industrial communication systems, sensor data processing or intelligent transport systems.

Time-Synchronized Wireless Sensor Network for Structural Health Monitoring Applications in Railway Environments

Iñaki Val, Aitor Arriola, Cristina Cruces, Raul Torrego, Eduardo Gomez and Xabier Arizkorreta

ABSTRACT:

In this work a time-synchronized Wireless Sensor Network (WSN) has been designed and implemented for a real-time Structural Health Monitoring (SHM) system for trains. Channel measurements have been done in the first place on a real operational scenario, and obtained results have been used as inputs for the design of the physical layer of the WSN. A specific Time Division Multiple Access (TDMA) MAC layer and a synchronization algorithm have also been developed for allowing a deterministic data collection and synchronized sampling, which are critical aspects in SHM applications. Performance measurements of the WSN have also been done, which have shown maximum sampling synchronization jitter values within 1 ms for sensor nodes belonging the same base station, and maximum jitter values within 2 µs for nodes of different base stations.

A Reference Architecture for Condition Monitoring

Martin Wollschlaeger, Stefan Theurich, Albrecht Winter, Frank Lubnau and Christoph Paulitsch

ABSTRACT:

Condition monitoring and diagnostic systems support the operators of machines and plants. By these means, machine operators can run their plants efficiently, perform effective preventive maintenance and supply superordinate information systems with valid machine data. This paper describes a reference architecture for condition monitoring systems. The components of the architecture are described and their application across all levels of an automation system is shown, combining the single functions to a complete condition monitoring system.

11:00 - 11:30: Coffee break

11:30 - 12:30: Session 4: Building Automation

Distribution of control functionality in energy-aware industrial building environment Aleksey Bratukhin, Aneeq Mahmood and Anetta Nagy

ABSTRACT:

Modern trends in automation require flexible production with an onus on saving energy. Till recently, the focus of production systems has been only saving production costs, but the growing concern over environmental impact of such system has led to a partial change in paradigm. The key for the future generation production system is to successfully integrate the manufacturing environment with energy optimisation. This relies on transparent representation of the building from the point of the Manufacturing Execution System (MES) that is not feasible using conventional centralized approaches to building thermal modeling and optimisation. This work



focuses on distributing the building automation system in a set of generic cells that encapsulate thermal energy models and optimisation algorithms to minimize computational resources required for the system implementation on embedded devices. Combined with a notion of the global overview of the energy optimisation with functional aggregation and dynamic clustering concepts, the proposed architecture provides a flexible energy saving solution that can be easily integrated in majority of conventional manufacturing systems as well as related factory buildings without compromising production operations.

Model-Driven Integration of Building Automation Systems into Web Service Gateways

Daniel Schachinger and Wolfgang Kastner

ABSTRACT:

Accessing building automation systems (BASs) via standardized interfaces gains importance in the context of the Internet of Things (IoT). Web service gateway technologies can be used to integrate BASs in order to provide access via common Web interfaces. Therefore, an integration approach supporting multiple building automation technologies as well as multiple gateway technologies is needed. For this purpose, the model-driven methodology is used to define such a procedure. In this paper, an efficient, automatic, and reusable workflow for the integration of BASs into the IoT is presented by means of specifying modeling languages, model transformations, and code generation in accordance with the concept of Model-Driven Architecture (MDA). The aim is to convert a platform-independent model of a BAS into executable program code representing the underlying datapoints. Furthermore, a proof-of- concept implementation based on an exemplary BAS is implemented and evaluated in order to demonstrate the functionality and the advantages of this model-driven approach.

12:30 - 14:00: Lunch break

14:00 - 15:00: WiP Session 2: Wireless Networks, Applications and Virtualized environments

Exploiting Voting Strategies in Partially Replicated IEC 61499 Applications

Mario de Sousa, Christos Chrysoulas and Aydin Homay

ABSTRACT:

In a modern industrial environment control programs are distributed among several devices. This raises new issues and challenges especially in failure modes. Building fault tolerant applications can be the solution in order a failure of one subcomponent not to jeopardize the execution of the whole application. The authors have proposed a framework to support replicated IEC 61499 applications. In this paper we augment this framework with the support for different voting strategies, propose an extension of the replication communication protocol, and analyse the resulting fault-tolerance semantics. A limited implementation of the framework is also described.

