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

Submission Title: [IG DEP Expanded Used Cases and Related Areas for Dependable Wireless Networks]

Date Submitted: [6 November, 2016]

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Re: []

Abstract: [This document contains expanded use cases and related applications of dependable or ultra reliable wireless netwroks.]

Purpose: [information]

Expanded Use Cases and Related Areas of Dependable or Ultra Reliable Wireless Networks

San Antonio, TX, USA
November 7th, 2016

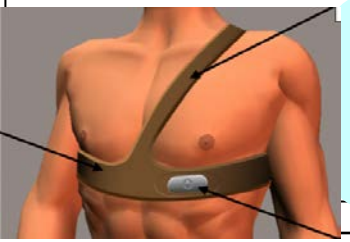
Ryuji Kohno
Yokohama National University (YNU), Japan
University of Oulu Research Institute Japan – CWC-Nippon Co. Ltd., Finland

BAN: Body Area Network for Human Body

Wearable BAN

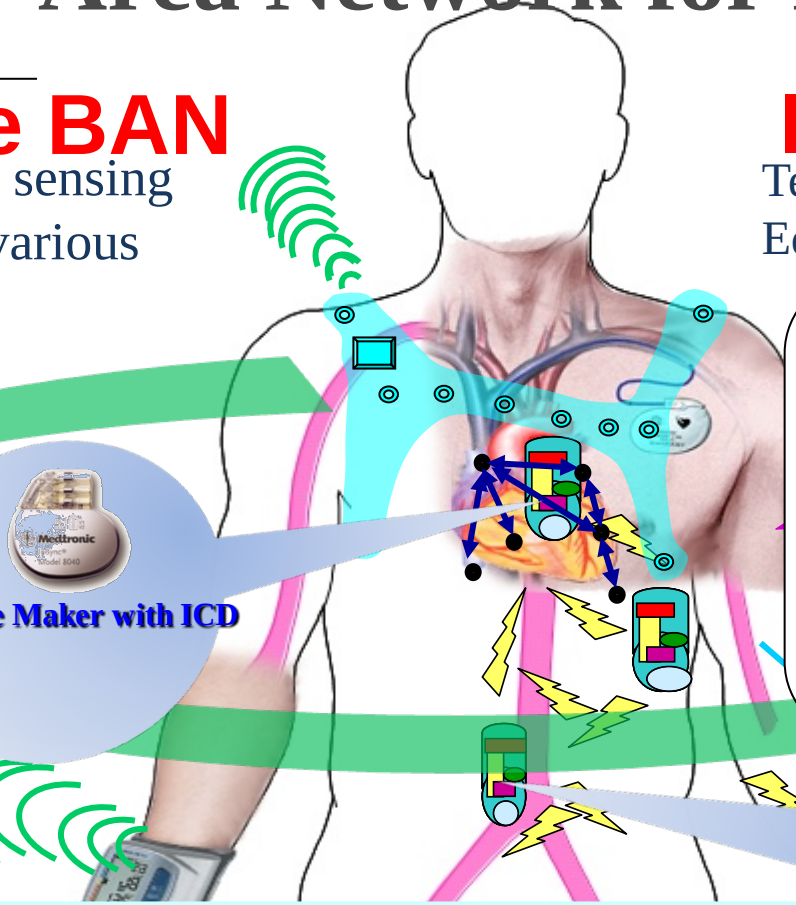
Tele-metering or sensing vital signs with various sensors

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



Implant BAN

Tele-control of Medical Equipment and Devices

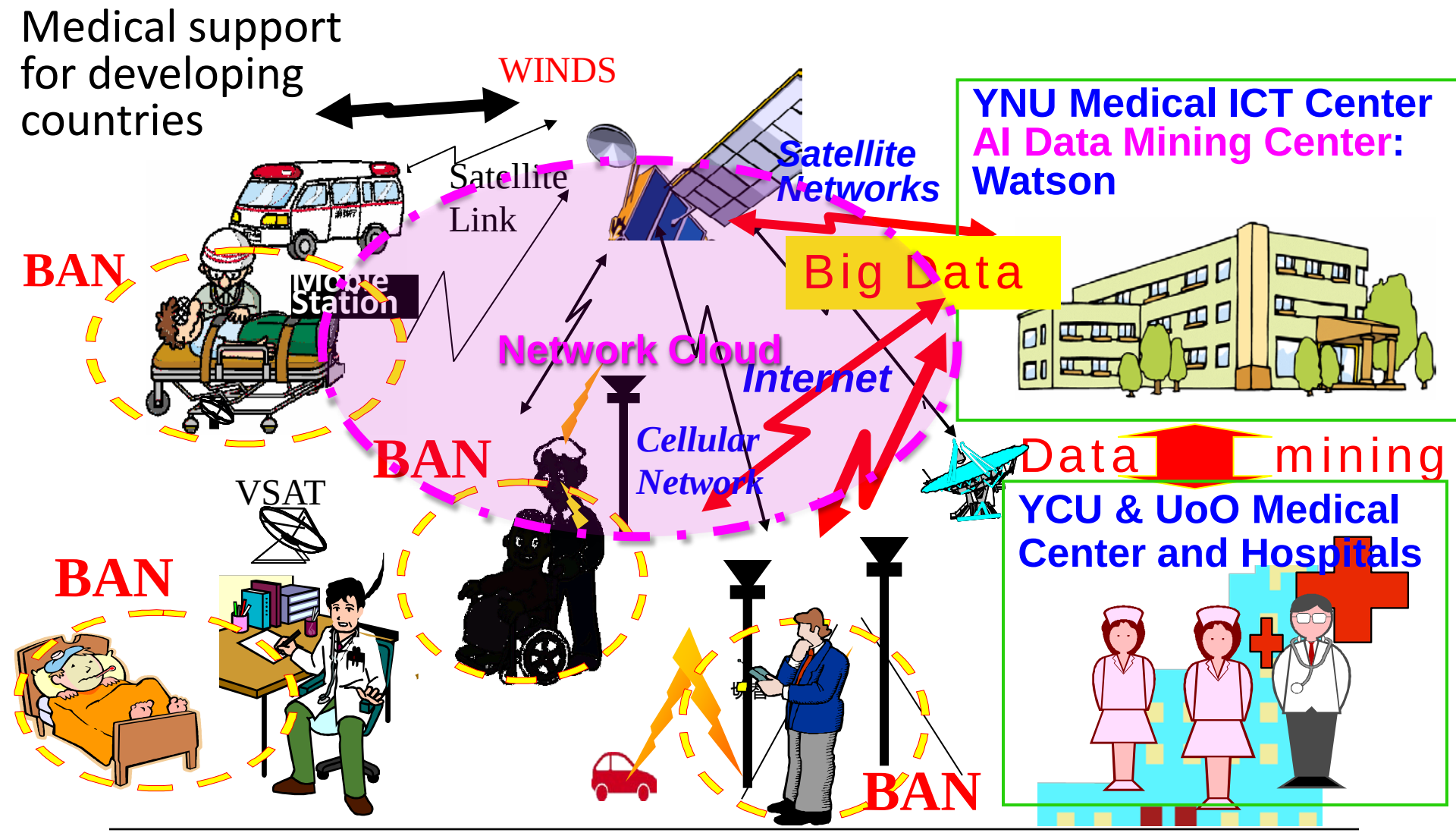


Break Thru Tec. :Ultra Wide Band (UWB) Radio can solve a EMC human body impact of Radio in, on and around a body.

