Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: [Overview of IG-DEP Activities on Enhanced Dependability in Wireless Networks for Automotive and Medical Healthccare Use Cases]

Date Submitted: [10 July, 2018]

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Abstract: [IG-DEP has been working to make a new standard on enhanced dependability of wireless networks such as M2M and BAN because demand for ultra reliable or dependable wireless sensing and controlling machines in cars, robotics, buildings, and other uses as well as medical uses. After long discussion, we primarily focus on automotive use cases. Specifications of MAC and PHY for dependable networks for more reliable, secure, fault tolerant, robust against undesired factors than current opportunistic consumer electronics wireless networks.]

Purpose: [This slides may overview activities of IG-DEP to get more participants in this group to make a new standard.]

Overview of IG-DEP Activities on Enhanced Dependability in Wireless Networks for Automotive and Other Use Cases

San Diego, CA, USA

10th July, 2018

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Agenda

1. Short Summary of IG-DEP Activities
2. Review of Previous Meetings
3. Definition of Dependability in Wireless Networks
4. Use Cases and Applications of Dependable Wireless
5. Theories and Technologies for Dependability
6. Related Activities
7. Action Plan

1. Short Summary of IG-DEP Activities

- IG-DEP started July 2012 but has been discussing on major use cases and applications and leads definition and requirement different from IEEE802.15.6 BAN to make a new standard.
- After IG-DEP called for interest(CFI), responses for CFI have been summarized to choose focused applications.
- Finally IG-DEP focuses on automotive use cases primarily according to demands of car manufactures and car electronics companies.
- IG-DEP has been summarizing technical requirement and preparing for PAR and CSD.
- In order to show up demand of car manufactures and electronics, IG-DEP is preparing for tutorial session at July meeting in Berlin.
- ITU-R has covered M2M in SG11 and others.
- IG-DEP requests IEEE802.15 TG-SRU, 802.24 and 802.11 to commit this activities.

2. Discussion Items in Previous Meetings(1/2)

1. Whether to go for M2M or BAN amendment is still under consideration. Depends on participant interests.
2. How to detect and control effect of device hardware failure?
   - Hardware fault tolerance in devices.
   - How to attain protocol fault tolerance?
3. Dedicated band would solve interference issues.
   - Amount of band available will constrict useable applications.
4. Dependability means the device will certainly work for a specified period.
   - It may work longer, but dependability is not guaranteed anymore.
5. Car control electronics may be too sensitive for wireless acceptance, but auxiliary electronics like entertainment, etc. would greatly benefit from wireless dependable technologies.
   - The systems would be a one whole set however.
6. Mass market may offset additional cost of reconfigurable and reliable technology.

2. Discussion Items in Previous Meetings(2/2)

To pursue dependability in network may be possible to go beyond IEEE802.15scope.

Document (doc #440r0) on techniques for dependability at communications layers.

Approach by layers: Management layer at the side with hooks to other layers.

(1) Application Layer: Quote from Hawaii session: “Collect trending retransmissions and other info to prevent failures.”

(2) Link Layer:

• Quote from Hawaii session: “MAC layer error may be able to correct by adaptation to guarantee delay specification (e.g. to switch to fragmentation, change to lower coding rate, change back-off window, change number of retransmission attempts, cooperate with other MACs to create virtual MIMO, use L2R), rather than incur delay by going to Apps layer.”

(3) Physical Layer:

• Quote from Hawaii session: “MIMO and multipath are friends of dependability with PHY layer redundant links.”

• Quote from Hawaii session: “PHY layer can be adaptable to environment, by switching frequency particularly, if you are in a null.”

• Quote from Hawaii session: “PHY layer error may be able to correct by adaptation (switch to a better antenna) to guarantee delay specification rather than incur delay by going to Apps layer.”

3. Dependablity in Wireless Networks

- **Meanings of Dependability:**
  - **For us, "Dependability in network" means to guarantee lowest performance enough high in a sense of highly reliable, safe, secure, fault tolerant, robust services in any predictable and even unpredictable worse environments.**

- **Demand for Dependable Networks:**
  - Need for **Highly Reliable, Robust Communications for Controlling**
  - Transition from Human centric communications **to Machine-to-Machine (M2M) communications.**
  - Highly reliable, safe, secure and robust communications for **M2M Controlling** is necessary.
  - **Integrated wired & wireless networks** provide dependable, green and ecological networks adaptable for environment.

4. Focused Use Cases and Applications

- Application Matrix Discussion: Participants are requested to send their envisioned use cases to start formulating the application matrix.
- So far Identified use cases are: Refer to Table ‘Use Cases’ in doc #412r2
- Use Cases
  - Medical
  - Car
  - Factory automation
  - Disaster prevention
  - Indoor positioning
  - Energy flow control
  - Building and smart city management
  - Public safety
  - Personal information space
  - Government information

doc. : IEEE 802.15-14-0163-00-0dep

Use Cases and Possible Technologies for Dependable Wireless M2M and BAN

17th March, 2014 Beijing

Ryuji Kohno*[1,2,3], Jussi Haapola*[2,3]

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*3 University of Oulu Research Institute Japan CWC-Nippon

Proposed applications

1. Remote healthcare monitoring
2. Remote sensing and controlling
3. Vehicle internal sensing and controlling
4. Collision avoidance radar
5. Inter-vehicle communications and ranging
6. Wearable and implant wireless medical sensing and controlling
7. Applications for ultra wideband radio
8. Reliable and robust radio control
9. Wearable healthcare sensing
10. Secure remote healthcare and medicine
11. Wireless sensing system for Factory with feedback control
12. Dependable multi-hop inter-vehicle communications
13. Inter-navigation and inter-vehicle information sharing in normal and emergency conditions
14. Single wireless communication network solution that functions both in normal and in disaster environments
15. Disaster prevention, emergency rescue and recovery

