WIRELESS COMMUNICATION FOR INDUSTRY 4.0

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Technologies
Adaptive and Reliable Communication Systems
Software-intense, embedded Systems

Markets
Automation
Automotive
Electricity Grids
Telecommunication

Facts & Figures 2014
Employees | 70
Location | Munich
Budget | 7.4 Mio. €
Presentation Outline

- Introduction
- Industry 4.0 example scenario
- Problem statement
- Solution approach: Cognitive Radio
- Cognitive Media Access Control
- Conclusions
Information and Communication Technology Trends: Increasing Degrees of Networking

- **1960s**: Mainframes (including terminals) with connectivity to peripherals
- **1980s**: PCs, Local Area Networks
- **1990s**: Notebooks, Wireless LAN, Embedded Systems
- **2000s**: Mobile devices, Networked sensors, Networked embedded systems
- **2020s**: Internet of things, Sensor networks, Cloud Computing, Smart Grid, Communication, Industry 4.0, Cyber physical systems
Introduction
Innovations through ICT Technologies

Personal Communication
- Smartphones with broadband access
- Mobile apps and services

Modern vehicles
- Software defined functions
- Assistance, Autonomous driving

Internet of Energy
- Smart Grids
- More renewable energies
Introduction
Characteristics and Impacts of Industry 4.0

Impacts: resource efficiency, shorter time-to-market, flexibility

Source: PWC Survey: “Opportunities and challenges of the industrial internet” 2014
Introduction
Motivation for Wireless in Industry 4.0

Advantage: Flexibility
- Fast installation
- Mobile devices
- Ad-hoc capability

Challenges
- Demands for reliability and realtime capabilities
- Physical characteristics of the wireless channel
- Different systems using the same transmission medium
Example: Wireless Production - Requirements

- Reliability
- Coexistence
- Infrastruktur / Cloud
- Störungen
- MES: Manufacturing Execution System
- ERP: Enterprise Resource Planning
- Realtime
- Flexibility

Example: Wireless Production
Different wireless systems in industry

- Physical transmission
  - ISM bands (for instance: 2.4 GHz, 5GHz, 868 MHz)
  - IEEE 802.11 (Wireless LAN)
  - IEEE 802.15.1 (Wireless PAN, Bluetooth)
  - IEEE 802.15.4 (Low Rate Wireless PAN)
- Industrial protocol stacks
  - PROFINET IO, IWLAN, WISA, Wireless HART, ZigBee

Challenges

- Different standards may use the same frequencies in same place at same time
- Spectrum usage is different
- Easy deployment of new systems
Wireless Coexistence Problem Statement

Wireless Coexistence
State of the art Approaches

- Definition (Wireless communication coexistence)
  „state, in which all wireless communication solutions of a plant using shared medium fulfill all their application communication requirements“

- Standards
  - Guideline VDI/VDE 2185: „Funkgestützte Kommunikation in der Automatisierungstechnik“ (in Germany)

- Approach
  - Consideration of three dimensions: Space, Time and Frequency
  - Future need: Automated validation of coexistence
Proposed Solution: Cognitive Radio

Objective

Increase of robustness and efficiency of wireless spectrum usage by adaptive methods

Spectrum Sensing

Spectrum Management

Adaptive selection of frequencies according to the application requirements

Spectrum Mobility

Spectrum Sharing

Intelligent multiple access of different wireless systems within one network

Objective

Increase of robustness and efficiency of wireless spectrum usage by adaptive methods
Proposed Solution: Cognitive Radio
Cognitive Radio Transmission System

Signal

Spectrum Sensing

Predicting Future

Channel Access Method

Efficient Use of Spectrum

Prediction: 00101000000
Transmitter: .......Wait.....1011
Time
Cognitive Radio MAC: CSMA/PCA

- Replacement of existing exponential backoff by a sensing and prediction algorithm
- A master node predicts frequency whitespaces and broadcasts reservations over a control channel

Source: Saad, Ahmad; Staehle, Barbara; Chen, Yun: On the Effectiveness of Medium Access with Predictive Collision Avoidance. 19th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA 2014)
Cognitive Radio MAC Algorithmus - Validation

- Simulation of CSMA/PCA with
  - IEEE 802.15.4 MAC-parameters
  - Different prediction error probability (PFA)
  - Background traffic: Poisson, Rate $\lambda$
  - Packet size: Random uniform (200-1000 symbols, symbol duration $T_S$)

- Metrics:
  - Probability of successful media access
  - Spectrum utilization
Project CAROUSAL – Cognitive Radio Prototype

**CAROUSAL:** Cognitive Radio-ARchitektur basierend auf Optimierten Zeit-Frequenz-SignAldarstellungen

- CR-Prototype for industrial applications
- Application example: Wireless PROFIBUS tunnel
- Master-Slave architecture
- Cognitive Radio
  - Adaptive MAC (ESK)
  - Adaptive PHY
    - (Uni Kassel, Uni Duisburg)
Conclusions

- Different Industry4.0 applications are based on wireless
- Coexistence of wireless transmission systems
- Cognitive Radio as an approach for industrial wireless systems
- Ongoing research for cognitive MAC-protocols
- CAROUSAL: HW/SW realization of a cognitive radio system
THANK YOU VERY MUCH!

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