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

Submission Title: [Dependable Wireless M2M Network for Controlling - Applications for Cars, Energy, Medicine, Cities --]

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Abstract: [Dependable wireless controlling network has a wide variety of applications in medicine, industries and social infrastructures. Although current existing wireless ad-hoc networks are not enough dependable to guarantee worst performance but average one, life critical applications such as medicine and disaster need much more reliable, secure, fault tolerant, robust against undesired factors.]

Purpose: [The presentation will introduce current ongoing research and development on dependable wireless networks in order to promote a new working group or merge with others.]

Dependable Wireless M2M Network for Controlling - Applications for Cars, Energy, Medicine, Cities -

WNG Session Presentation
18th July 2012 San Diego, CA

Ryuji Kohno, Ph.D., IEEE & IEICE Fellows
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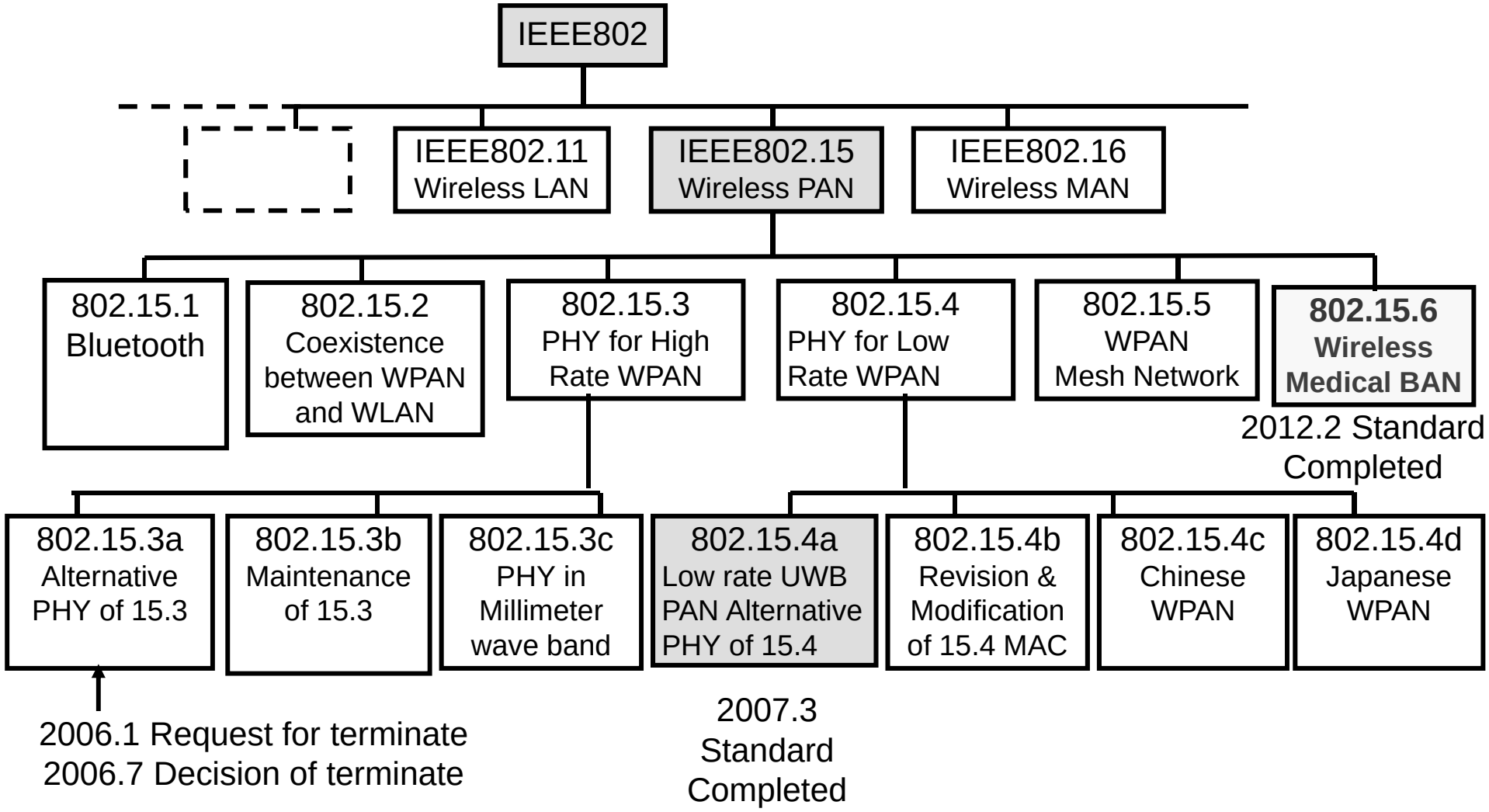
Contents

1. Background and Aim of This Action

- Background:
  - We have completed standardization of WBAN: IEEE802.15.6 in February 2012, but its amendment may be needed for wider applications.
  - Dependability of wireless ad-hoc networks must be more important in machine-to-machine(M2M) remote sensing and controlling for medicine, car, FA, bldgs. in a city and energy than opportunistic ones for CE.
- Aim:
  - We may open a new WG for amendment of WBAN or independent WG on Wireless Dependable M2M Net

Wireless Network Standardization(IEEE802)



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2. Future Vision of Safe & Secure Infrastructures Based on Advanced ICT