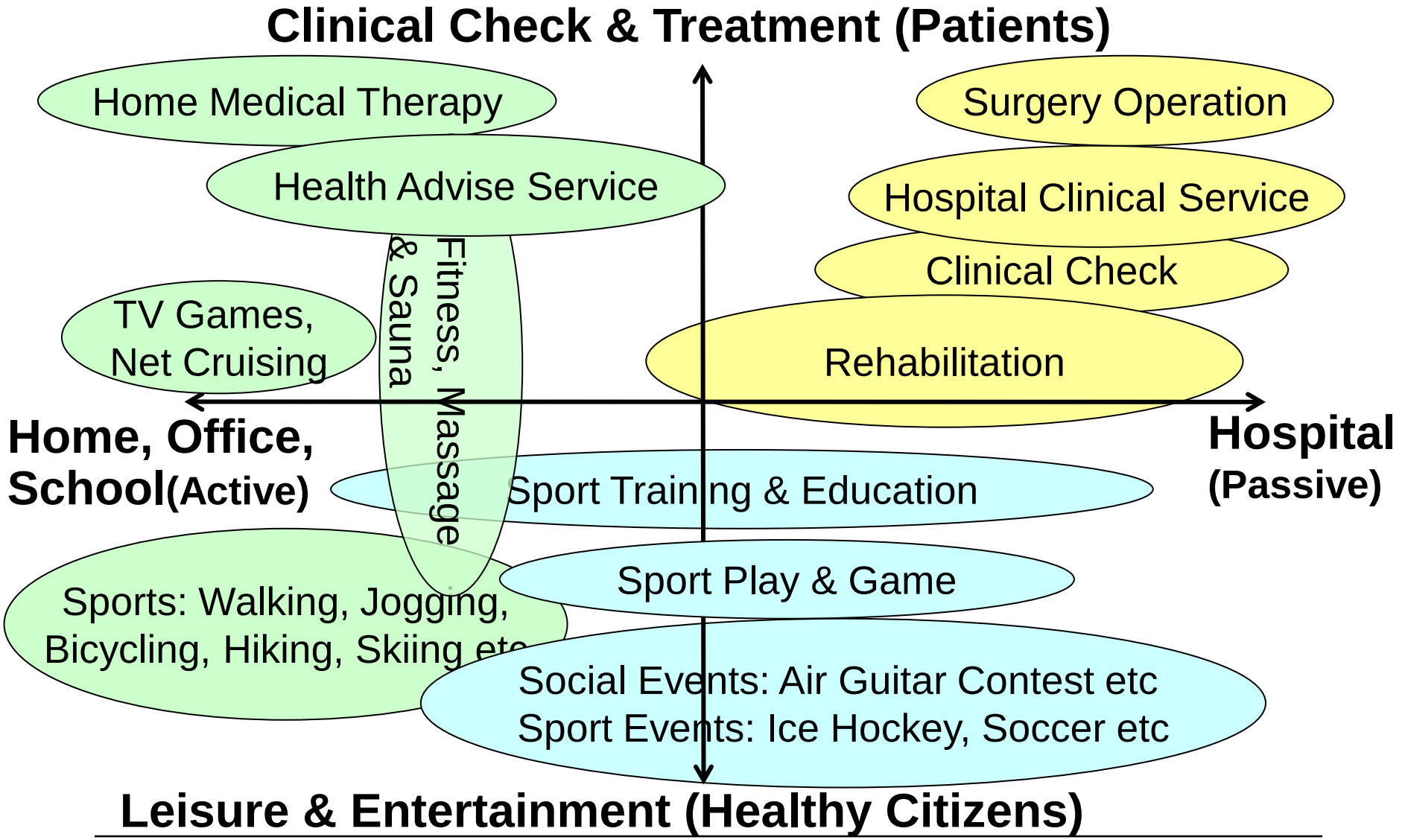
Capsule Endoscope

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

Ubiquitous Medicine Based on Medical ICT with BAN



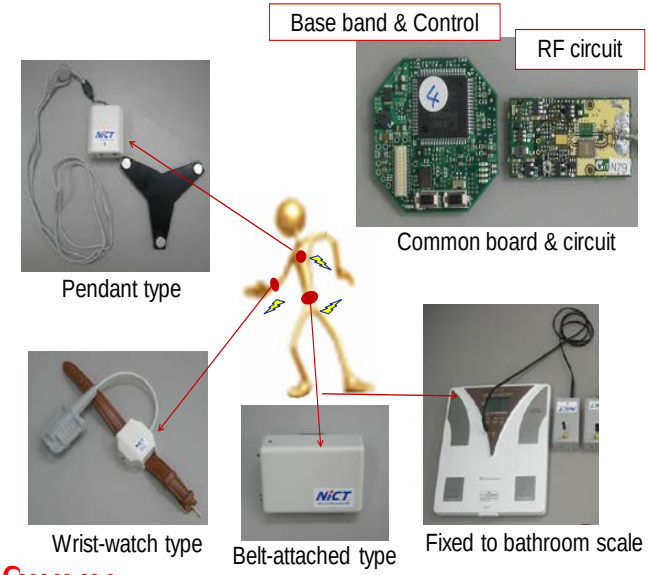
Medical Healthcare Service and Social Activities



UWB-BAN Applications for Disasters

- **UWB-BAN** must be applicable for emergency rescue in disaster such as earthquake, fire, terrorism.
- **Real time of Disaster**

1. **Warning** for each person against Tsunami and earthquakes
2. **Navigating** for evacuation of suffered people to safer places or shelters
3. **Rescuing** injured persons in emergent 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

DWN in Disaster Recovering

- **Specific requirements**
  - Enable technolgies to design safe and secure social infrastructure for high QoL against disaters.
  - Adaptive reconfigurability according to variance of liveing and working condition. Total design of ready existing and newly buiding system.
- **Key technology requirements**

(a) Available technologies: design technology for assumed case and predictable case.

(b) Lack of technologies:cognitive and reconfigurable technology in case beyond assumed and predictable cases.

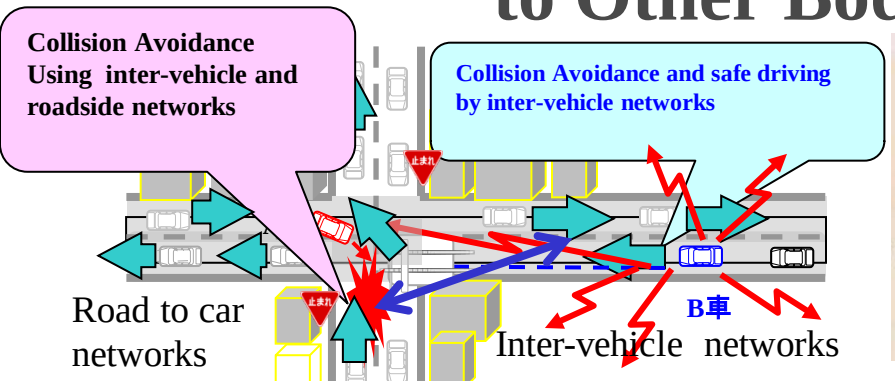
- **Potential industrial parties** (financing expected)

(1) Government (houses, roads, infra building etc)

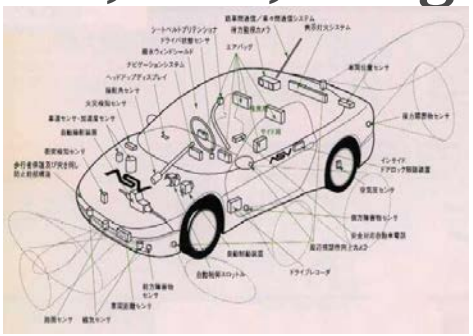
(2) Infra and Building contructures,

(3) Network infra operators and manufactures

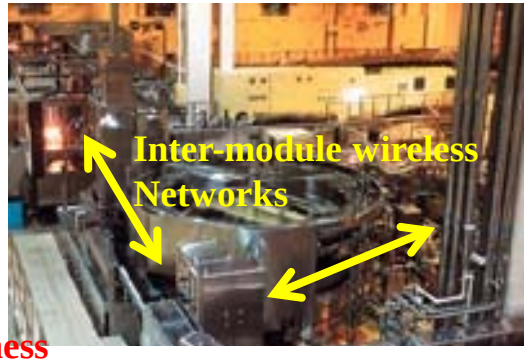
Demands for Highly Dependable BAN from Human Body to Other Bodies, Car, Bldg.,…



Car Navigation & Collision Avoidance Radar



Car LAN & Wireless Harness



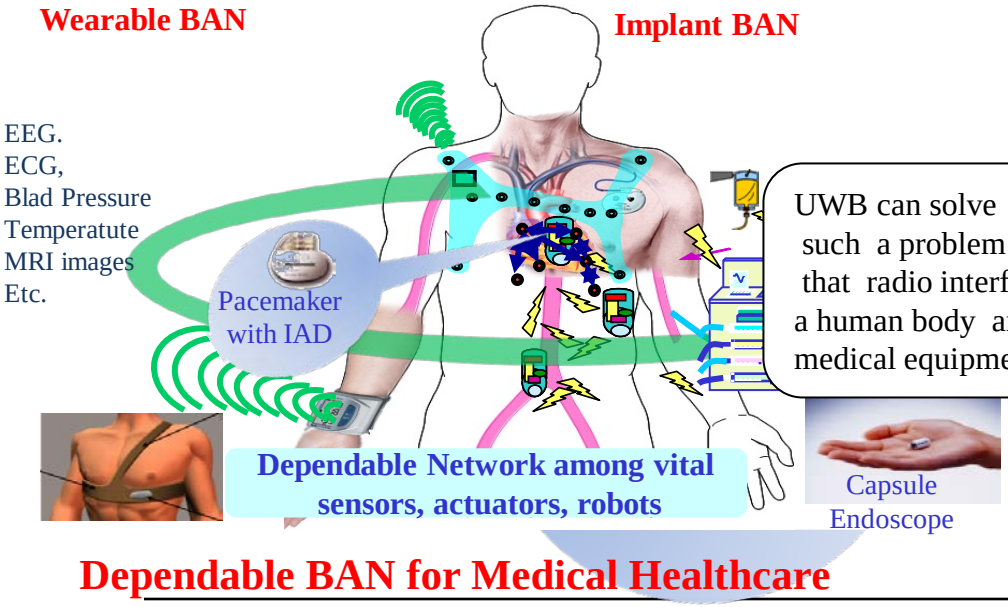
Factory Automation (FA)

Dependable Wireless Networks for Transportation

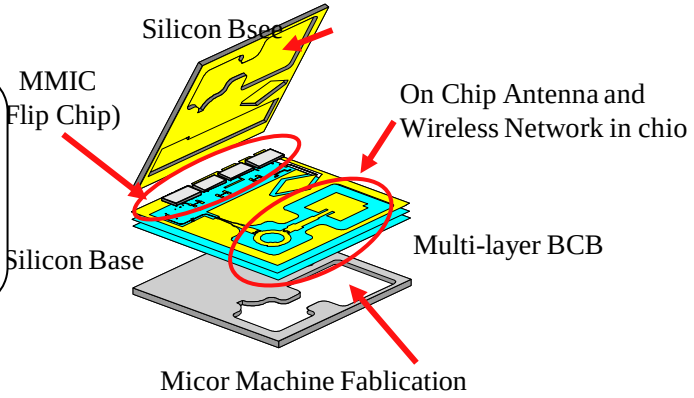
Dependable Wireless Sensing & Controlling for Manufacturing (CIM)