doc. : IEEE 802.15-16-0111-00-0dep

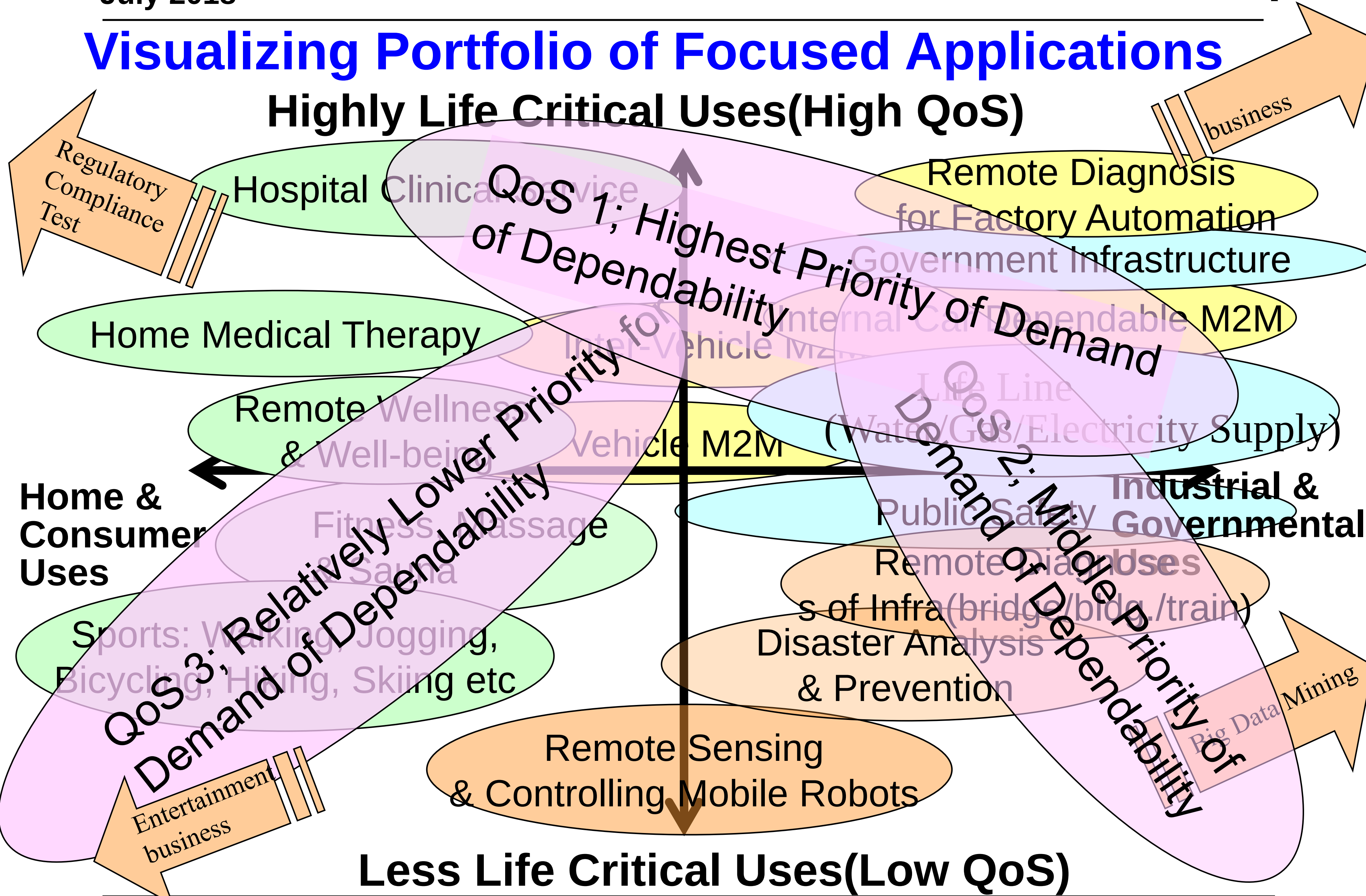
IEEE 802.15 IG DEP

Scope and Focused Applications with Different QoS Levels

Ryuji Kohno
(Yokohama National University/CWC-Nippon Co.)

Atlanta, GA, USA
January 20th, 2016

Visualizing Portfolio of Focused Applications



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Three Classes of Focused Potential Applications

We have classified focused potential applications into three classes according to demands of dependability.

QoS 1 Class: Highest Priority Level for Demand of Dependability

1.1 **Car Internal M2M**
1.3 **Remote Diagnosis in Factory**
2.3 **Professional Medicine**
3.2 **Public Safety**

QoS 2 Class: Meddle Priority Level for Demand of Dependability

1,2 Inter-vehicle M2M
2.2 Healthcare
3.1 Life Line (Water/Gas/Electricity Supply)
4.1 Remote Diagnosis of Infra(bridge/bldg./train)

QoS 3 Class: Low Priority Level for Demand of Dependability

2.1 Wellness, Wellbeing
3.3 Government System
4.2 Remote Sensing and Controlling Mobile Robots
4.3 Disaster Analysis and Prevention

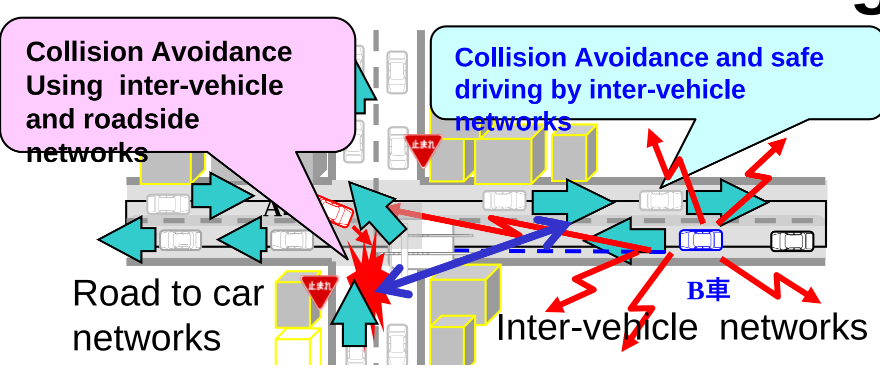
(Case 6) **Would a good wireless solution benefit your application?**

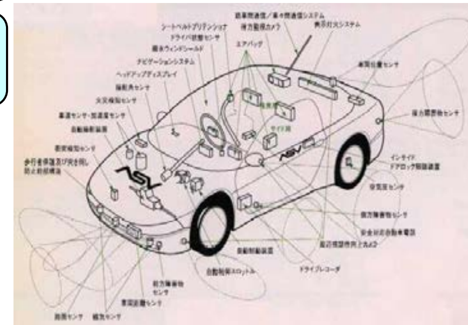
If yes, please describe the benefits you would like to realize

Wireless sensing and controlling system for Factory

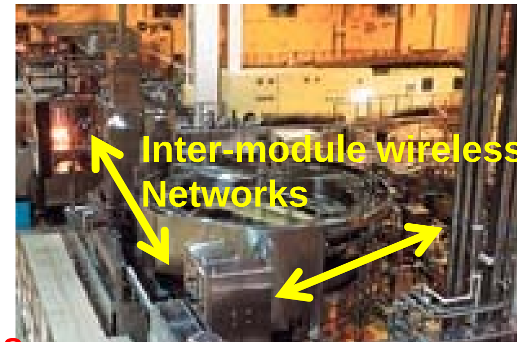
1. Equipment Diagnosis System in Real-time with real-time feedback
    1. Real-time measuring
    2. Judge immediately with a certain threshold level
    3. Feedback controlling
2. Equipment Diagnosis System in Real-time (1)
    1. Real-time measuring and sending data in real-time
    2. Judge based on the comparison with the past data
    3. Analysis of big data
    4. Feedback controlling machines in remote
3. Equipment Diagnosis System in Real-time (2)
    1. Real-time measuring and sending data intermittently
    2. Judge based on the comparison with the past data
    3. Database and data mining with cloud networking

Possible Use Cases of Dependable M2M and BAN for Sensing and Controlling





Car LAN & Wireless Harness



Factory Automation (FA)

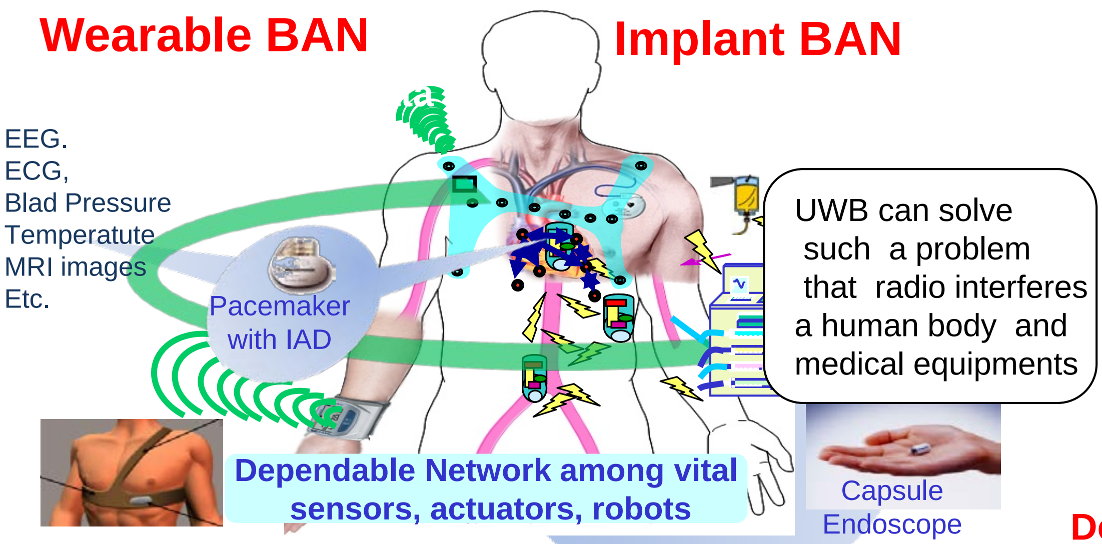
Car Navigation & Collision Avoidance Radar

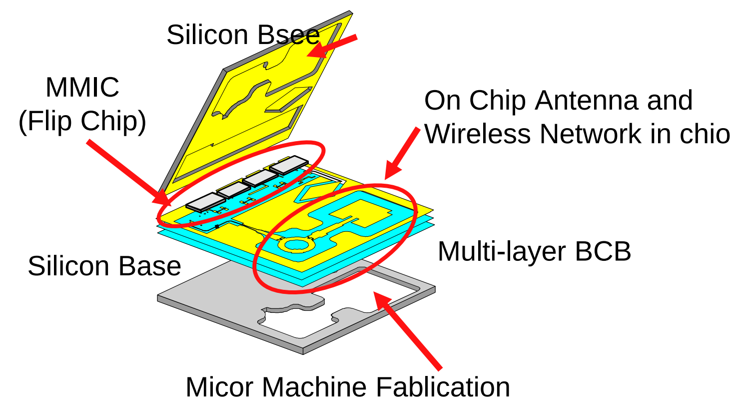
Dependable Wireless Networks for Transportation