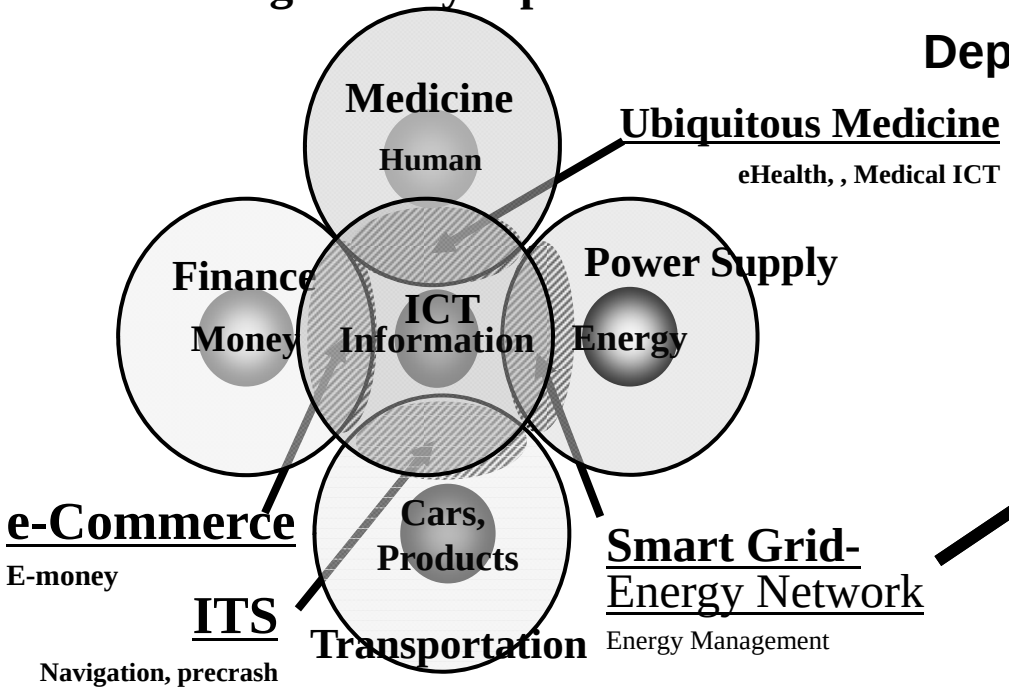
Integrated Infrastructures on transport, Energy, Finance, Medicine and Information

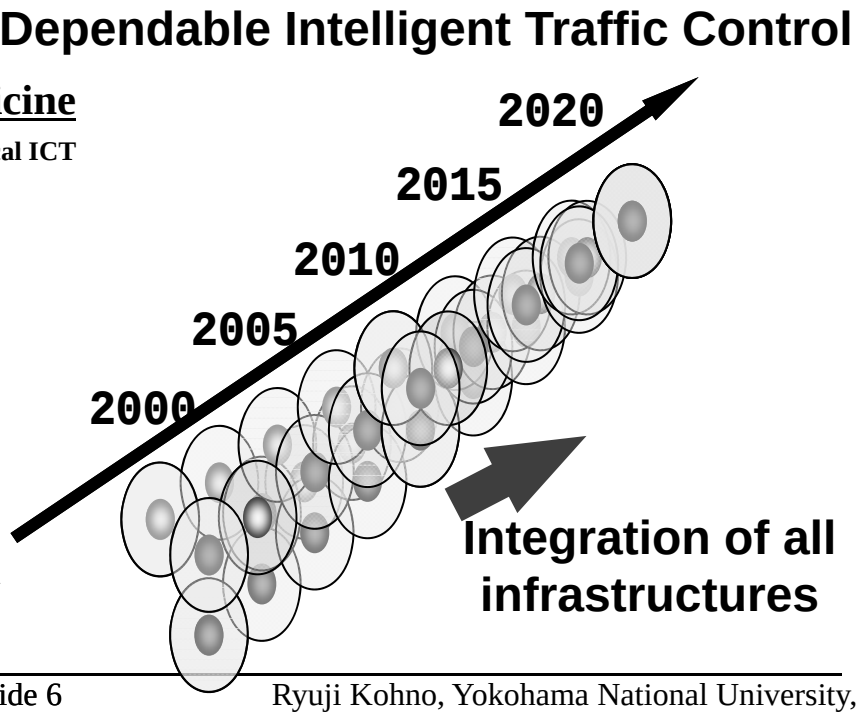
A. Communications (Traffic of Information)
B. Transportation (Traffic of Cars and Products)
C. Finance (Money Flow)
D. Power Supply (Traffic of Energy)
E. Medicine (Traffic of Healthcare & Drugs)

could be integrated by sophisticated traffic management

(Example)

A+B ➔ ITS (Intelligent Transport System)
A+C ➔ Smart Grid (Flexible Energy Network)
A+D ➔ E-Commerce (Borderless Secure Trade)
A+E ➔ Medicine ICT (Ubiquitous Medicine)





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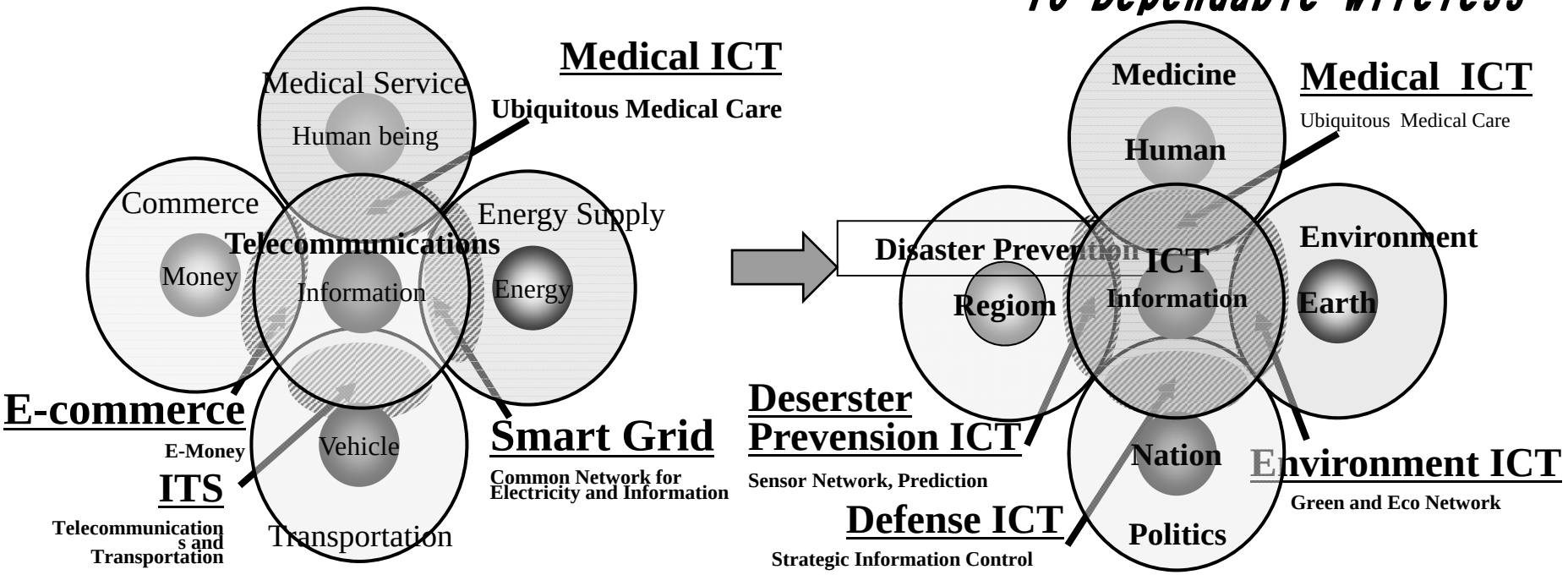
2.2 Future Vision of Safe and Secure Social Infrastructures by Dependable ICT