Wearable BAN

Implant BAN



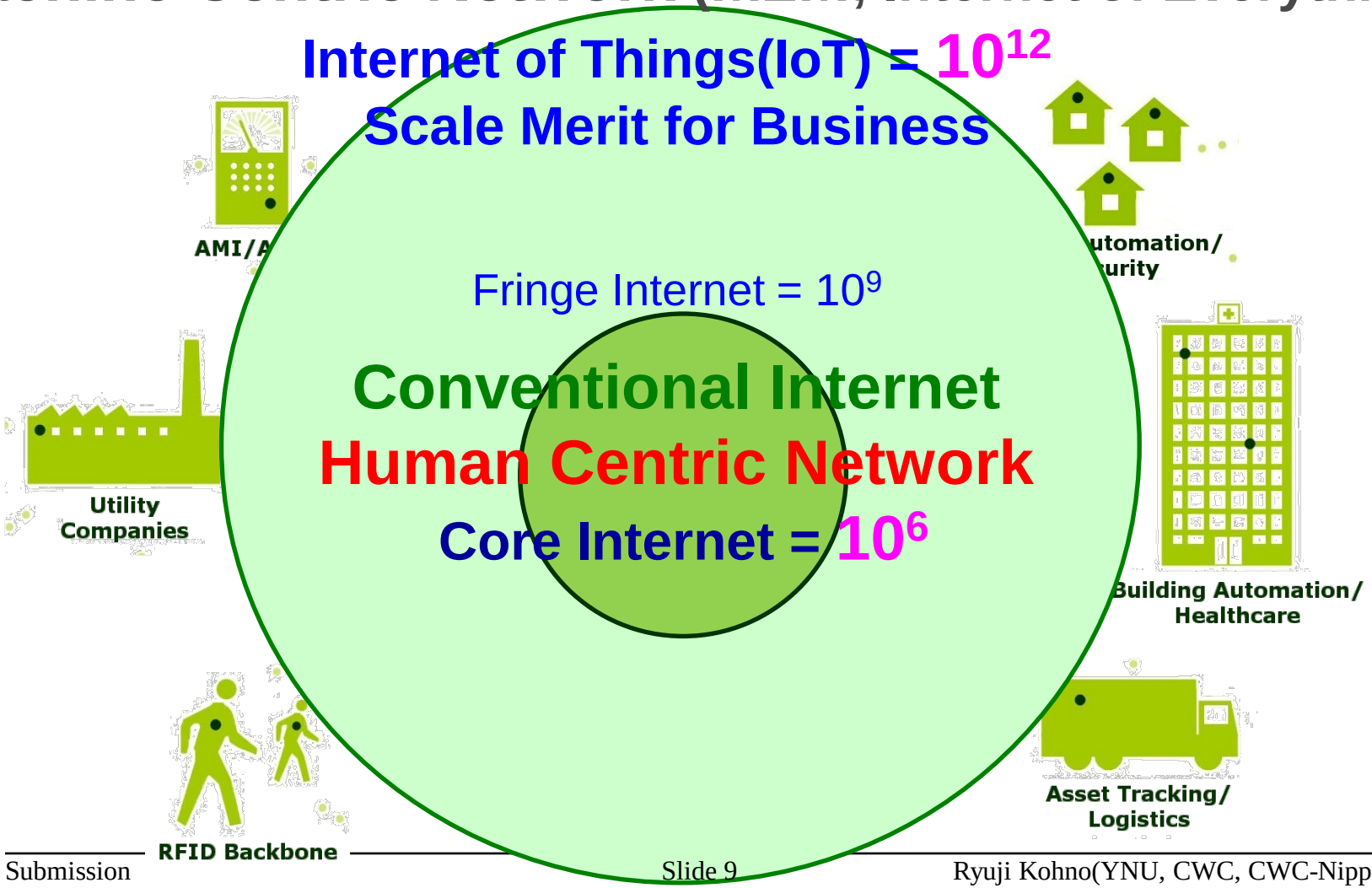
Dependable BAN for Medical Healthcare



Dependable Wireless System Clock in Micro Circuit & Network in Devices

Internet of Things (IoT)

Machine Centric Network (M2M; Internet of Everything)