Dependable Wireless Sensing Controlling for Manufacturing (CIM)

Wearable BAN

Implant BAN

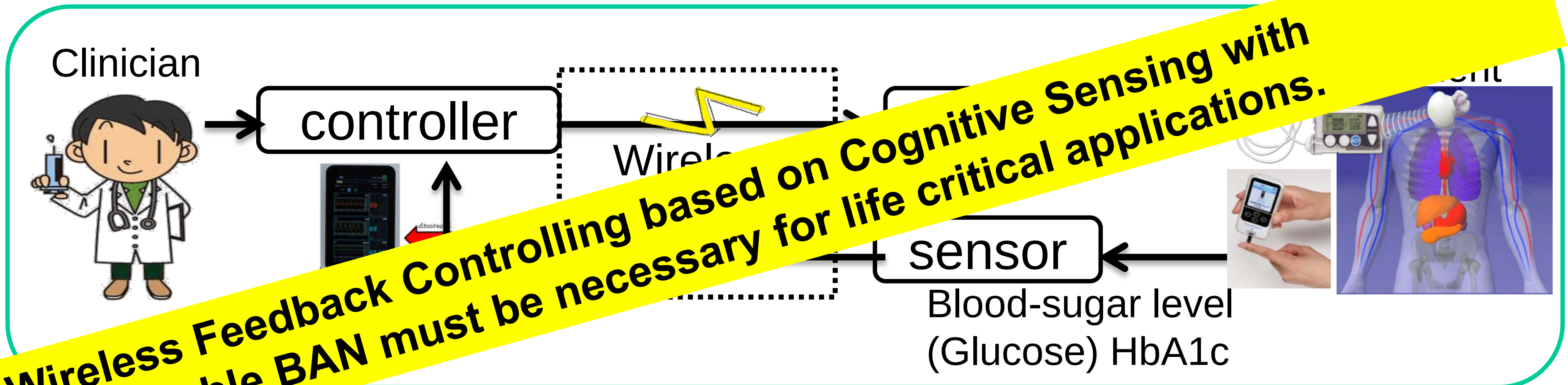




Dependable Wireless System Clock in Micro Circuit & Network in Devices

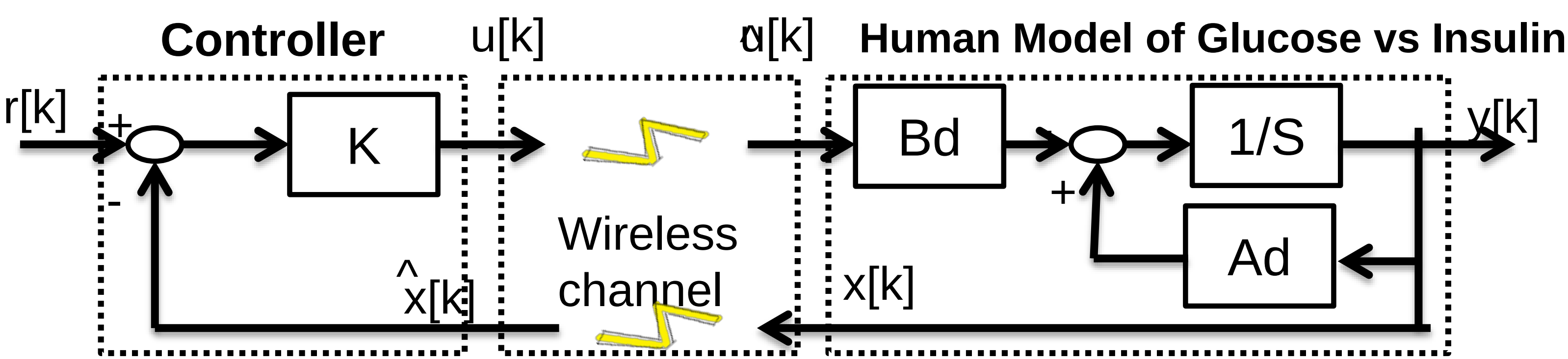
Dependable BAN for Medical Healthcare

Automatic Remote Sensing Glucose and Controlling Insulin Pump for Diabetes Patients Using Wireless BAN



Wireless Feedback Controlling based on Cognitive Sensing with Dependable BAN must be necessary for life critical applications.

Feedback Sensing and Controlling Loop for Diabetes Patients



Feedback Delay Loop Model with Motion Equation

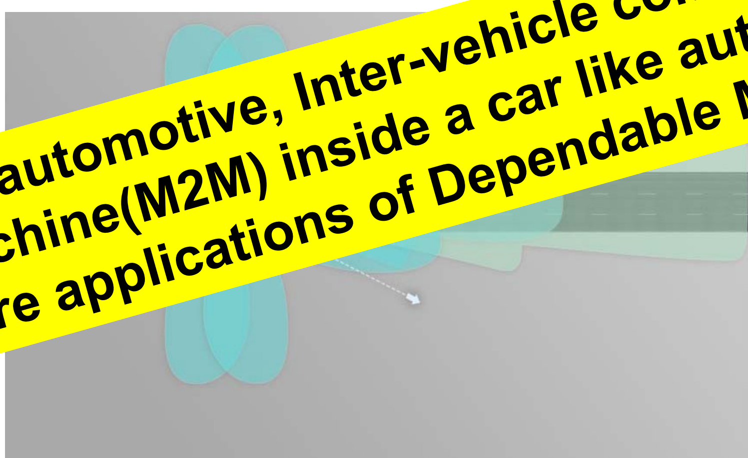
Ryuji Kohno(YNU, CWC, CWC-Nippon), Jussi Haapola(CWC)

Dependable IoT/M2M for Advanced Driver Assistance Systems(1/2)

- 4-6 Mono Cameras
- 1-2 Stereo Cameras
- 2-4 Mid-Range Radar
- 2 Long Range Radar
- 8-16 Ultrasonic Sensors, 4 Wheel Speed Sensors
- Redundant Data Center
  - Number Crunchers for Data Fusion
  - ABS, ESP, …
  - Some ECUs we can't tell you details today ☺
- Interaction with Powertrain, Body Domain, Navigation, Airbag, CAR2CAR, CAR2Infrastructure

…the Research Labs.
…ass production.

For automotive, Inter-vehicle communications(IVC) and Machine-to-Machine(M2M) inside a car like auto braking and autonomous driving must be core applications of Dependable M2M and IoT.



Surround vision with redundant sensors

…es this look familiar to data centers?

Dependable IoT/M2M for Advanced Driver Assistance Systems(2/2)

Demands for Internet of Things increase but Machine-to-Machine (M2M) should be reliable and secure, so Dependable BAN for Medicine must be good matched with Dependable M2M and IoT.