Major Infrastructures using ICT have almost done and should be extended to Dependable Networks for Disaster Prevention, Green Innovation, Public Safety. （Examples of Dependable Wireless）

- **A. Information Traffic（Telecommunications）** ➔ **Medicine ICT (Ubiquitous Medicine)**
- **B. Vehicular Traffic（Transportation）** ➔ **Disaster ICT (Emergency and Rescue)**
- **C. Energy Traffic (Power & Energy Supply）** ➔ **Environment ICT(Green Innovation)**
- **D. Money Traffic（Commerce）** ➔ **Defense ICT (National Security)**
- **E. Patient, Drag Traffic (Medicine)**



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2.3 Future Vision of ICT

Prospective Core ICT Field

ICT for Safe and Secure QoL : *" Dependable ICT"*

(1) ICT must guarantee highly safe, reliable and secure Quality of Life (QoL) by intelligent traffic controlling Finance, Transportation, Energy Supply, and Medical Healthcare , i.e. e-Commerce, ITS, Smart Grid, and Medical ICT

(2) ICT should be dependable to support green environment, national defense, disaster prevention, medical healthcare.

Specific Core Disciplines

(1) Medical ICT : can solve such social problems as lack of medical treatment budget, surgery errors by applying advanced ICT. Ubiquitous medicine can be performed by connecting BAN with infra networks, e.g. internet, cellular network, NGN.

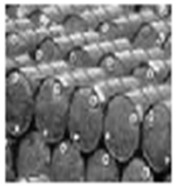
(2) Environment ICT: can control energy network and reduce pollution for ecology by using sensor networks to promote Green Innovation.

(3) Defense ICT: can contribute protect a nation using satellite networks and remote sensing.

(4) Disaster ICT: can predict and prevent disaster by sensor network and remote sensing and controlling.

2.4 Demands for Dependable Wireless

Population Ageing & Medical crisis
Healthcare Service(Medical ICT)



Cost of energy … fuel supply & demand
Energy Network(Smart Grid)

Increasing environmental requirements
CO_2 Reduction, Green Innovation

Escalating security concerns
Public Safety, National Defense

Heightened investor demands
Global Borderless Economics

Driving Technology

Dependable Wireless

3. Dependablity in Wireless Networks

- **Meanings of Dependability:**
  - **In Wikipedia, “Dependability” is a value showing the reliability of a person to others because of his/her integrity, truthfulness, and trustfulness, traits that can encourage someone to depend on him/her. The wider use of this noun is in Systems engineering.**
  - **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.

3. Dependablity in Wireless M2M Networks for Sensing ad Controlling(2/2)

- **Emotion and Sustainability**
  - **Medicine, Robot, ITS, Energy Supply, and Manufacturing** require more dependability in **controlling network, integrated circuit, link in micro devices.**
  - Medical equipments and industrial products need **long life time, fault tolerancy.**
  - **Dependable Network Architecture** for **M2M controlling**.

4. Major Prospective Applications of Dependable Wireless M2M Networks

- One of major possible applications of dependable wireless M2M is medicine like BAN and its extension because medical therapy needs high level of dependability in network due to life critical service.
- Another timely application is emergency rescue in disaster and public safety because under emergent and urgent situation in disaster with usual network infrastructure damaged like 911 and 311 dependable ad-hoc network is truly necessary for rescue, triage and recovering.
- More applications in daily life are Machine-to-Machine(M2M) links for feedback controlling in cars, robots, factory automation, building management and energy traffic control in cities and more.

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4.1 Medical Application of Dependable M2M like BAN

Wearable BAN

Tele-metering or sensing vital signs with various sensors

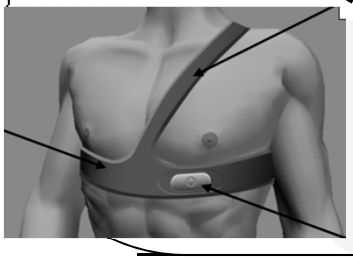
ECG
EEG
Blood Pressure
Heart Beat
Body temperatur
Sugar rate
Medical images
And video
Etc.

Implant BAN

Tele-control of Medical Equipment and Devices

Pace Maker with ICD

Capsule Endoscope



Novel Concept
Intelligent Network of Vital Sensors, eHR, Medical Robots etc.