ZigBee Cluster Tree Formation For Time-Bounded Data Flows in One Collision Domain

Aasem Ahmad and Zdenek Hanzalek

ABSTRACT: We study one-collision domain ZigBee cluster-tree design problem to satisfy periodic



time-bounded data flows. The formation of the cluster-tree topology can be seen as a bounded-degree-and-depth tree which is NP-complete problem. The objective is to minimize the number of clusters such that all flows in the network can take place and there exists a clusters schedule that meets all the flows deadlines. For the resulted tree, the clusters schedule is required to be an energy efficient which can be achieved by maximizing the length of the schedule period, and consequently, increasing the lifetime of the network. We present Cluster-Tree Formation and Energy-Efficient clusters scheduling algorithm CFEFS based on Hungarian algorithm, Maximum Matching algorithm and the Branch and Bound algorithm to tackle this designing problem that integrates the clusters formation and the clusters scheduling in one problem.

Developing CPPS within IEC-61499 based on Low Cost Devices

Marcelo Garcia, Federico Pérez, Isidro Calvo and Guadalupe Moran

ABSTRACT:

The adoption of new technologies and automation standards, such as OPC-UA and IEC61499, is essential in order to satisfy the flexibility and reconfiguration needs required at the Factories of the Future. Currently, the Cyber-Physical Production Systems (CPPS) are at the core of the new control and automation distributed systems. However, it is necessary to provide the research community with low cost platforms capable of integrating these new technologies and standards for prototyping new products and concepts. This work presents a low-cost embedded architecture capable of providing process data by means of OPC-UA services, integrated as IEC61499 blocks. Thus, IEC61499 provides high-level capabilities by combining easily software components with independence of the hardware platform used.

Control of Robots and Machine Tools with an Extended Factory Cloud

Axel Vick, Christian Horn, Martin Rudorfer and Jörg Krüge

ABSTRACT:

This paper describes our concept for control of robots and machine tools through a private factory cloud which is dynamically extended by additional public resources. After discussing the opportunities and drawbacks of the virtualization of robot controllers (RC) and software programmable logic controllers (soft-PLC), we present first experiences with the setup of private and public infrastructures. Finally, we introduce our experimental design for investigating the requirements of machine control algorithms regarding availability, dependability and real-time capability in local and public configurations.

Evaluation of Cognitive Radio for Mission-Critical and Time-Critical WSAN in Industrial Environments under Interference

Pedro M. Rodríguez, Iñaki Val, Aitor Lizeaga and Mikel Mendicute

ABSTRACT:

The evaluation of Cognitive Radio (CR) for Wireless Sensor and Actuator Networks (WSANs) in industrial wireless automation applications is presented in this contribution. Current wireless solutions do not ensure enough performance for hard real-time and reliability requirements, based on time-critical data traffic. These industrial



applications are characterized by harsh environments, where the robustness of wireless communications plays an important role. In these kinds of environments, CR can increase the system's reliability and robustness. Thus, several cognitive and noncognitive MACs which ensure mission-critical and time-critical data transmission have been evaluated through OPNET network simulator over several fading and interference channels. The provided results show that CR-based MACs are able to maintain the performance of the network in harsh channels and under interference.

Evaluation of Open Source SIEM for Situation Awareness Platform in the Smart Grid Environment

Rafal Leszczyna and Michał Ryszard Wróbel

ABSTRACT:

The smart grid as a large-scale system of systems has an exceptionally large surface exposed to cyber-attacks, including highly evolved and sophisticated threats such as Advanced Persistent Threats (APT) or Botnets. When addressing this situation the usual cyber security technologies are prerequisite, but not sufficient. The smart grid requires developing and deploying an extensive ICT infrastructure that supports significantly increased situational awareness and enables detailed and precise command and control. The paper presents one of the studies related to the development and deployment of the Situation Awareness Platform for the smart grid, namely the evaluation of open source Security Information and Event Management systems. These systems are the key components of the platform.