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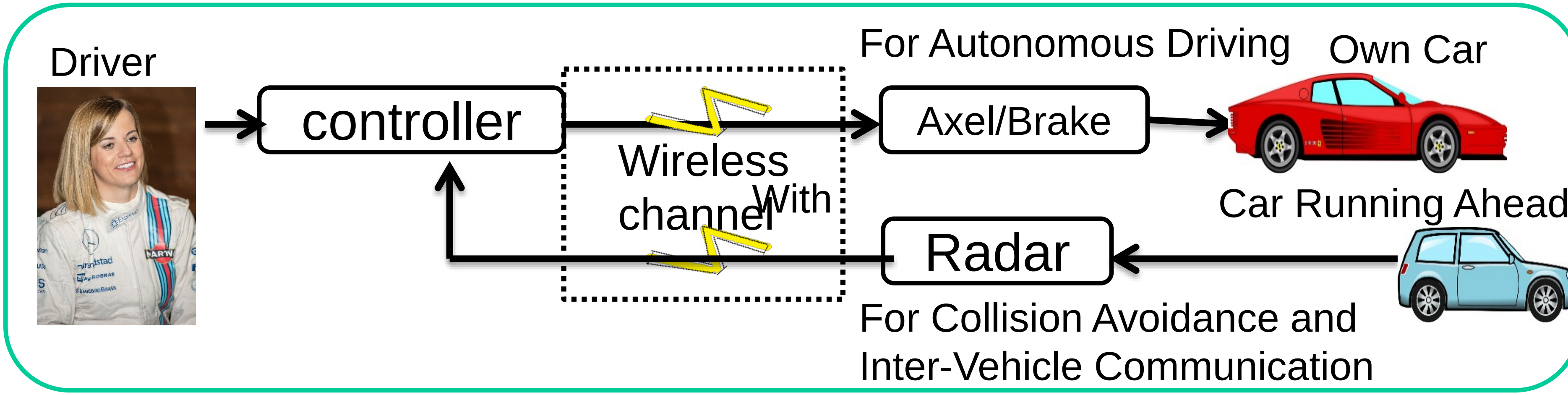
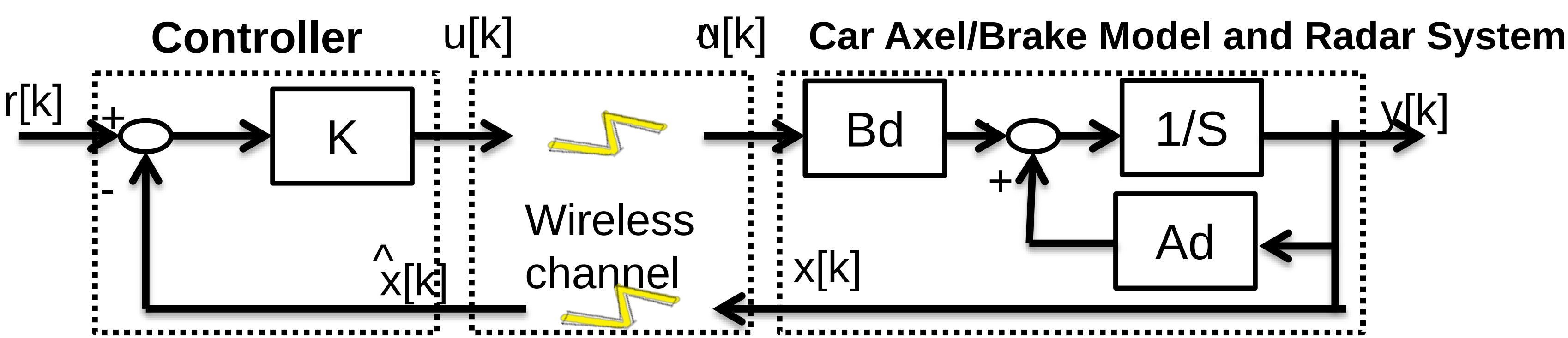
Jussi Haapola(CWC)

Collision Avoidance Radar and Automatic Braking Using Wireless Dependable M2M/BAN



Wireless Feedback Sensing and Controlling Loop for Autonomous Driving



Feedback Delay Loop Model with Motion Equation

Ryuji Kohno(YNU, CWC, CWC-Nippon), Jussi Haapola(CWC)

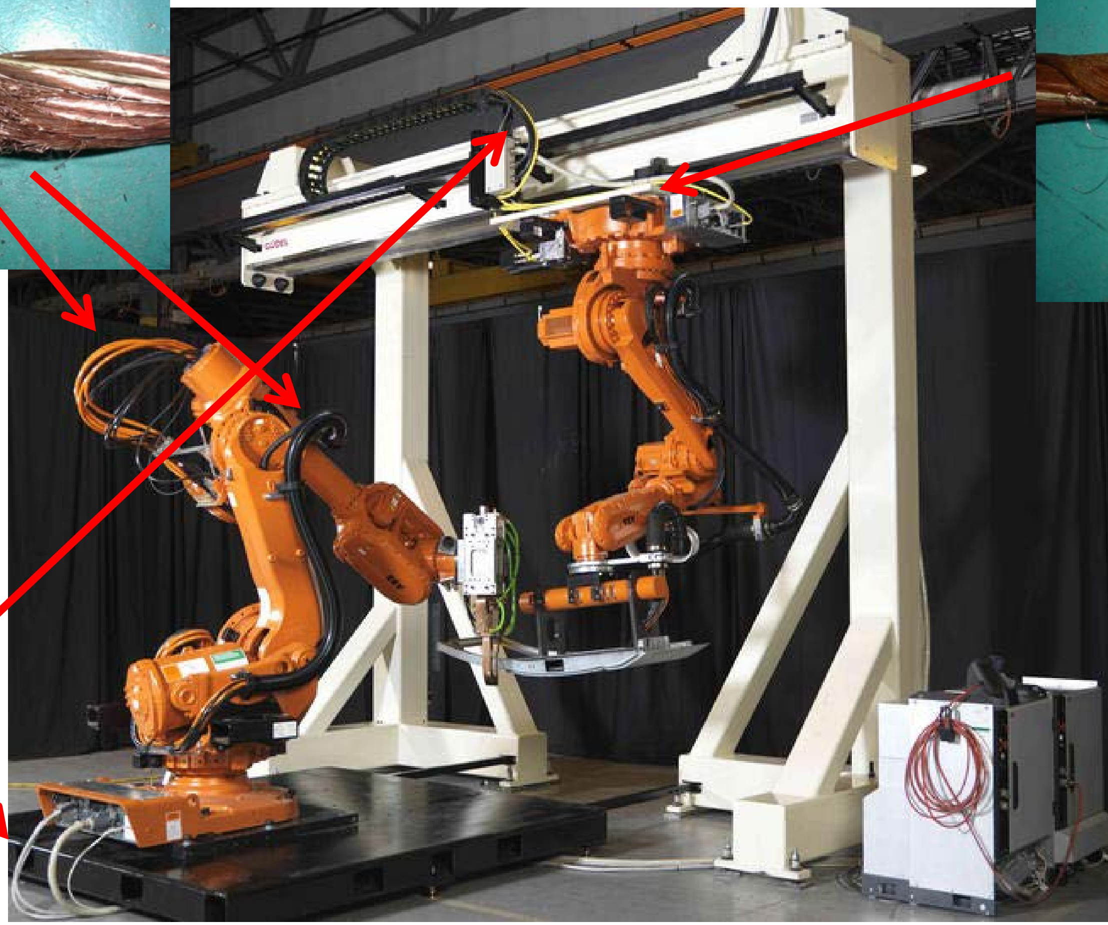
Response to CFI: Case 6

Hiroshi Kobayashi, Nissan Automotive Co. Ltd.

Update in Development of Wireless Sensing System for Factory

Doc.:IEEE802-15-15-0221-01-0dep
IEEE802-15-15-0711-00-0dep
IEEE802-15-15-0711-01-0dep
IEEE802-15-16-0077-00-0dep
IEEE802-15-17-0398-00-0dep

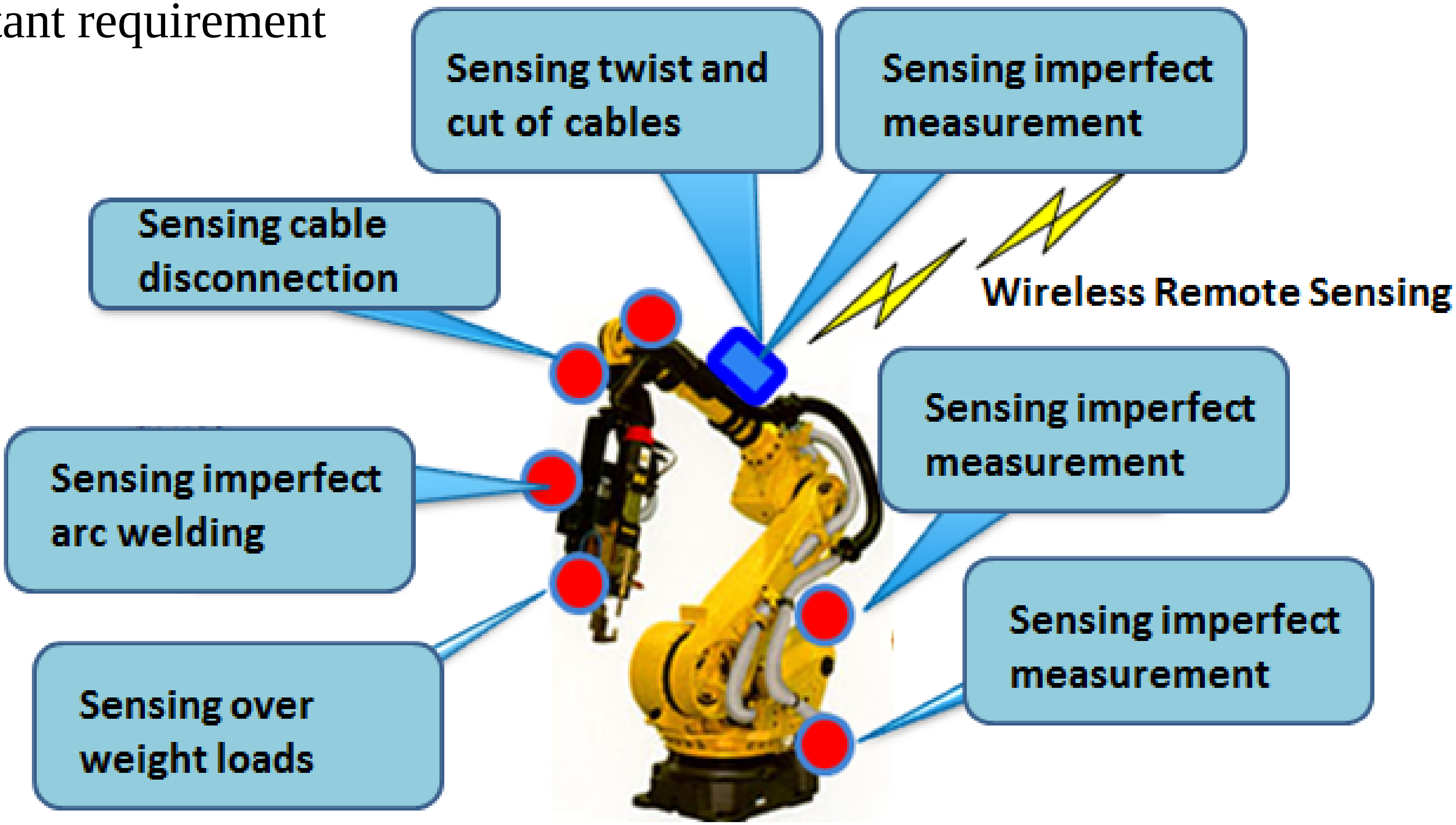
Use case 2; Detection of Twist and Cut of Cables