4.2 Dependable M2M Applications for Disasters

- **Dependable M2M like BAN or its extension** may be applicable for emergency rescue in disaster such as earthquake, fire, tunami …
- **On site of Disaster**
  1. **Warning** for each person against Tsunami and earthquakes
  2. **Navigating** each person to safer places or shelters
  3. **Rescuing** persons in dangerous situation with triage
- **After Disaster**
  1. **Identifying** each survivor alive or not, and health condition
  2. **Finding** each missing person using geo-location
  3. **Monitoring** environment as well as health condition
  4. **Remote medical maintenance and health care.**
  5. **Recovering** life lines and social infrastructure

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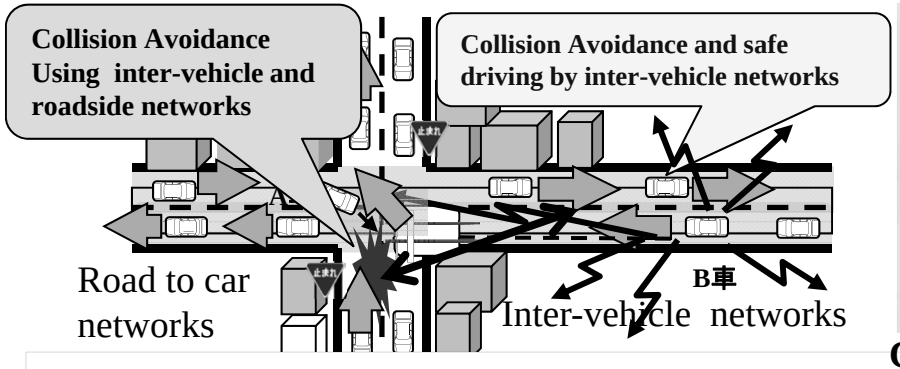
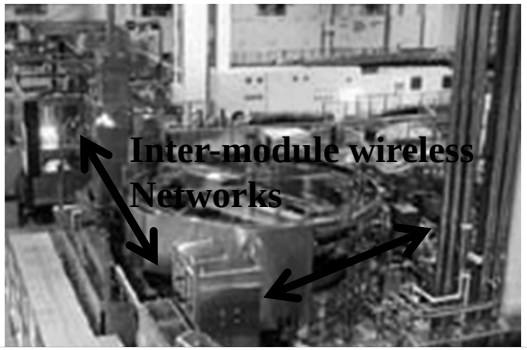
4.3 Demands for Highly Dependable Communications for Controlling



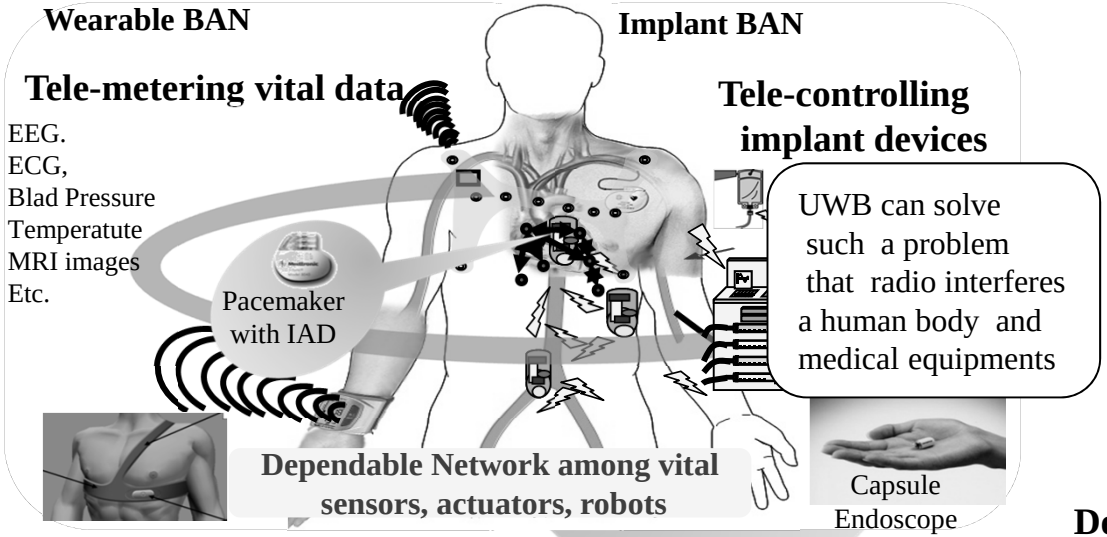
Car Navigation & Collision Avoidance Radar

Car LAN & Wireless Harness



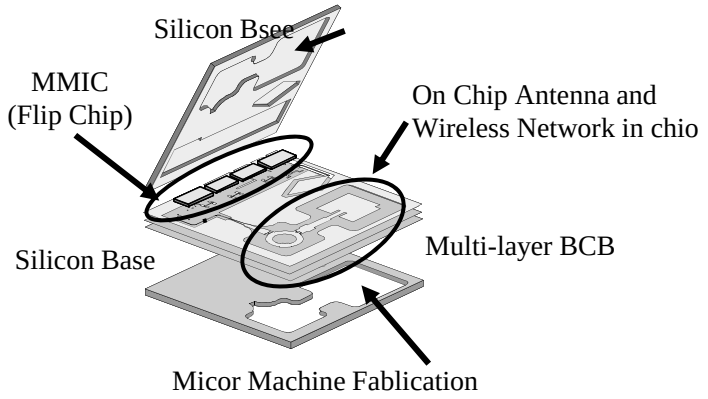
Factory Automation (FA)

Dependable Wireless Networks for Transportation



Dependable BAN for Medical Healthcare

Dependable Wireless Sensing & Controlling for Manufacturing (CIM)



Dependable Wireless System Clock in Micro Circuit & Network in Devices

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4.4 Why do we need a standard for Wireless Dependable M2M?

- **Demands for Wireless Dependable M2M**
  - Future direction of wireless major applications seems to be focusing on more **dependable networks** for **higher QoS** than **opportunistic networks** in medicine, energy, environment, disaster etc.
  - Most of wireless networks for controlling machines needs more reliable, safe, secure, robust, heavy-duty and fault tolerant, so-called dependable links than current major networks for CE, AV, game, entertainment of which opportunistic and less trustable networks may be good enough because more economics and efficiency are more important.
  - **Machine-centric networks** need higher dependability than **human-centric networks**
- **What standard body is appropriate?**
  - Although other industrial associations originated from mechanical engineering and controlling theory can cover dependable controlling system, little expertise in wireless PHY and MAC cannot establish an appropriate standard.
  - A new standard of wireless dependable networks should be addressed within IEEE802.15 while keeping **uniqueness and some commonality with other SG, TG and so on.**