A Sleep-Scheduling Scheme for Enhancing QoS and Network Coverage in IEEE 802.15.4 WSN

Tiago Semprebom, Carlos Montez, Gustavo Araújo and Paulo Portugal

ABSTRACT:

Many Wireless Sensor Network (WSN) applications operate autonomously in unreliable or inaccessible environments, precluding maintenance or human intervention. Redundant deployment schemes are usually considered in this scenario, making the network resilient to failure and environmental changes. Furthermore, sleep-scheduling techniques can also be applied, enabling redundant nodes to turn off their radios, while active nodes perform monitoring services. This paper investigates the behavior of the (m,k)-Gur Game approach. The main goal of the (m,k)-Gur Game is to provide an uniform network coverage for monitoring applications, with autonomic nodes performing a self-regulated choice between sending message to a base station or sleep until the next period. The proposal was evaluated using the OMNeT++ simulator tool under the MiXiM framework. Preliminary results shows that the (m,k)-Gur Game outperforms the traditional GurGame approach in terms of QoS provision and network coverage.

Enhancing the Real-Time behavior of IEEE 802.11n

Federico Tramarin, Stefano Vitturi and Michele Luvisotto

ABSTRACT:

IEEE 802.11 systems are drawing an ever increasing interest for wireless industrial communication, also thanks to the interesting features provided by the most recent and advanced amendments to this standard, such as IEEE 802.11n. Due to the



intrinsic unreliability of the wireless medium, the current research efforts aim at improving both timeliness and reliability of such a protocol in view of its adoption for real-time applications. A significant issue in this context is represented by the reduction of the randomness that affects packet delivery times. An important benefit in this direction can be obtained by the deactivation of the standard legacy carrier sensing and backoff procedures. In this paper we show, through a simulative assessment, that a fine control of such features leads to improved real-time performance.

Towards Low-datarate Communications for Cooperative Mobile Robots

Gaetano Patti, Giovanni Muscato, Nunzio Abbate and Lucia Lo Bello

ABSTRACT:

Communication networks for cooperative mobile robot applications have to cope with some peculiar requirements that make them quite different from typical MANETs or WSNs. Recent cooperative robot applications envisage the support of low datarate communication technologies, as this choice is beneficial in terms of energy consumption, weight reduction and integration with WSNs. In this context, this paper discusses the design choices behind a novel protocol for cooperating mobile robot applications that operates on low datarate networks and is able to provide bounded latencies, mobility and reliability.

15:00 - 15:30: Coffee break and Poster session 2

15:30 - 17:00: Session 5: Reliability and Safety

Minimizing Revalidation and Recertification in Evolutionary Embedded Systems

Waled Almakhawi and Roman Obermaisser

ABSTRACT:

Embedded systems have gained immense importance in various domains and they evolve rapidly driven by the necessity to cope with new emerging technologies and new required functionalities. The requirements of evolving embedded systems are subject to changes, thereby leading to repeated redesigns. In model-driven engineering the application's functional and nonfunctional requirements are specified separately from the underlying execution platform. Scheduling is the process of allocating the services of the application model onto the available resources of the platform model. Due to the continuous changes and updates in evolving embedded systems the rescheduling process becomes a critical challenge, because the output of scheduling can be significantly different even upon small changes. This avalanche effect leads to high effort and cost for recertification and revalidation. The contribution of this paper is a method for incremental scheduling, which minimizes the number of changed resource allocations while also satisfying the application's temporal constraints. The incremental scheduling is realized using Mixed Integer Linear Programming (MILP) and the IBM CPLEX optimizer. The presented results allow to reduce cost for recertification and revalidation compared to state-of-the-art scheduling methods.



Improving Safety Message Delivery through RSU's Coordination in Vehicular Networks Nuno Ferreira and José Fonseca

ABSTRACT:

Modern society lives surrounded by technology intended for enhancing human commodity, entertainment and safety. The use of novel technological solutions in transportation led to a relatively new field often called Intelligent Transportation Systems (ITS). Due to its highly dynamic nature, wireless communications are applied to implement vehicular communication systems. The concern of reducing road injuries/fatalities is of utmost importance, being nowadays a public health question. This led the development of vehicular communication standards focused in safetyrelated applications. These, demand typically low channel access delay with a welldefined upper bound, which is mainly addressed in the Medium Access Control (MAC) layer. This paper emphasizes some key points favoring the use of an infrastructural architecture with full Road Side Unit (RSU) coverage, presents an overview of the used time-slotted oriented MAC approach based on the Wireless Access in Vehicular Environment (WAVE) standard, addresses the issue of RSUs' coordination using beacons, and discusses the vehicle slot choice for the initial broadcast of safety-critical messages, in order to guarantee that they are timely delivered.