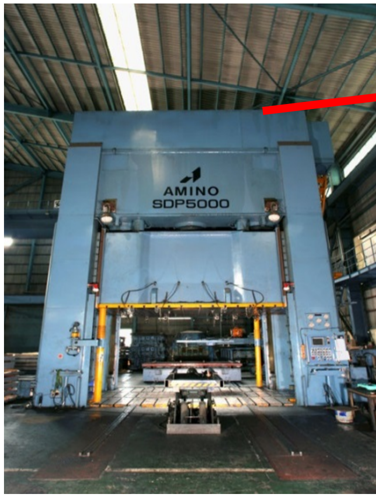
Prediction and Real-time Detection of twist and cut in signal and power cables

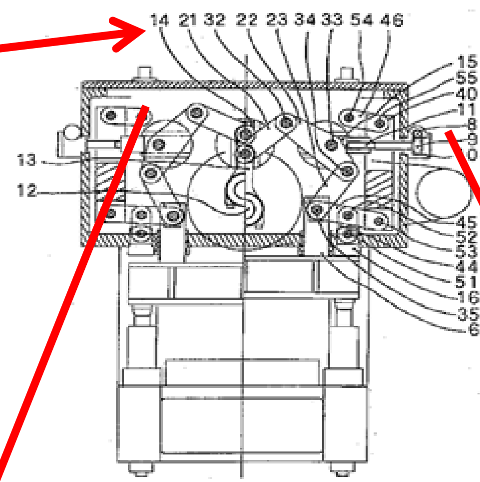
Use case 3; Real-time Monitoring or/and Controlling Robots

In order to improve QoS of controlling robots in factory lines, real-time sensing and controlling with permissible feedback control loop must be important requirement



Use case 1; Detection of Cracks in Press Machine





Prediction of cracks and any damages in press machines is keen to keep stable operation of lines in factory automation.

5. Theory and Technology for Dependable Network: Interdisciplinary Works between Controlling Theory and Communication Theory

1. A transceiver has to know the aim of controlling.
2. Controlling theory describe the action by mathematical form for the aim.
3. Conventional controlling theory does not care of transmission errors in a wireless channel but focus on stability of controlling.
4. Conventional communication theory or information theory does focus on transmission errors but does not care of different importance or priority of each information segment.

We need to combine Controlling Theory and Communication Theory for Dependable Wireless Controlling or M2M.

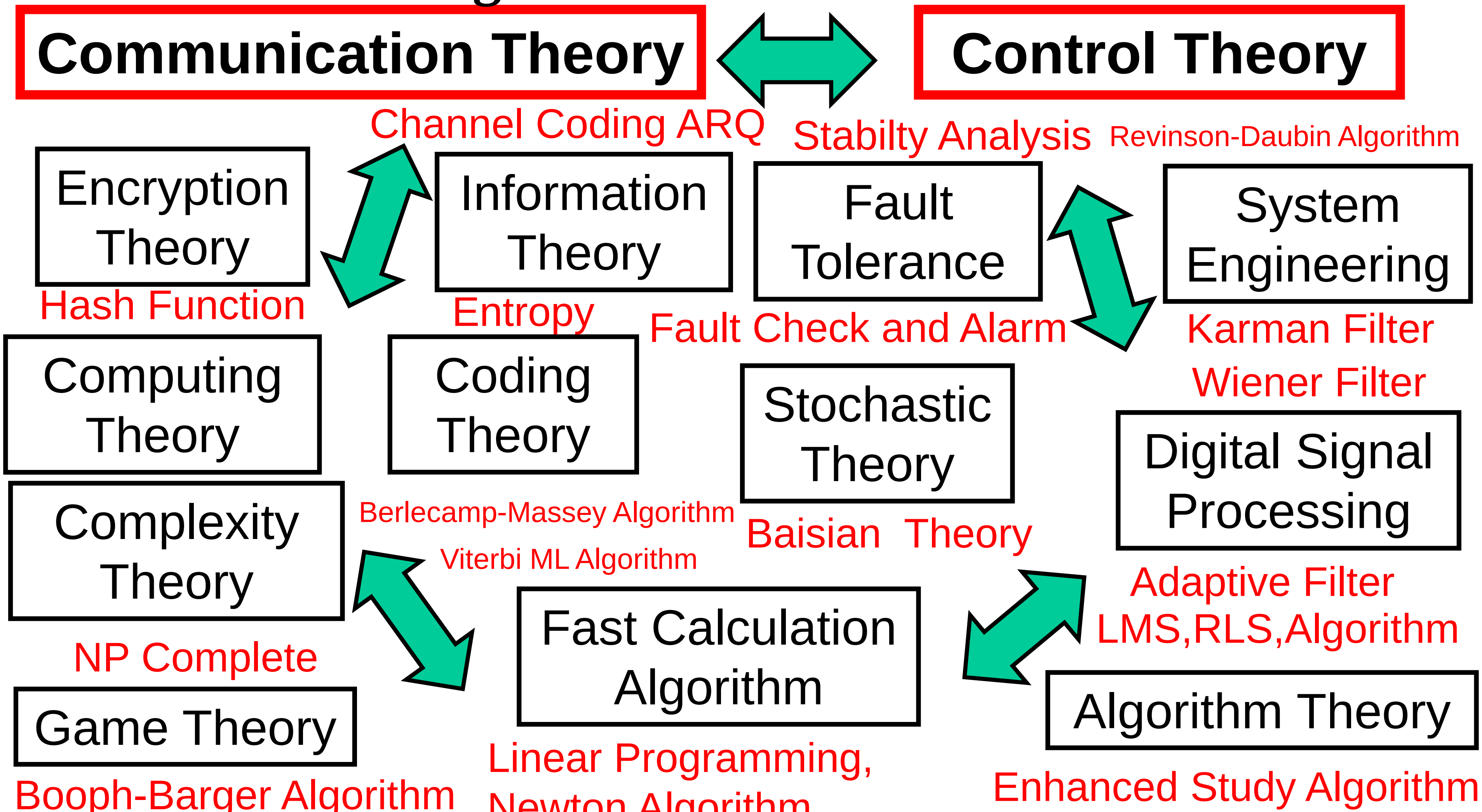
5.1 Research Subjects of Dependable Wireless

（１） Although conventional controlling theory does not care of errors in a link or a channel, a new controlling theory will be established in a case of assuming channel errors in a controlling link or network. A new communication theory for M2M controlling should be established to achieve much more reliable, secure, robust against errors, or dependable connection.

（2） Common theories and algorithms between controlling and communication theories will be established. For instance, Levinson-Darvin algorithm in linear prediction has commonality with Barlecamp-Massy algorithm of coding theory.

（3) Dependable wireless M2M may promote a new global trend of R&D and business in wide variety of industries, car, energy, communications, finance, construction, medicine in a world.