4.5 Requirements for the purpose

- Network Requirements for Dependable M2M
  - Definition of dependability with scientific criteria and numerical necessary values as well as design policy.
  - Classification of applications; application matrix
  - Mandatory technical requirements in PHY and MAC to satisfy the dependability criteria and values
  - Optional technical requirements in upper layer such as fault tolerant network, authentication and encryption.
  - Self organizing (forming /reforming network within minutes)
  - Feasibility study (bandwidth and power efficiency)
  - Compliance testing body

5. 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**

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5.1 Physical Layer Technologies Satisfying Multiple Demands for Dependable Wireless

(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

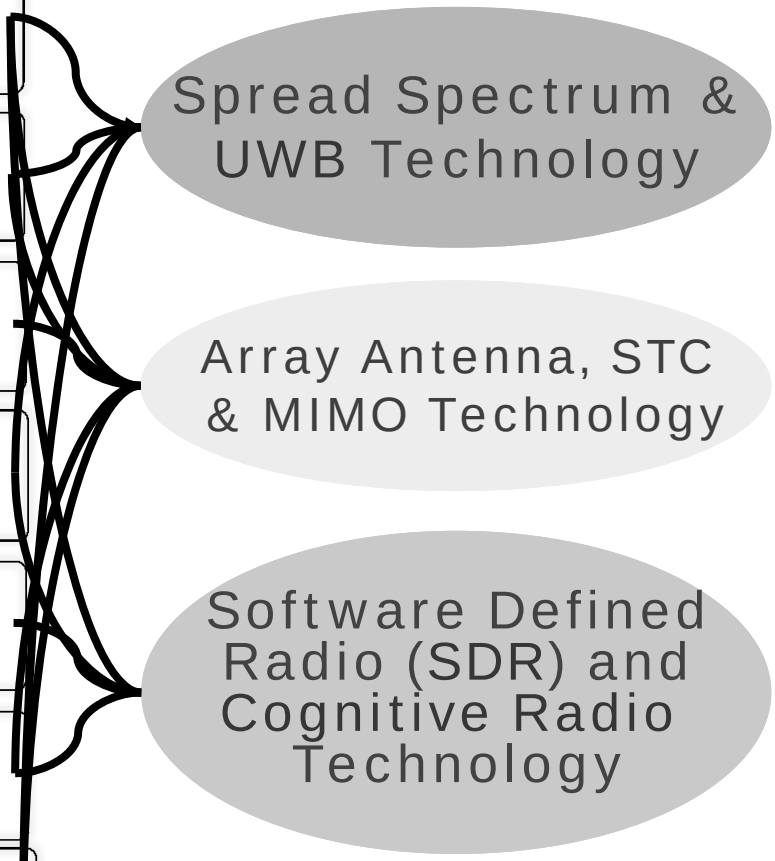
(3) **Awareness and Control＝Inside body sensing**
: Observation of environment, Sensor, Adaptive control

(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



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5.2 Communication Technologies in each Layer for Dependable Control

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

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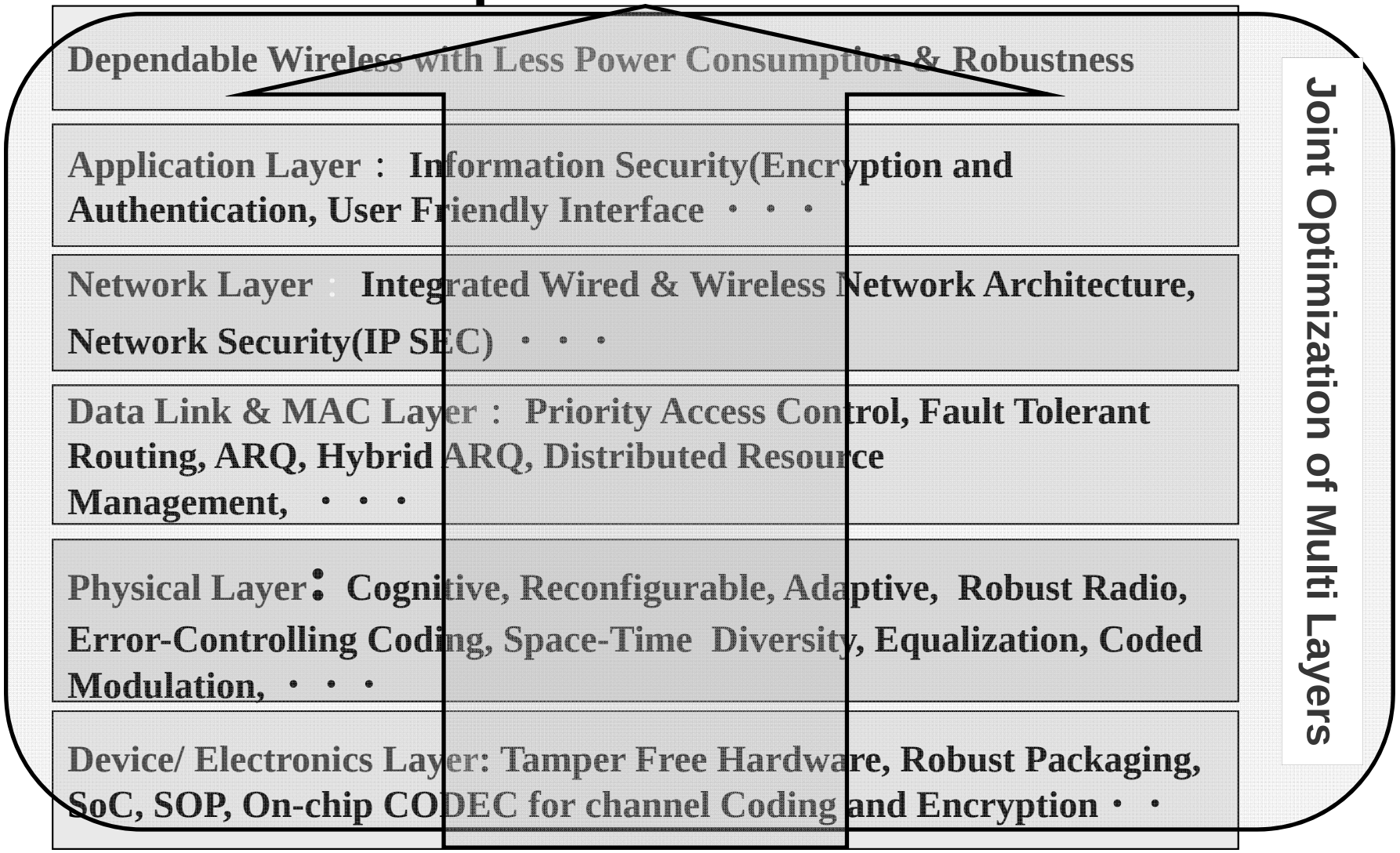
5.3 Cross Layer & Multi-Layer Optimization for Dependable Wireless



5.4 Higher Layers Technologies for Dependable Wireless

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)

6. Interdisciplinary Works between Controlling and Communication Theories

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 while 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 in controlling machine stable.