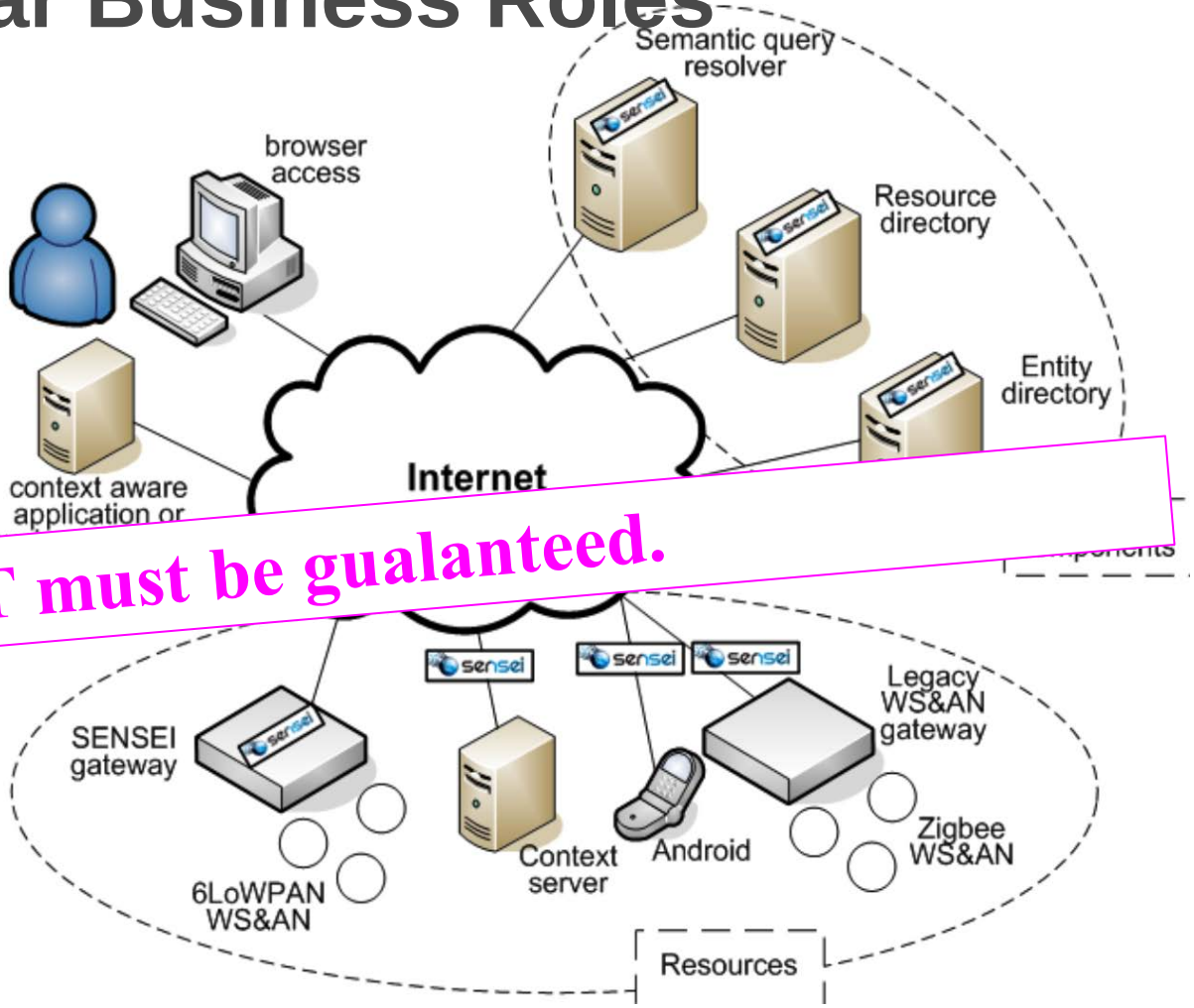


IoT for Global System Platform with Clear Business Roles

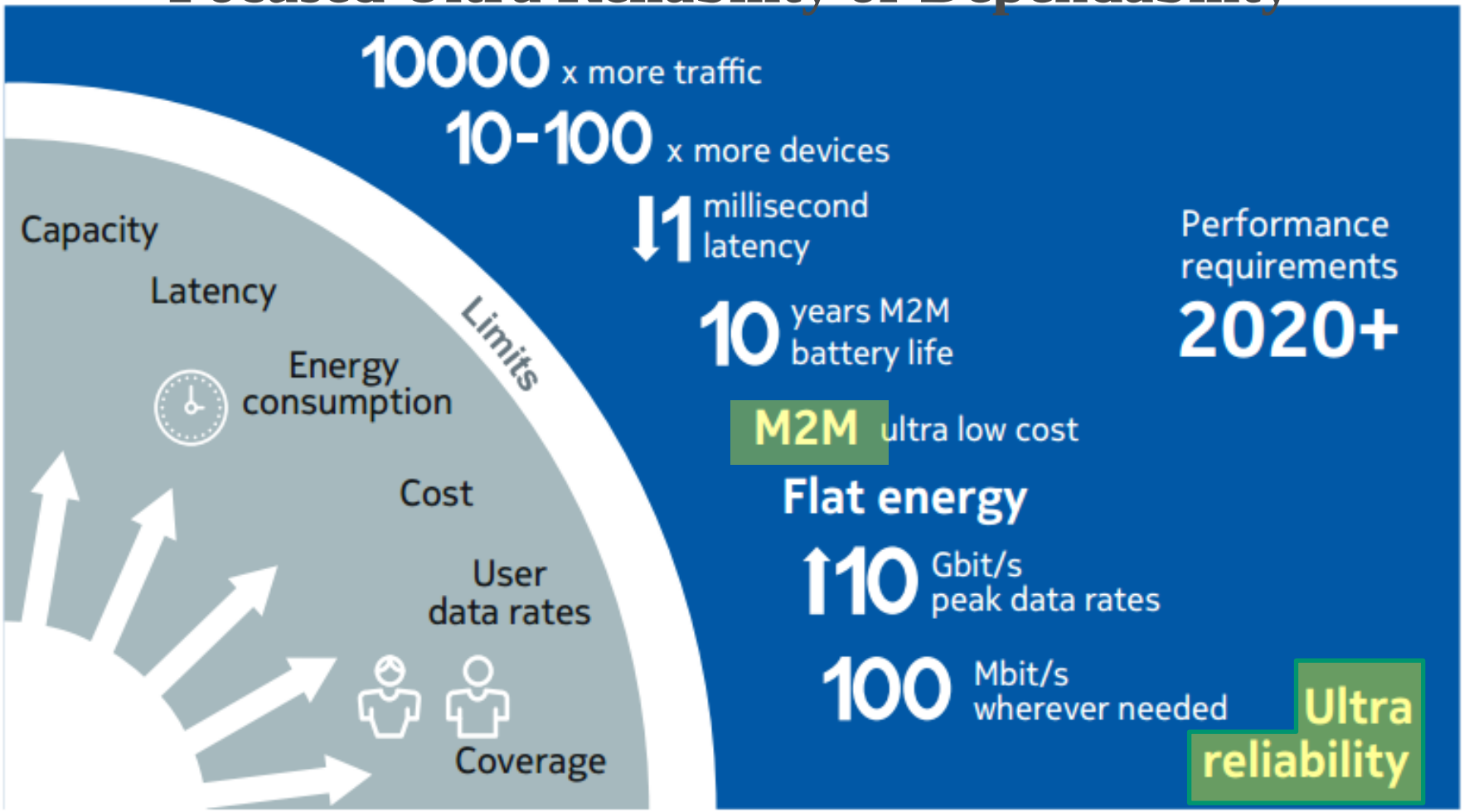
Key Components

- Resource Directory
- Entity Directory
- Semantic Query Resolver
- WS&AN gateways
- Resource End Points
- Heterogeneous resources (6lowPAN, ZigBee, IEEE802.15.4 based WS&AN)
- **Safety, Safety and Security, so-called Dependability Mechanisms** to enable controlled access to components

Dependability of IoT must be gualanteed.

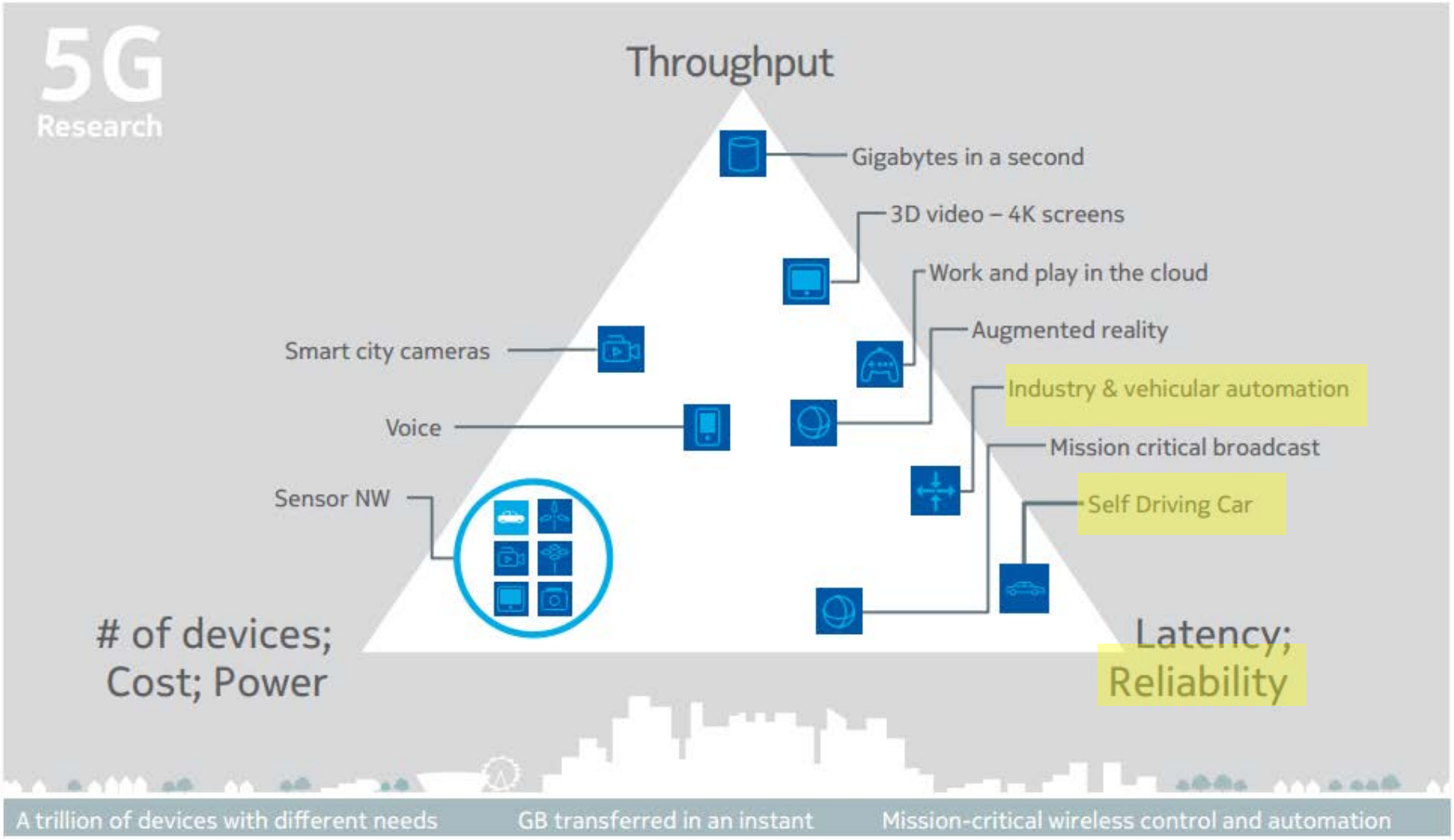


Key Technical Requirements for 5G: Focused Ultra Reliability or Dependability



Ref. “5G Use Cases and Requirements,” NOKIA, Co,

Services, Use Cases & Requirements for 5G



Future Vision of Dependable Social Infrastructures Based on Advanced ICT

Major 5 Infrastructures of Communications, Transportation, Energy, Commerce and Medicine

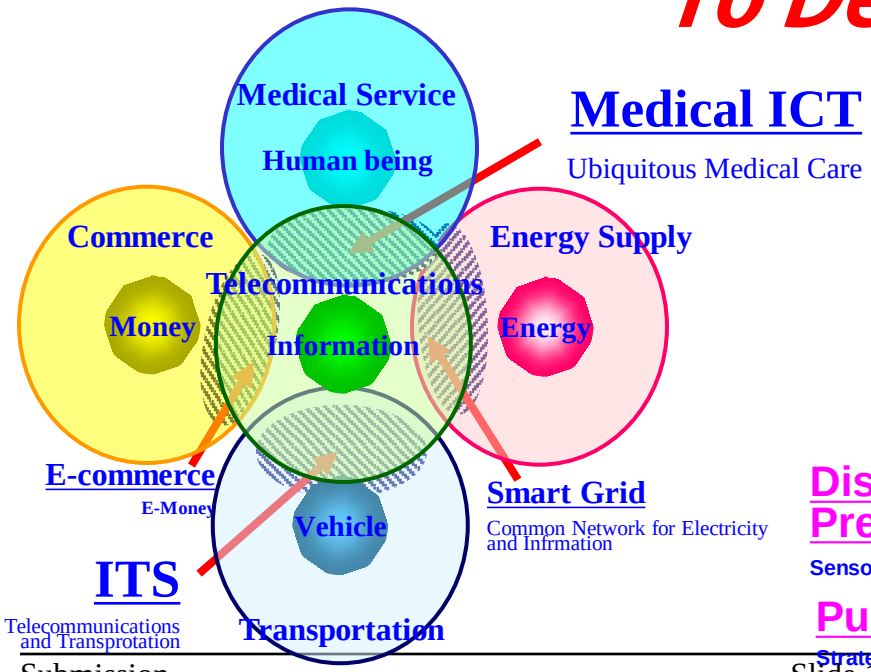
A. Information Traffic（Telecommunications）
B. Vehicular Traffic（Transportation）
C. Energy Traffic(Power & Energy Supply）
D. Money Traffic（Commerce）
E. Patient, Drag Traffic(Medicine)

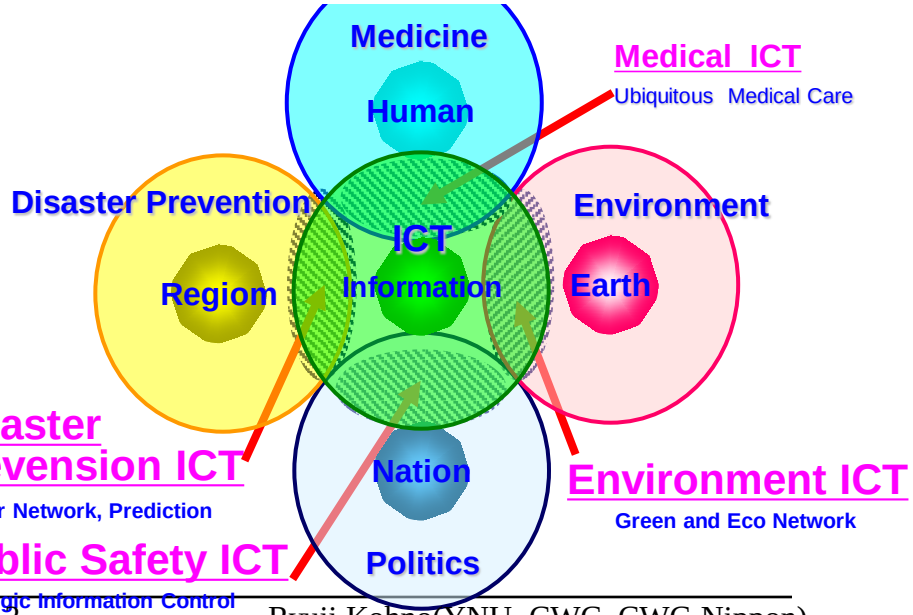
should be integrated to control all flows in future infrastructure