5.2 Common Themes and Algorithms between Controlling and Communication Theories



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5.3 Basic Technical Requirements

- After defining dependability in network, we need to find reasonable technologies to satisfy requirements.
- **Application Layers:**
  - Information Security: Encryption and Authentication
- **Network Layers:**
  - Redundant Routing: Parallel, Relay or Multi-hop, Network Coding etc.
- **Date Link & MAC Layers:**
  - Non-opportunistic and reliable, secure MAC
- **Physical Layers:**
  - Diversity technologies in time, frequency and space domains
  - Channel coding for error-controlling, Hybrid ARQ, Space-Time Coding etc.

5.4 PHY Technologies for Dependable Wireless

1. **Spread Spectrum (CDMA, Radar)**
2. **Adaptive Array Antenna(Smart Antenna, MIMO, Space-Time Coding, Collaborating Beamforming)**
3. **Diversity** (Space, Time, and Frequency Domains)
4. **Multi-band, Multi-Carrier(OFDM), Multi-Code**
5. **Coding(Turbo Coding and Decoding, LDPC, Space-Time Coding, Network Coding)**
6. **Software Reconfigurable Radio （SDR:Software Defined Radio), E2R(End-to-End Reconfigurability),**
7. **Cognitive Radio & Network**
8. **Ultra WideBand (UWB) Radio**
9. **Collaborative Communications and Sensing**

5.5 Physical Layer Technologies Satisfying Multiple Demands for Dependable M2M and BAN

(1) **Countermeasure techniques against fading Interference from other systems in a body area**
: Equalization, Diversity, Coding, Antenna etc.

(2) **Positioning・Ranging＝Position recognition in Implanted Devices**：Radar, Navigation, Roaming

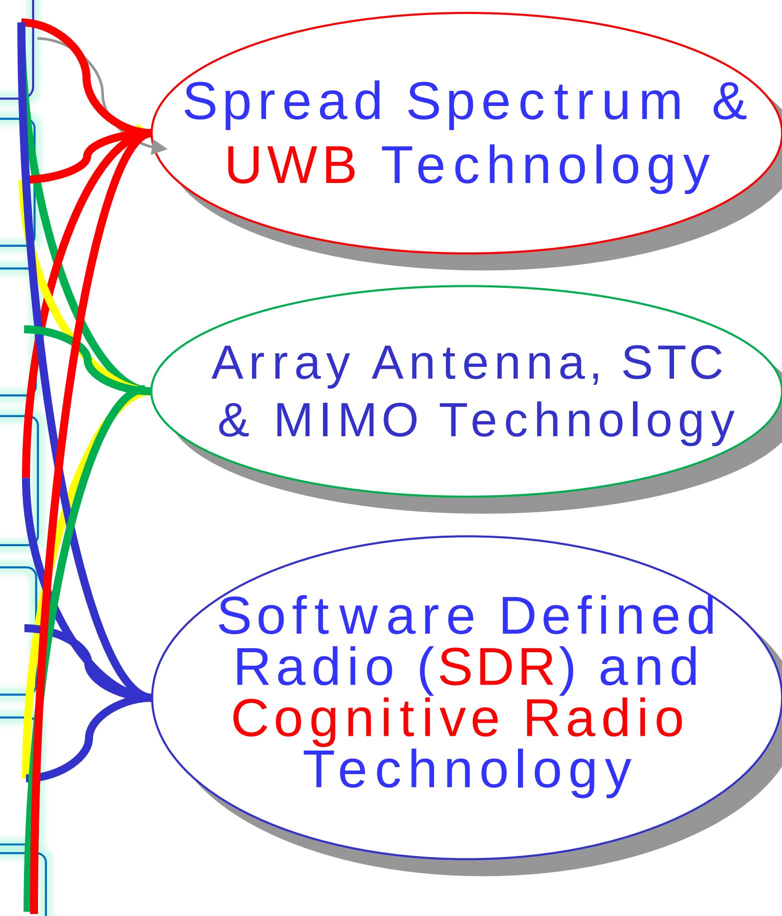
(3) **Awareness and Control＝Inside body sensing**
: Observation of environment, Sensor, Adaptive control

(4) **Security＝Authentication・Privacy for vital**
: Charge information, Privacy protection, terror measure

(5) **Reconfigure＝Changing operation・Fault searching**: Changing to new technology, Fault maintenance

(6) **Antenna and Diversity**
: Securing of good wireless communication environment

(７) **Low power consumption＝Long operable time**
Implementation of low power consumption and high quality



5.6 Communication Technologies in each Layer for Dependable M2M and BAN

Application layer	Control algorithm
Network (NWK) layer	Scheduling (packet order control) Routing (route control)
Medium access control (MAC) layer	Time slot control (TDMA) Frequency control (FDMA) Contention window control (CSMA)
Physical (PHY) layer	Transmit power control Modulation level control Coding rate control

5.7 Higher Layers Technologies for Dependable M2M and BAN

1. **Contention Free Protocol in MAC** (TDMA, Polling, Hybrid CFP & CAP etc)
2. **ARQ and Hybrid ARQ in Data Link** (Type I, II) combination of transmission and storage(buffering)
3. **Parallel Routing** (Risk Diversity) and **Network Coding** in network architecture
4. **Fault Tolerant Network** (Redundant Link and Parallel Hopping) and **Cognitive Networking**
5. **Encryption and Authentication in Application Layer** (AES, Camellia, Secret Sharing)

5.8 Cross Layer & Multi-Layer Optimization for Dependable M2M and BAN

Dependable Wireless with Less Power Consumption & Robustness

Application Layer： Information Security(Encryption and Authentication, User Friendly Interface ・・・

Network Layer： Integrated Wired & Wireless Network Architecture, Network Security(IP SEC) ・・・

Data Link & MAC Layer： Priority Access Control, Fault Tolerant Routing, ARQ, Hybrid ARQ, Distributed Resource Management, ・・・

Physical Layer： Cognitive, Reconfigurable, Adaptive, Robust Radio, Error-Controlling Coding, Space-Time Diversity, Equalization, Coded Modulation, ・・・

Device/ Electronics Layer: Tamper Free Hardware, Robust Packaging, SoC, SOP, On-chip CODEC for channel Coding and Encryption ・・