Scheduling feedback for scalability and reliability in a streaming multicast protocol

Julio Cano, Ana Pereira, Luis Oliveira and Luis Almeida

ABSTRACT:

The number of mobile devices accessing the Internet is continuously increasing, creating new problems. For example, when many wireless clients try to access the same video stream in the same hot spot, multicast transmission must be used. However, multicast packets are unconfirmed and present a high loss rate that may jeopardize the quality of the streaming. In a severe scenario, packet losses may affect all video frames, preventing the clients from receiving the video stream at all. Therefore, we propose a novel reliable multicast protocol, tailored to streaming applications, that also scales to many clients under the same access point. It uses a feedback repeat request mechanism per client and such requests are adequately scheduled by the streaming server. This mechanism, which is the focus of this paper, also allows differentiating the quality of service provided to the clients, polling their feedback independently. We show experimental and simulation results that confirm the desired scalability and reliable streaming, with efficient bandwidth usage. The results also show a clear superiority in mitigating lost packets with respect to other approaches to the same problem, with benefits reaching and even going beyond one order of magnitude in packets recovery.

17:00 - 17:30: Closing Session



Venue

The WFCS 2015 conference will take place on the campus of the University of the Balearic Islands (UIB). The UIB Campus is located 7.5 km north of the city of Palma, in the middle of a scenic landscape, and quite close to the "Serra de Tramuntana" mountain range.

More specifically, the talks will be held in the "Gaspar Melchor de Jovellanos" building:



Gaspar Melchor de Jovellanos Universitat de les Illes Balears. Cra. de Valldemossa, km 7.5. E-07122, Palma (Illes Balears), Spain

How to get from Palma downtown to the UIB campus

Depending on the location of your hotel you will find it more convenient to use either the metro or the bus.

Metro (subway)

Take line M1 which departs from Plaza España (marked as *Estació Intermodal* on ticket machines) and ends at the UIB campus. Travel time is 13 min. Ticket price is 1.60 EUR. Tickets can be purchased at the ticket machines located in the station hall (bills larger than 20 EUR are not accepted). Keep the ticket until the end, since it is needed to leave the station. When you exit the metro station you should walk to the *Gaspar Melchor de Jovellanos* building.

Bus

You can also take the bus line 19 (labelled as "Universitat") to go to the UIB campus (ticket price 1.50 EUR). This bus also stops at Plaza España. Bus frequency is about one every 15 minutes. Trip time is about 30 minutes. Tickets can be purchased from the bus driver (bills larger than 10 EUR are not accepted). Once you are on the UIB campus you should go out at the bus stop signaled as *Edifici Beatriu de Pinos* and then walk to the *Gaspar Melchor de Jovellanos* building.



Social Events

Wednesday, May 27th 18:30 – 22:00.

Guided Walk in Palma and Welcome Reception

At 18:30 at the Plaza Mayor, a walk through the historical part of Palma will start, which will be guided by professional guides. The walk will end at the restaurant on the terrace of the Es Baluard Museum at 20:00, where the welcome reception will take place. A finger-food dinner will be served. The address of the restaurant is:

ES BALUARD RESTAURANT & LOUNGE

Pl. Porta de Santa Catalina, 10 07012 Palma. Spain Phone: +34 871 234 954

Thursday, May 28th 18:00 – 00:00.

Conference Dinner

Two transportation choices will be offered. If enough participants are interested, a bus will leave at 18:00 from the conference venue to visit some landmarks in the north part of the island before going to the restaurant. For the other attendees, buses will depart from Palma (from a meeting point to be indicated during the conference) at 19:00 to go directly to the place of the dinner, La Granja in Esporles. Upon arrival a visit to the house and museum of Majorcan countryside traditions will take place. At 20:15 a cocktail will be served in the house terrace. Finally at 21:00 the dinner will start in the main dining room of the property. The address of La Granja is:

LA GRANJA DE ESPORLAS

Ctra Banyalbufar, KM 1.5 07190 Esporles (Mallorca). Spain Phone: +34 971 610 032



WFCS 2015

Places for WFCS 2015

Meeting point for the guided walk

Stop for bus 19 (to the venue)

Metro station (to venue)

Welcome reception (go inside the museum)