(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)

To Dependable Wireless ICT





Reliable, Secure and Dependable BAN for Global Social Services

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

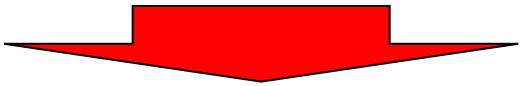
Driving

Technology

Dependable Wireless BAN: IoT & M2M

Dependable IoT and BAN of Things

- Current **IoT** mainly assumes **sensing and data acquisition** but **IoT** should be applied to **remote controlling** like M2M controlling.
- In current **IoT performance is not guaranteed and too opportunistic**.



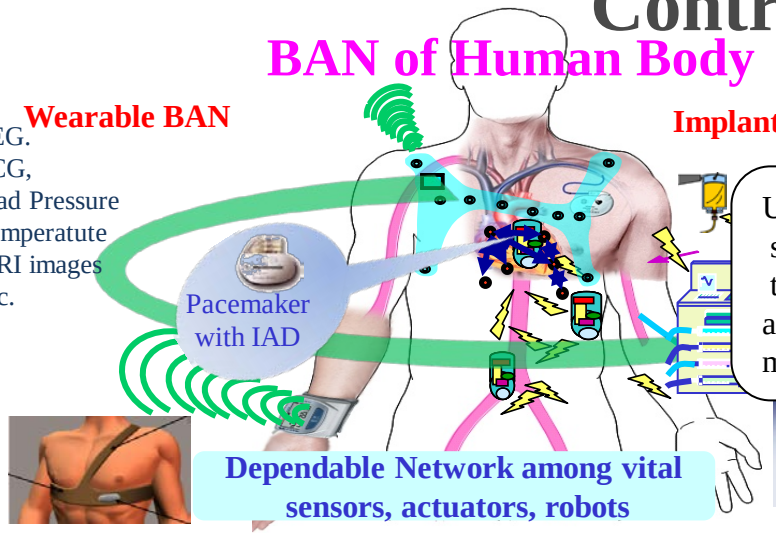
- **BAN** has been applied for wireless **sensing and controlling for Dependable Medicine.**
- **BAN** can be also applied for **reliable, safe, resilient or dependable wireless sensing and controlling of machine, that is Dependable IoT/ M2M or BAN of Things.**

Demands of Dependability for Sensing and Controlling for M2M

BAN of Human Body

Wearable BAN

EEG.
ECG,
Blad Pressure
Temperatute
MRI images
Etc.



Implant BAN

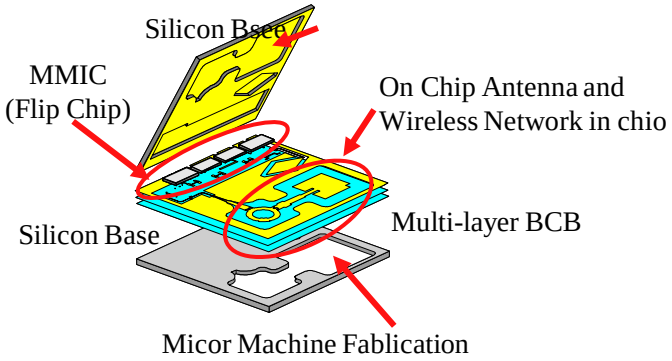
UWB can solve such a problem that radio interferes a human body and medical equipments

Capsule Endoscope

Dependable Network among vital sensors, actuators, robots

Dependable BAN for Medical Healthcare

BAN of Device Body

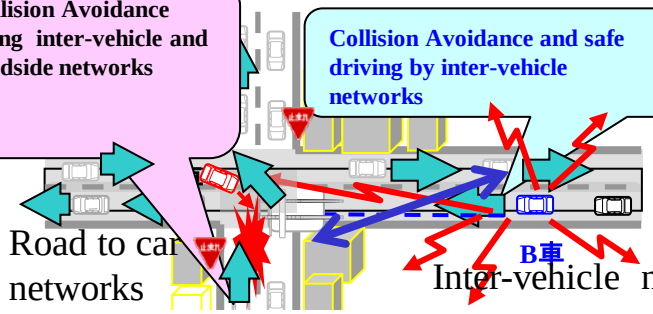


Dependable Wireless System Clock in Micro Circuit & Network in Devices

BAN of Car Body

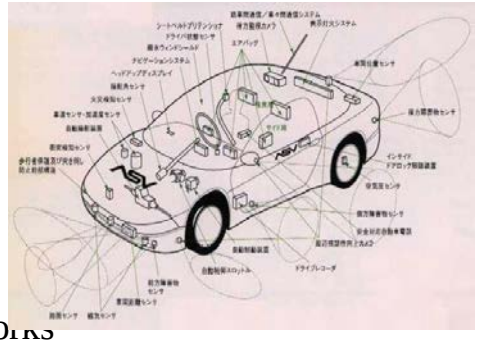
Collision Avoidance Using inter-vehicle and roadside networks

Collision Avoidance and safe driving by inter-vehicle networks



Road to car networks

Inter-vehicle networks

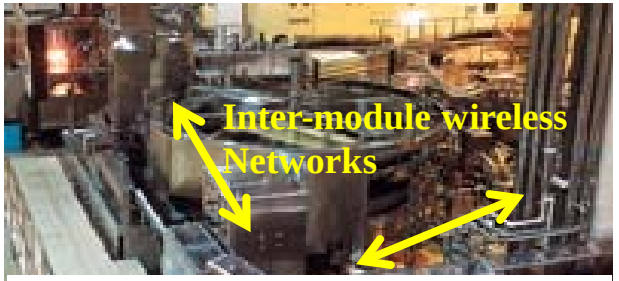


Car Navigation & Collision Avoidance Radar

Car LAN & Wireless Harness

Dependable Wireless Networks for Transportation

BAN of Factory



Factory Automation (FA)

Dependable Wireless Sensing & Controlling for Manufacturing (CIM)

Dependable IoT and M2M for Advanced Driver Assistance Systems

- 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?

Demands for Dependable M2M and IoT in Industrial Automation and Broadcast

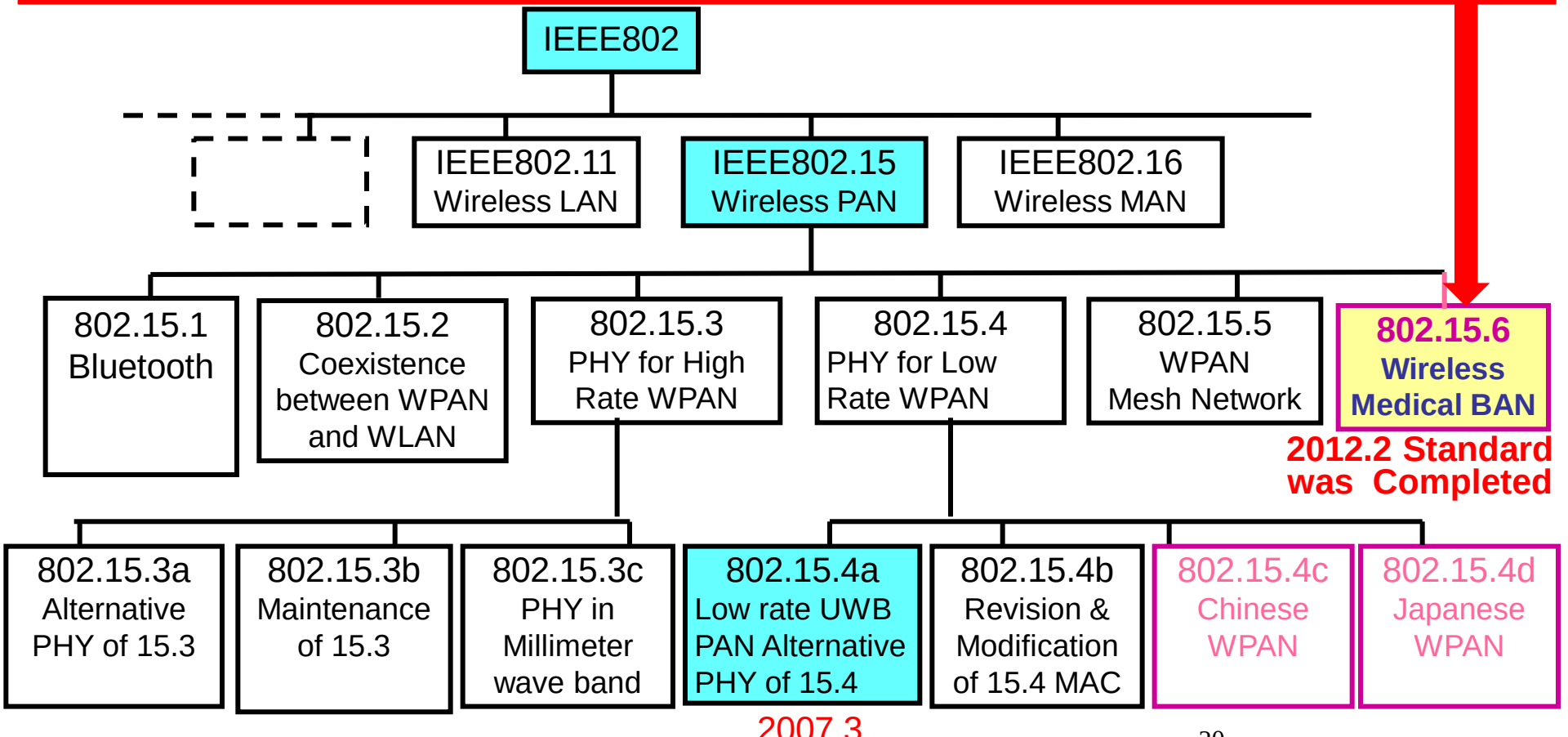
Demands for Internet of Things increase but Machine-to-Machine (M2M) should be reliable and secure, so Dependable BAN for Medicine must be good matched with Dependable M2M and IoT.