Joint Optimization of Multi Layers

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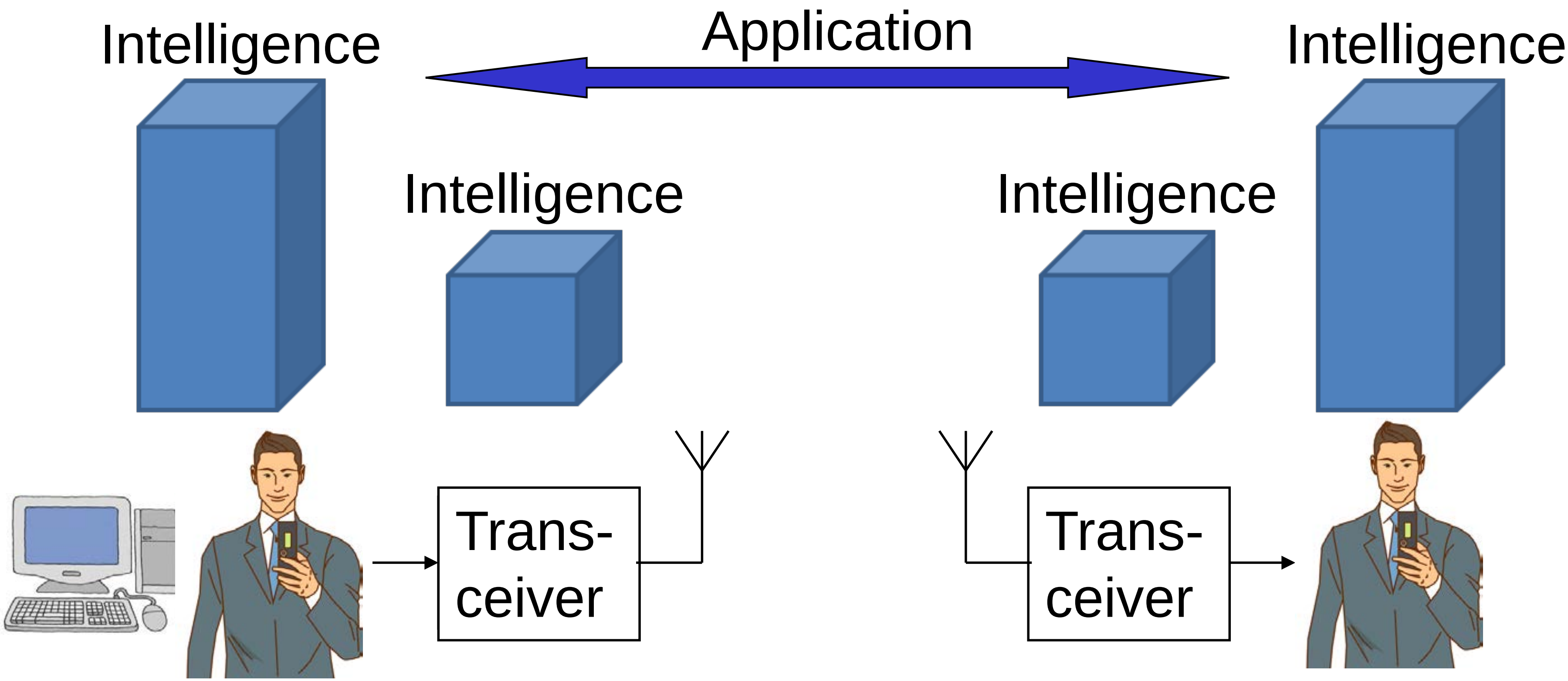
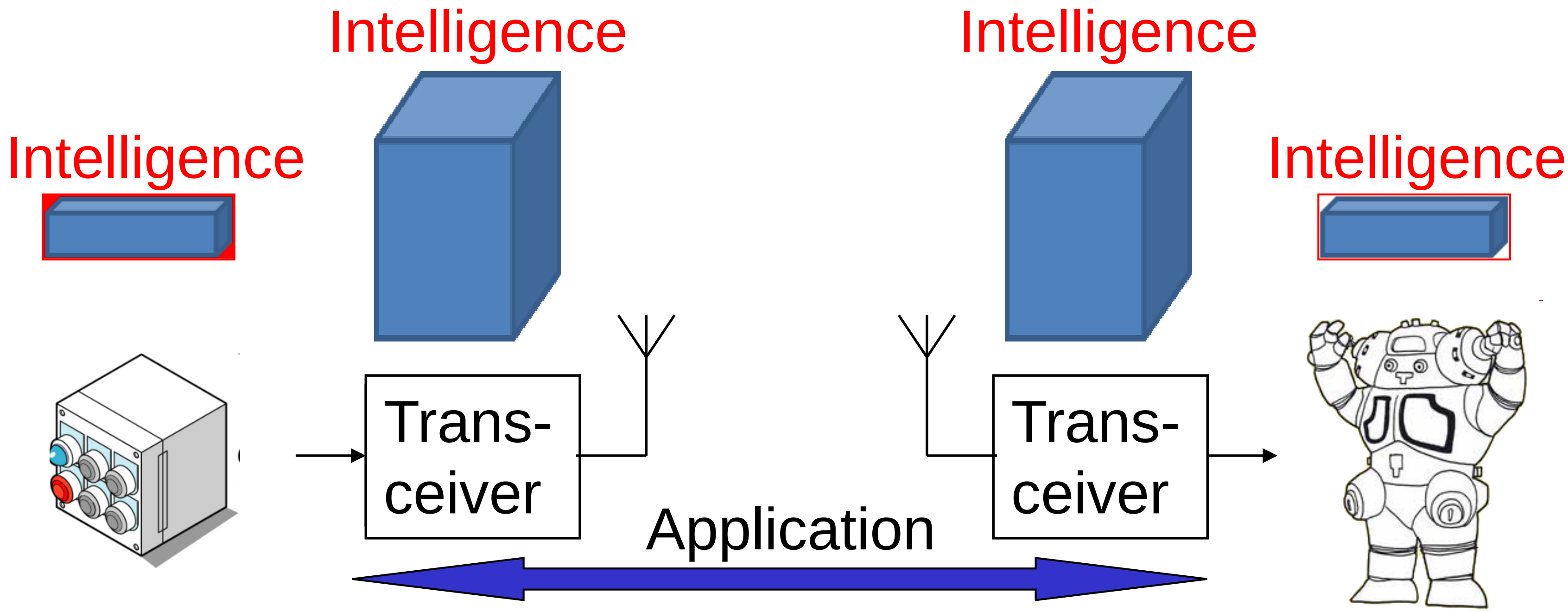
M2M Controlling Communication Different from Usual Human-Base Communication



Transceiver has no need/intelligence to understand the meaning of the application in a usual Human-base communications.

M2M Controlling Communication Different from Usual Human-base Communication



Dependable Wireless M2M communications for controlling needs intelligence to understand the aim and the meaning of the application between Source and Destination.

Cognitive Radio or Beyond Cognitive Radio

Establishment of IEICE Study Group & Committee on Dependable Wireless

IEICE EES Society, May 2010

Aim of This Study Group

- Promote R&D and business in an interdisciplinary field between controlling and communications.
- Create new ICT theories and technologies for dependable wireless not assuming intelligence of nodes unlike human communications in an usual communications.
- Create new controlling theories and technologies for dependable control assuming errors in M2M and controlling network.
- Promote researching activities in multi-disciplinary fields among fault tolerance, information security, artificial intelligence, and related fields around communication and controlling theories.
- Promote business activities in wide variety of industries such as medical healthcare, transportation, smart grid of energy, disaster prevention, public safety, emergency rescue, factory automation, building construction etc.

Automotive use cases

- Wireless intra-vehicle communications (car bus supplement)
- Wireless inter-vehicle (V2V) and vehicle to infrastructure communications (V2I)
- Remote sensing and control in factory

Summary of Requirements

- Number of sensors: few tens to hundreds per network
- Support for multiple network co-existence & interoperability: few tens of networks
- Types of topologies: star, mesh, inter-connected networks
- Data rate requirement: up to 2 Mbps per sensor
- Latency in normal operation: 250 ms to 1 s
- Latency in critical situation: few ms to 15 ms
- Aggregate data rate per network: up to 1 Gbps (in some applications) / few Mbps (in others)
- Delivery ratio requirement: >99.9 % (in some applications) / > 99 % (in others)
- Disconnection ratio < 0.01 % (of time)
- Synchronization recovery time: < 100 ms
- Coverage range: up to 1000 m (in some applications) / 20 m (in others)
- Feedback loop response time: less than 1 s (10 ms In collision avoidance radar)

Summary of Requirements (cont.)

- Handover capability: seamless between BANs and/or PANs, walking speed, 2 seconds
- Transceiver power consumption: SotA acceptable
- Module size: wearable for hospital use, maximum size 5 cm x 2 cm x 1 cm for automotive
- Module weight: < 50 g for hospital, < 10 g for automotive & body
- Data packet sizes (typical, maximum):
    - Hospital: 100 bytes, 1000 bytes
    - Automotive: 10 bytes, 1000 bytes
    - Compatibility with CAN and RIM buses for intra-vehicle
- Security considerations: Handover peers need to have trust relationship. High confidentiality and privacy requirements in hospital environment. Lifecycle management.
- Sensor lifetime: minimum 1 year, up to equipment lifetime
- Jitter: < 50 ms in regular case, < 5 ms in critical situations. 5 % outliers acceptable.

Summary of Requirements (cont.)

- Interference models:
  - Intra network interference (MAC&PHY specification dependent)
  - Inter-network interference (take a look at literature, coexistence statements)
- Channel models:
  - in intra-vehicle (needs to be measured),
  - inter-vehicle (exists in literature),
  - in factory (partially exists in literature),
  - in hospital (exist in literature),
  - in emergency rescue field (exists?)
- Any other?

Technical Requirements

	Car bus supplement	V2V	V2I	Factory automation	Reference standard 802.15.6
Number of sensors	Up to ten per network	Up to Few tens	Less than ten	Up to ten per network	256
Support for multiple network co-existence & interoperability	Less than 100	Up to Few tens	Less than 50	Up to 100	0
Topology	Extended star	mesh	Star	Star + bus	(extended) star+one hop
Data rate	Comparable to CAN, RIM or FlexRay	Up to 2 Mbps/vehicle	Up to 2 Mbps/sensor	2 Mbps/sensor	1 Mbps (mandatory rate)
Aggregate data rate over interoperating networks	Few hundred Mbps	Few hundred Mbps	Few hundred Mbps	Up to 1 Gbps	N/A

Technical Requirements (cont.)