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

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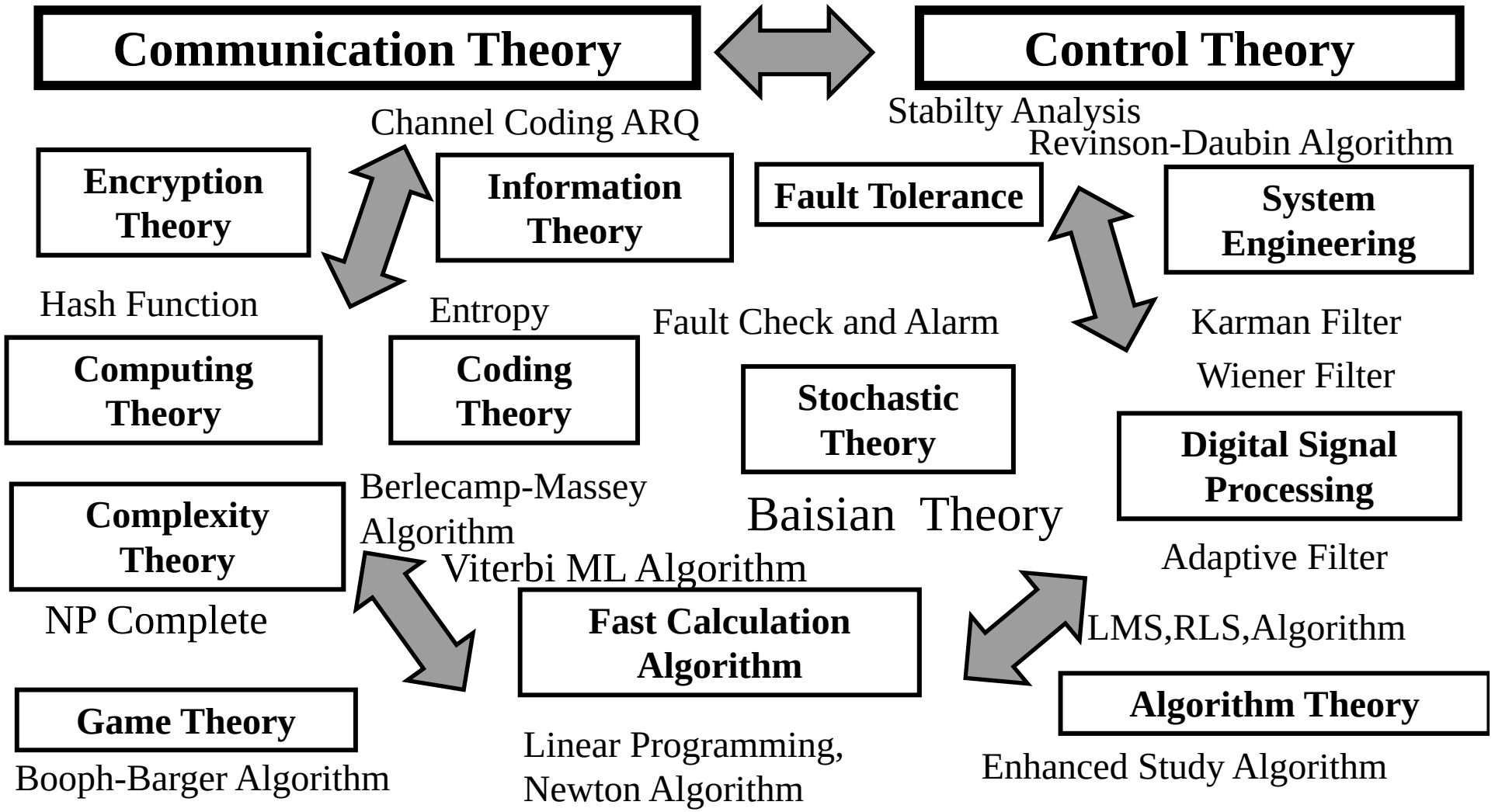
6.1 Interdisciplinary Research Field between Control and Communications