Demands and Subjects of Dependable IoT/M2M in Industry and Academic

- **Demands in Industry**
  - Much more reliable and secure **Dependable Wireless for M2M controlling** must open innovation in business while current mobile ICT, LTE and 4G may be saturated.
  - **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 beyond 5G.**
- **Research Subjects in Academia**
  - **Joint Optimization in Multiple Layers** for Dependable Wireless
  - Multi Disciplinary R&D subjects among **Control Theory and Communication Theory**

Standardization of BAN(IEEE802.15.6 Amendment and ETSI Smart BAN)

IEEE802.15 IG-DEP Started Amendment of BAN Standard（IEEE802.15.6）for MAC, Security and Others Issues since July 2012.



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]

*1 Yokohama National University, Japan
*2 Centre for Wireless Communications (CWC), University of Oulu, Finland
*3 University of Oulu Research Institute Japan CWC-Nippon

IEEE 802.15 IG DEP

Review of Responses to Call for Interest(CFI)

Bangkok, Thailand
September, 2015

Ryuji Kohno, Jussi Haapola

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

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

Focused Potential Applications

We have been discussing on focused potential applications according to demands in a world.

1.Automotive

- 1.1Car Internal M2M
- 1,2 Inter-vehicle M2M
- 1.3 Remote Diagnosis in Factory

2. Medical Healthcare

- 2.1 Wellness, Wellbeing
- 2.2 Healthcare
- 2.3 Professional Medicine

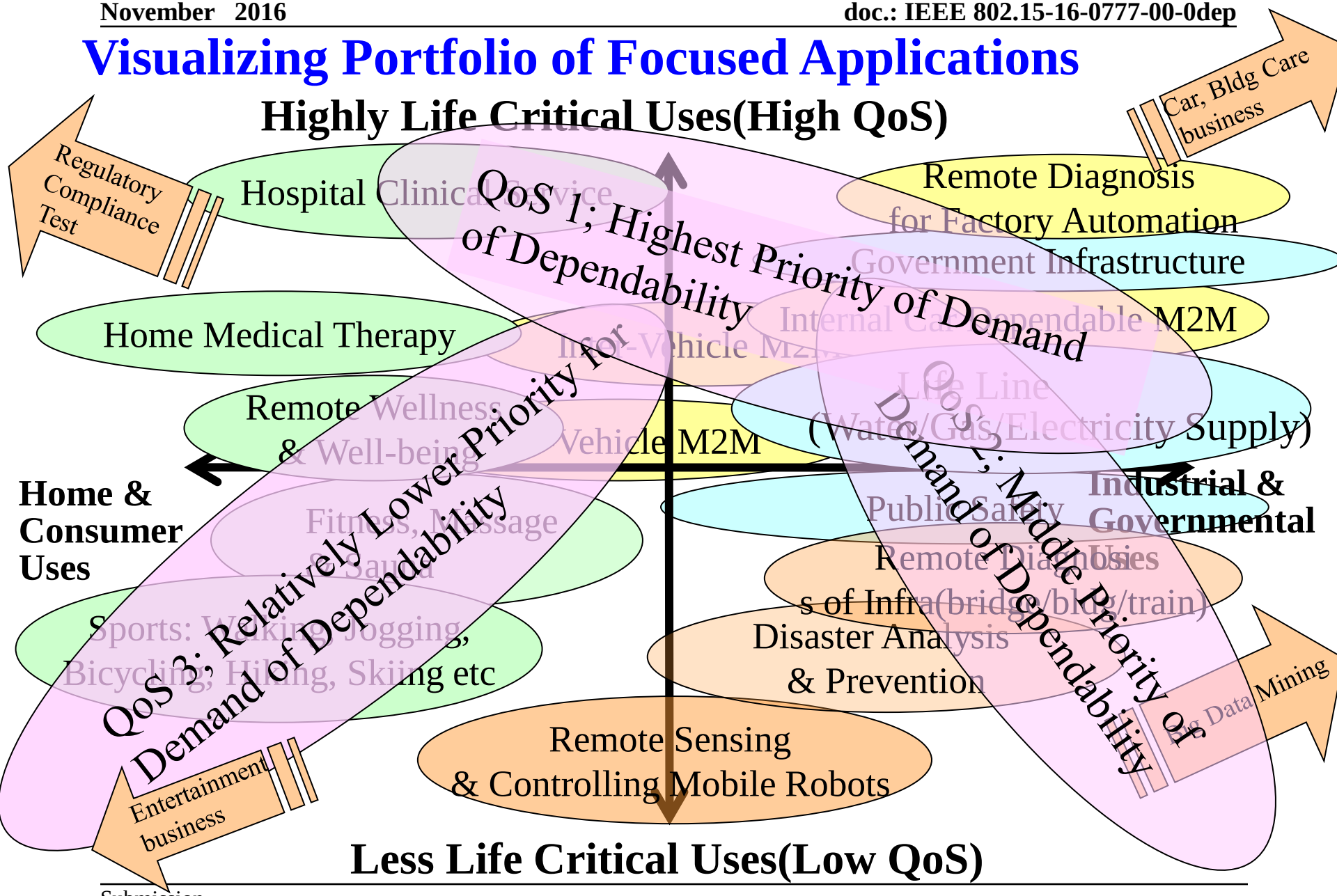
3. Social Public Service

- 3.1 Life Line (Water/Gas/Electricity Supply)
- 3.2 Public Safety
- 3.3 Government System

4. Remote Infra Monitoring and Maintenance

- 4.1 Remote Diagnosis of Infra(bridge/bldg/train)
- 4.2 Remote Sensing and Controlling Mobile Robots
- 4.3 Disaster Analysis and Prevention

Visualizing Portfolio of Focused Applications



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

1.1Car 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

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

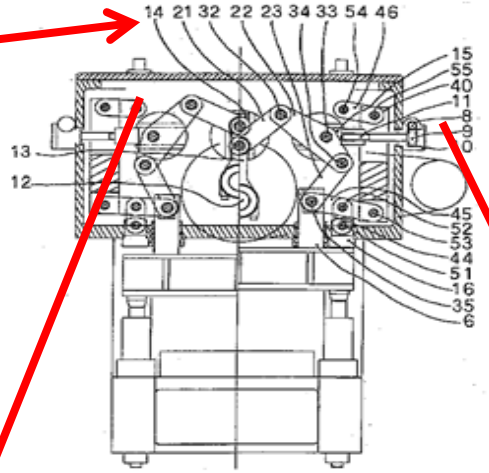
(Case 6) **Would a good wireless solution benefit your application?**

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

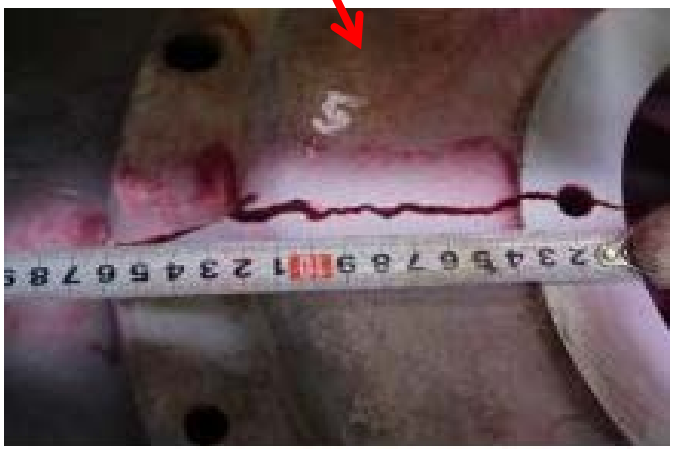
Wireless sensing and controlling system for Factory