	Car bus supplement	V2V	V2I	Factory automation	Reference standard 802.15.6
Latency in normal operation	Comparable to CAN, RIM or Flex Ray	250 ms to 1 s	250 ms to 1 s	250 ms to 1 s Ref.802.15.4e for probabilistic case	Typical 50 to 100 ms Ref. 15.4e
Latency in critical situation	Comparable to CAN, RIM or Flex Ray	100 ms	100 ms	Few ms to 15 ms Ref.802.15.4e for deterministic case	Less than typical case
Association delay	N/A	Pending	Pending	N/A	Less than 1 s Optional requirement
Authentication and security delay	N/A	Pending	Pending	N/A	Seconds Optional requirement

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Technical Requirements (cont.)

	Car bus suppleme nt	V2V	V2I	Factory automation	Reference standard 802.15.6
Delivery ratio requirement	> 99.9%	> 99.9%	> 99%	> 99%	95%
Disconnection ratio (of time)	< 0.01%	Pending	Pending	< 0.01%	?
Synchronizati on recovery time	< 100 ms	< 100 ms	N/A	< 100 ms	seconds
Coverage range	6 m	200 m (highway)	Pending	5 m	< 10 m
Feedback loop response time	< 10 ms	< 1 s	N/A	< 1 s	< 500 ms

Technical Requirements (cont.)

	Car bus supplement	V2V	V2I	Factory automation	Reference standard 802.15.6
Handover capability	N/A According to verosity	Pending (according to desity and relative spped)	< 500 ms (according to car verocity)	< 2 s(? must be shorter)	N/A Need interview of car manufactures
Data packet size	CAN and RIM compatibility	Pending	Pending	10 to 1000 bytes	Up to 255 octets
Jitter: typical max	5 ms	N/A	N/A	50 ms	QoS dependent
Jitter: critical max: 5% outliers acceptable	5 ms	N/A	N/A	5 ms	QoS dependent

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Technical Requirements (cont.)

	Car bus supplement	V2V	V2I	Factory automation	Reference standard 802.15.6
Interference models (A) Intra network interference	Driver/Passengers room: <10	<50 according to a car cruster	<20 according to a car cruster	<50 according to a coverage range	By a few use case models, worst interference can be defined
	Engine room: <10				
(B) Inter network interference	Driver/Passengers room: < 5 kinds	<10 according to a car cruster	<10 according to a car cruster	<10 according to a factory condition	By a few use case models, worst interference can be defined.
	Engine room: < 2 kinds				

Technical Requirements (cont.)

	Car bus supplement	V2V	V2I	Factory automation	Reference standard 802.15.6
Channel model	Driver/Passengers room: Light multipath	Mostly light of sight with a few shadowing	Mostly light of sight with a few shadowing	Heavy multipath with shadowing	By a few use case models, worst interference can be defined
	Engine room: Heavy multipath with shadowing				

Key policy in this standard

- First of all, we should recognize that any technology in PHY and MAC cannot guarantee full dependability in every use case.
- However, we can design a new standard which can guarantee a certain level of enhanced dependability in a specific defined use case.
- As an analogy of informed consent in medical doctor to a patient, a manufacturer of a dependable wireless network can describe such a specific defined use case that the manufacture can guarantee a defined level of dependability showing necessary cost and remained uncertainty. This is an honest manner and much better than no guarantee for any use case.
- Therefore, an expecting standard describes a specific use case in which worst performance can be guaranteed enough high while most of exiting standards have been designed with average performance base.
- Technical requirement for the specific use case can be guaranteed.

Discussion

Scope of project:

- Address PHY and MAC layer functionality
- Possibility to create management plan on the side of PHY and MAC layers
- Enabling adaptive behaviour in 802.15 PHY and MAC layers
- Enable hub to hub communications
- PHY layer additions?
- ETSI Smart Ban project status
- IEICE Study Group of Reliable Controlling Communications status
- Collaboration with FFPJ(Flexible Factor Project in Japan)

Uniqueness for an expecting new standard in IG-DEP different from existing IEEE802.11 & 15 standards

1. **MAC protocol for around packets and recursive access for feedback loop in remote sensing and controlling**;
   A) Most of major use cases taken care in IG-DEP assume feedback loop for remote monitoring sensors or radars and feedback controlling actuators such as robotics and a brake. IG-DEP defines a new MAC protocol for such around packets that are pairs of corresponding packets in between uplink from sensor nodes to a coordinator and downlink from a coordinator to actuator nodes.
   B) Such around packets are used to robotics etc. So such MAC as to guarantee maximum feedback around or loop delay should be less than a threshold.
2. Level of dependability can be defined with showing necessary cost and remained uncertainty. This is an honest manner and much better than no guarantee for any use case.
3. Worst performance can be guaranteed enough high while most of exiting standards have been designed with average performance base.

Contributions

- Every application may not be comprehensively described but major applications must be covered.
- If you can offer further details, any updated parameters or free comments are always welcome.
- Send content contributions to

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Ryuji Kohno <kohno@ynu.ac.jp>

Major Reference documents

- Applications Summary Document of IEEE802.15.6 BAN
  - 15-08-0407-00-0006-tg6-applications-summary.doc
  - 15-08-0406-00-0006-tg6-applications-matrix.xls
- IG-DEP kick-off documents
  - IEEE802.15-12-0370-00-wng0 & IEEE802.15-13-0192-01-wng0
  - 15-14-0449-06-0dep-call-for-interest
  - 15-15-0217-06-0dep-ig-dep-review-of-responses-to-call-for-interest-cfi
  - 15-17-0420-01-IG-DEP-Discussion on Necessity of a New Standard for Enhanced Dependability in Wireless Networks for focused applications
- IG-DEP Focused Use Cases
  - 15-16-0557-06-0dep-ig-dependability-selected-applications-technical-requirements.
  - 15-17-0394-00-0dep-ig-dep-summary-of-FFPJ-presentations-March-2017-and-relationship-with-IG-DEP
  - 15-17-0398-00-0dep-demand-of-highly-reliable-wireless-network-and-future-vision-for-car-manufacturing-line-in-factory
  - 15-17-0399-01-IG-DEP-On the way to Industry4.0

Major Reference documents

- IG-DEP Focused Use Cases(continue)
  - 15-18-0124-00-0dep-IG DEP Wireless Dependable IoT M2M for Reliable Machine Centric Sensing and Controlling of Medical Devices, Cars, UAVs and Others
  - 15-18-0132-00-0dep-IG DEP Wireless Technologies to Assist Search and Localization of Victims of Wide-scale Natural Disasters by Unmanned Aerial Vehicles(UAVs)
  - 15-18-0000-00-0dep-IG DEP An Adaptive Control System for Anesthesia during Surgery Operation Using Model Predictive Control of Anesthetic Effects
- IG-DEP Technical Requirement
  - 15-16-0557-05-0dep-ig-dependability-selected-applications-technical-requirements
  - 15-18-0115-00-0dep A dependable MAC protocol matched to bi-directional transmission in WBAN
  - 15-18-0138-00-0dep Superframe controlling scheme based on IEEE 802.15.6 for dependable WBAN
  - 15-18-0000-00-0dep-IG DEP dependable wireless feedback controlling schemes considering errors and delay in sensing data and controlling command packets
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Major Reference documents

- IG-DEP Enable Dependable Technologies
  - Dependable Tech. IEEE802.15-13-0440-00-0dep in July 2013
  - Smart BAN IEEE802.15-13-0415-00-0dep in Sept. 2013
  - Focused Use Cases & Timeline IEEE802.15-13-0691-00-wng0 in Nov. 2013
  - Dependability-Tech.-at-communications-layers IEEE802. 15-13-0440-00-0dep
- Related Activities for Enhanced Dependability in Wireless Networks
  - ◆ IEEE802.1., 3. & 15 Joint Activities
    - ➢ new-maruhashi-general-industrial-usage-part1-0317-v00
    - ➢ new-itaya-general-industrial-usage-part2-0317-v00
  - ◆ IEICE TC RCC & TC MICT
    - ➢ 15-18-0306-01 Overview of Japanese IEICE TC on Reliable Communication and Control (RCC).
    - ➢ 15-18-0307-01 Overview of Japanese IEICE TC on Healthcare and Medical Information Communication Technology (MICT)
  - ◆ ETSI Smart BAN
    - ➢ 15-18-0304-01 15-18-0308-01-dep0-ETSI TC Smart BAN Updates
- Update draft PAR and CSD
  - 15-16-0290-00-0dep-par-for-ieee-802-15-13