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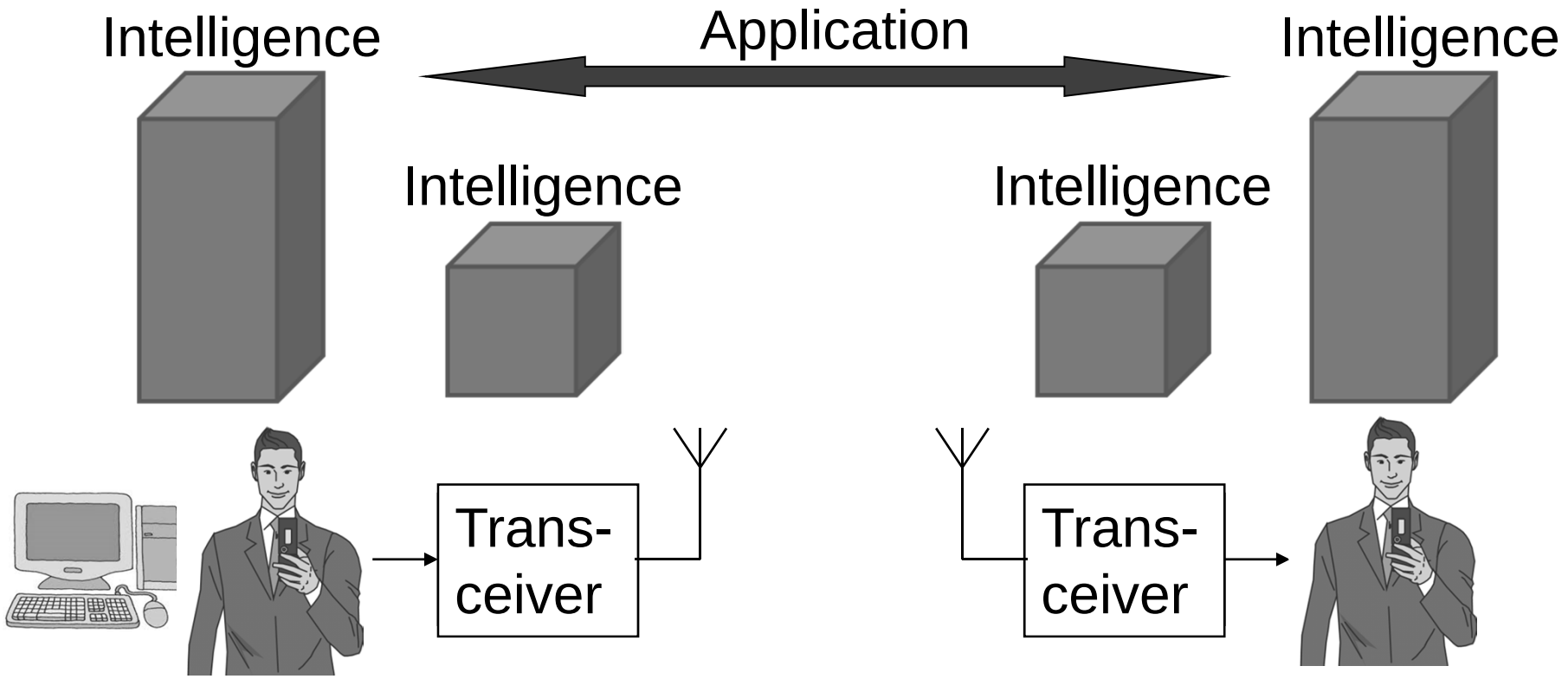
6.2 M2M Controlling Communication Different from Usual Human-Base Communication



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

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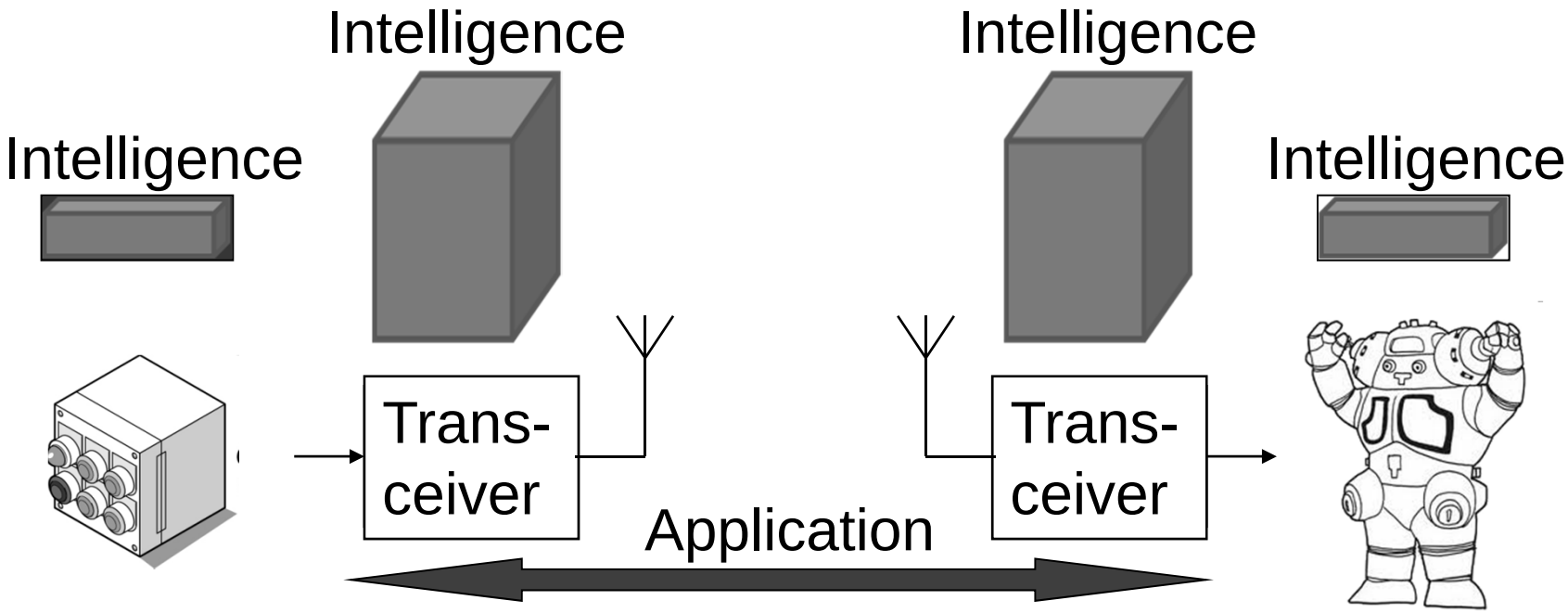
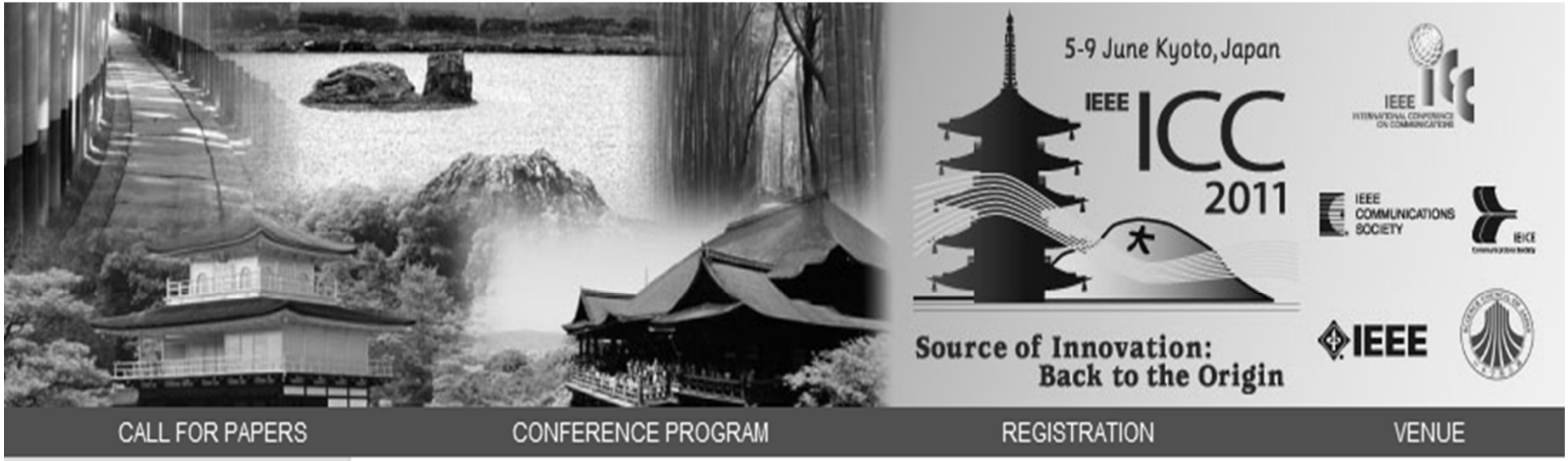
6.3 M2M Controlling Communication Different from Usual Human-base Communication