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

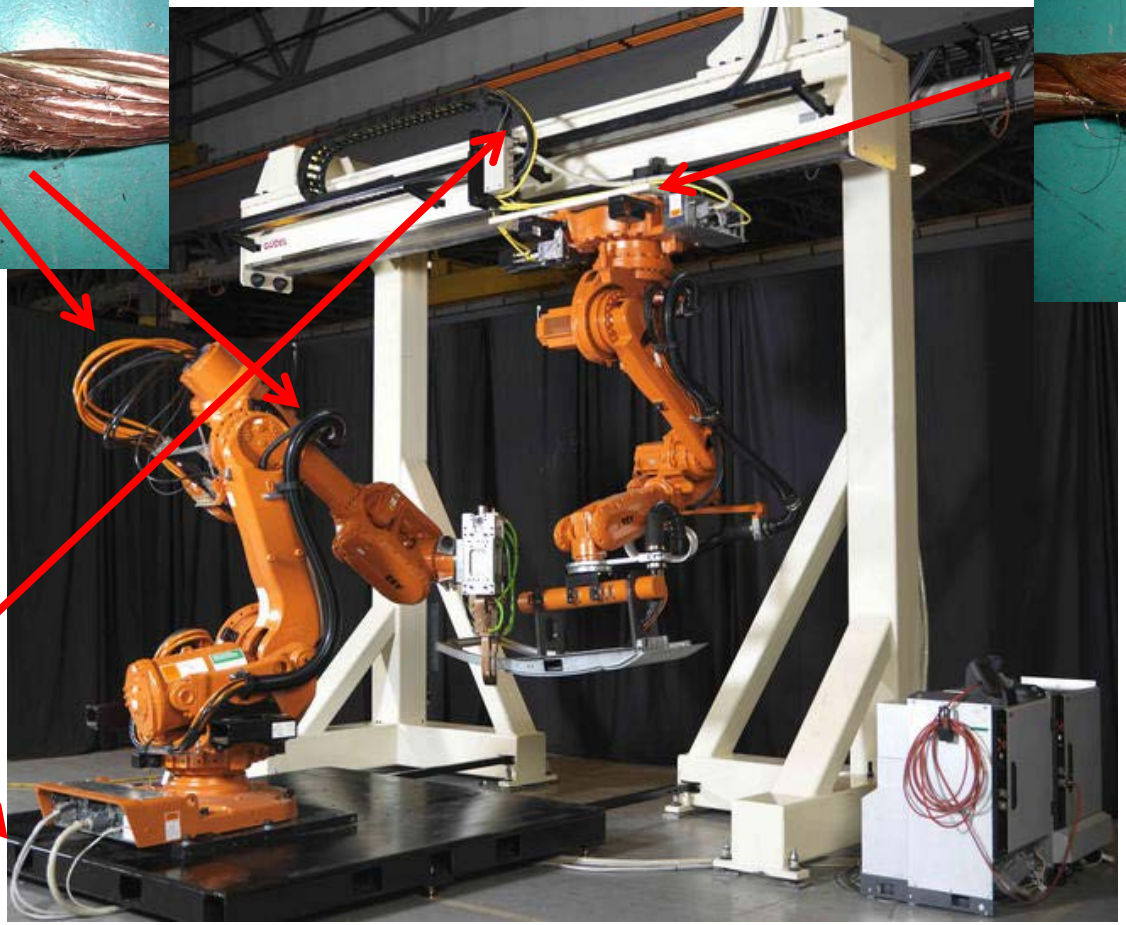
Use case 1; Detection of Cracks in Press Machine



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



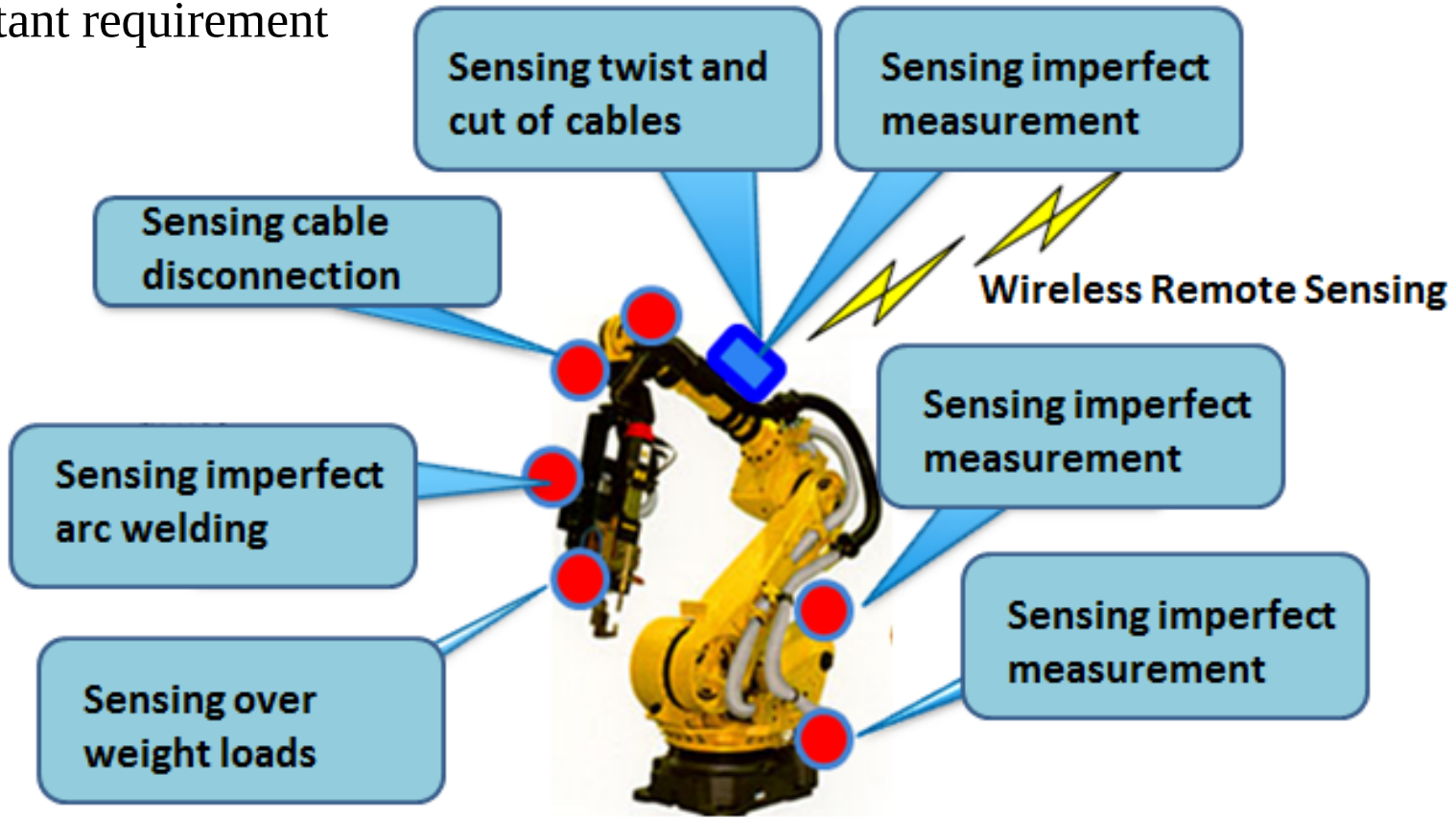
Use case 2; Detection of Twist and Cut of Cables



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



Required specification

- 3 types of Diagnosis System
  1. Equipment Diagnosis System in Real-time with rea-time feedback
     1. Real-time measuring
     2. Judge immediately with a certain threshold level
  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. 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

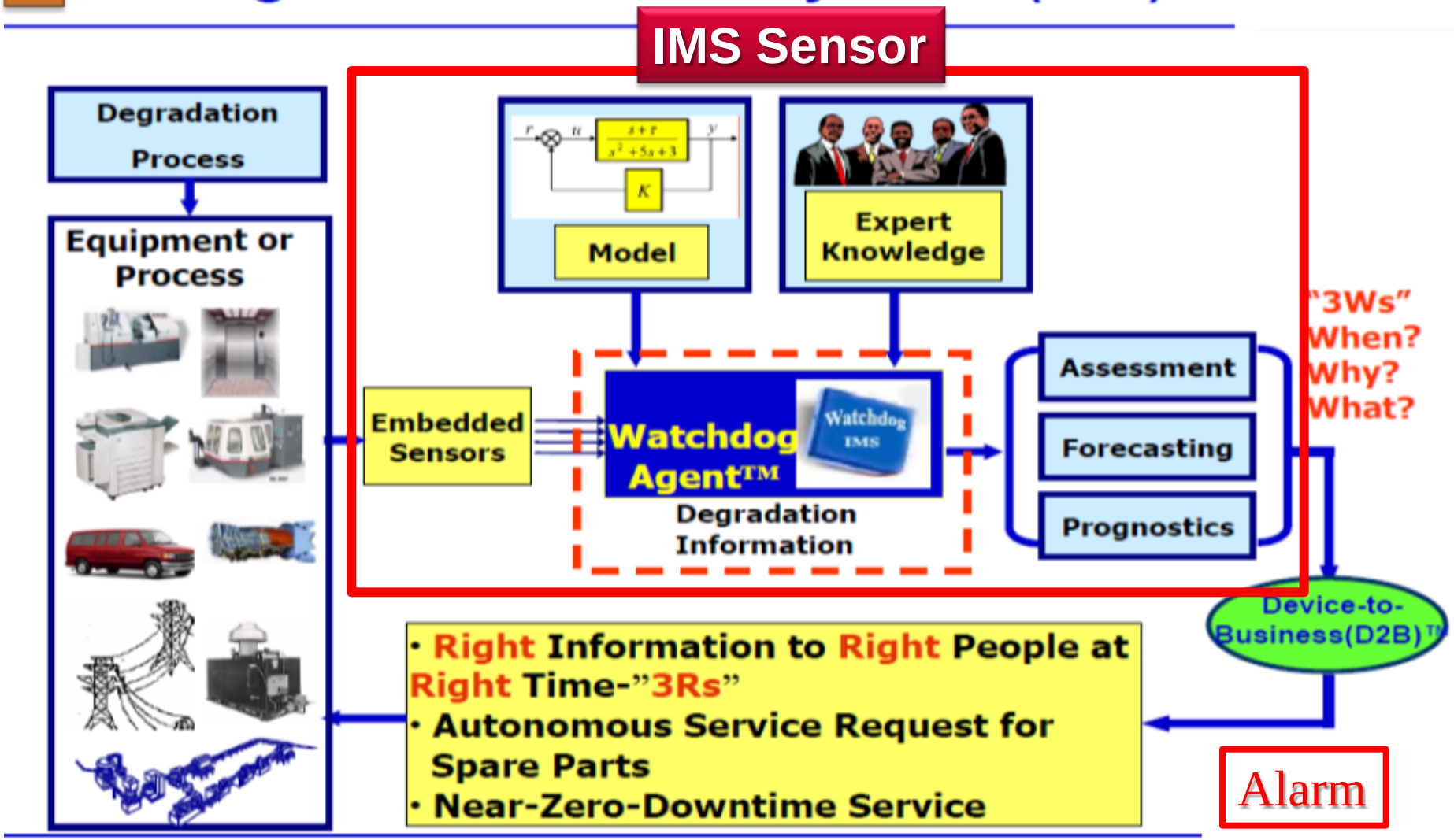
A

B

C

A

Intelligent Maintenance Systems (IMS)