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



Keynote Speech:

Dependable Wireless: Future M2M for Medicine, Vehicle, Robot, Energy and Others

Ryuji Kohno (Yokohama National Univ., Japan)

http://www.ieee-icc.org/2011/business_forum.php

IEEE PIMRC'11 KEYNOTE SPEAKERS

Dependable Wireless for Medicine and Disaster Prevention- Future M2M for Medicine, Vehicle, Robot, Energy and Others -

Dr. Ryuji Kohno
Finnish Distinguished Professor

Ryuji Kohno received the Ph.D. degree from the University of Tokyo in 1984. Since 1998 he has been a Professor of the Division of Physics, Electrical and Computer Engineering, and the Director of Center on Medical Information and Communication Technology, in Yokohama National University in Japan. In his career he was a director of Advanced Telecommunications Laboratory of SONY CSL during 1998-2002, a director of UWB Technology institute of National Institute of Information and Communications Technology (NICT) during 2002-2006, and a program coordinator of Medical ICT institute of NICT since 2006.
In his academic activities, he was elected as a member of the Board of Governors of IEEE Information Theory (IT) Society in 2000, 2003 and 2006.

He has played a role of an editor of the IEEE Transactions on IT, Communications, and Intelligent Transport Systems (ITS). He is a fellow of IEICE, and has been vice-president of Engineering Sciences Society of IEICE, the Chairman of the IEICE Technical Committee on Spread Spectrum Technology, that on ITS, and that on Software Defined Radio(SDR). Prof. Kohno has contributed for organizing many international conferences, such as an chair-in honor of 2002 & 2003 International Conference of SDR(SDR02 & SDR03), a general co-chair of 2003 IEEE International Symposium on IT (ISIT03), UWBST&IWUWB04, IWUWBST05, 2006, 2007&2010 International Symposium on Medial ICT (ISMICT2006, 2007, 2010, 2011), 2010 Joint International Symposia on Information Theory and Its Applications (ISITA2010) and on Spread Spectrum Technology and Applications (ISSSTA2010). He was awarded IEICE Greatest Contribution
Award and NTT DoCoMo Mobile Science Award in 1999 and 2002, respectively.

Since 2007, he became a Finnish Distinguished Professor (FiDiPro). Currently he is in charge of Global COE (Centre of Excellence) program on "Innovative Integration between Medicine and Engineering Based on ICT," in MEXT, Japan to promote joint research and education between Finland and Japan for five years.

6.4 Related activities in Japan: Establishment of IEICE Study Group & Committee on Dependable Wireless

Aim of This Study Group IEICE EES Society, May 2010

- 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.

7. Importance of Dependable Wireless in Industry and Academic

- **Importance in Industry**
  - Much more reliable and secure **Dependable Wireless for M2M controlling** must open innovation in business while current mobile ICT for IMT-advance and 4G may be enough.
  - **Dependable Wireless** has wide variety of clean, efficient and ecological applications such as **medicine, robot, ITS, energy supply, factory automation in macro infrastructure** and **integrated circuit, internal and external connection of devices in micro networks.**
- **Importance in Academia**
  - **Joint Optimization in Multiple Layers** for Dependable Wireless
  - Multi Disciplinary R&D subjects among **Control Theory and Communication Theory**

8. Concluding Remark

- Dependable Wireless can commonly promote and support Medical ICT, Green ICT, Defense ICT. Disaster Preventing ICT as public social services.
- Dependable Wireless can promote a global new business in industry to provide intelligent traffic control of energy, money, vehicles, medicine flows in a sense of dependable smart grid, ITS, e-Commerce, and ubiquitous medicine.
- Dependable Wireless can create a new research and business paradigm in interdisciplinary fields between control and communications, and promote more multi-disciplinary related fields.
- Establishing SG for IEEE802.15 standard on Dependable M2M Network can promote a global business and lead innovation of communications for controlling and sensing with joint optimized multilayer technologies in order to guarantee expected necessary performance.

What to be documented

- Extend IEEE802.15.6 or make another specification?
- Best Practice or Amendment of IEEE802.15.6?
- What to be included in the document?
  - Routing and error-controlling protocols which have not done in IEEE802.15.6 and others
  - Joint optimization among technologies multiple layers of PHY, MAC and upper layers including network architecture, authentication and encryption for dependability

Questions & comments

- How many companies and institutes have interest on this activity?
- If it is enough, we would like to establish a study group(SG) rather than an interest group(IG) within IEEE802.15 to make a standard shortly.

- Please contact: kohno@ynu.ac.jp