Required specification

- 3 types of Diagnosis System
  1. Equipment Diagnosis System in Real-time with rea-time feedback
     1. Real-time measuring
     2. Judge immediately with a certain threshold level
     3. Send alarm
  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. 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

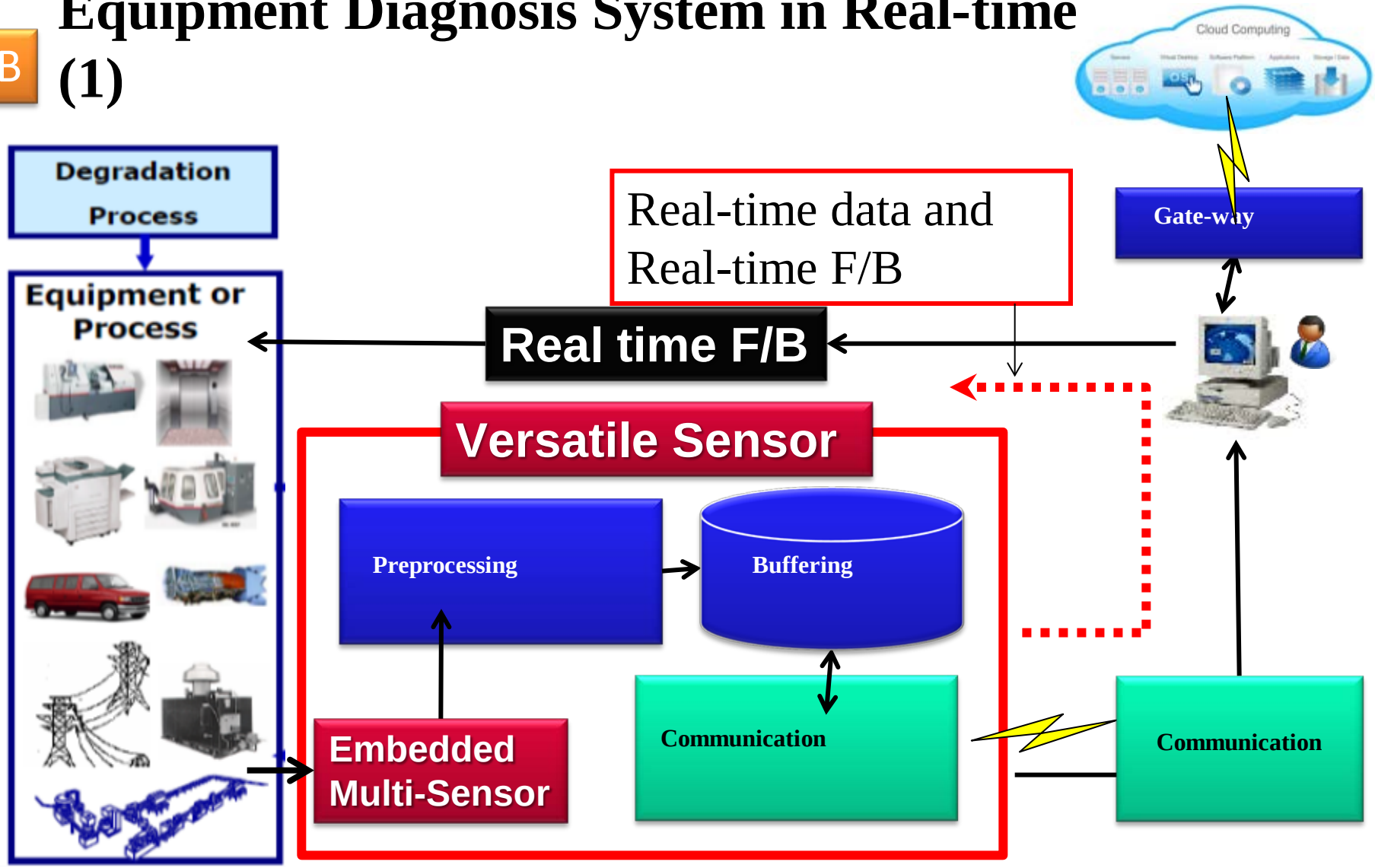
A

B

C

Equipment Diagnosis System in Real-time (1)

B



(Case 9) **Would a good wireless solution benefit your application?**

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

Major applications for

-Disasters such as earthquake, tsunami, typhoon, hurricane, water flood etc:

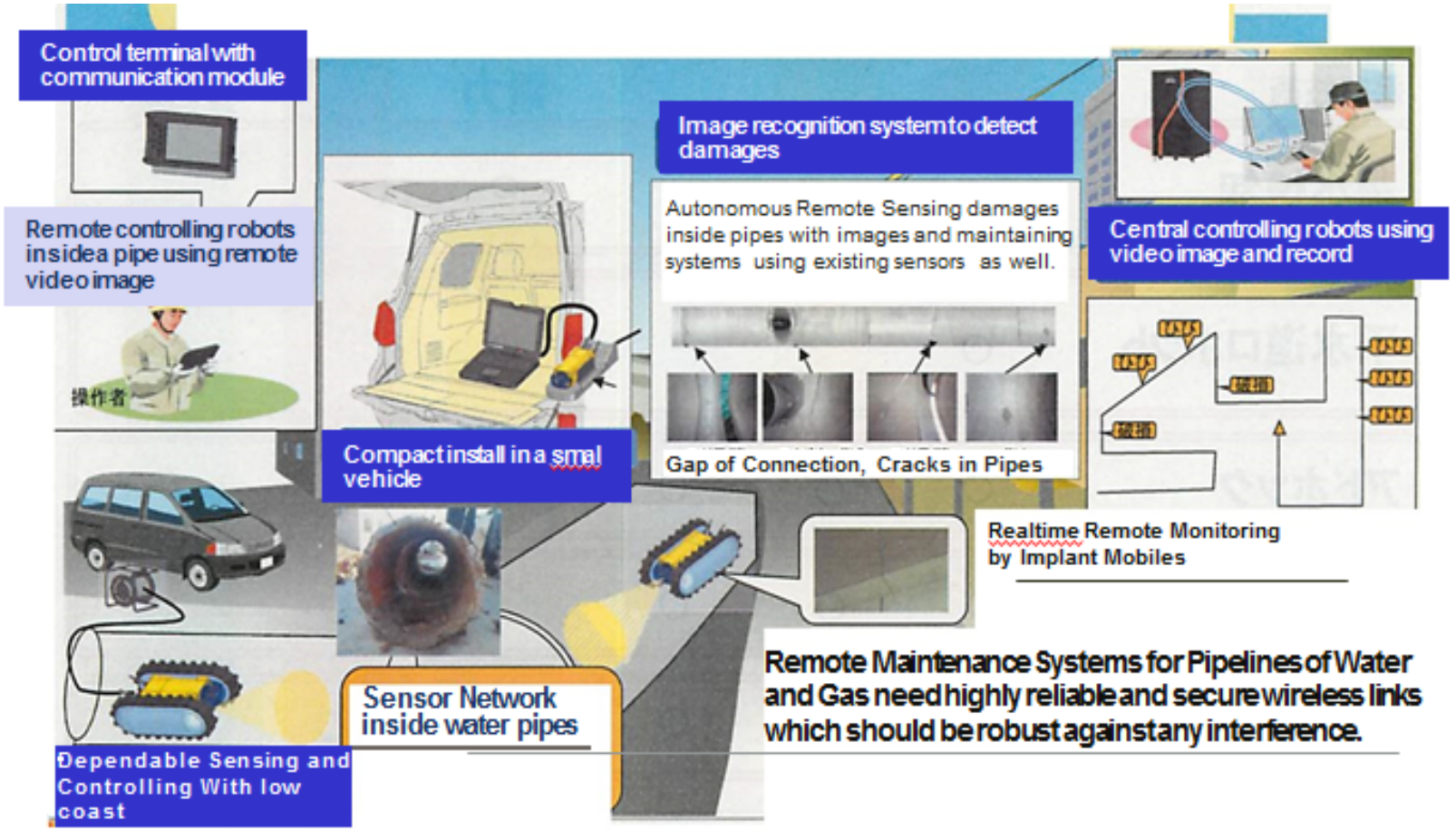
- Disaster prevention
- Rescue and evacuation
- Recovery

-Social service infrastructures:

- Water supply and control networks
- Gas supply and control networks
- Electricity supply and control networks
- Other city services

doc.: IEEE 802.15-16-0777-00-0dep

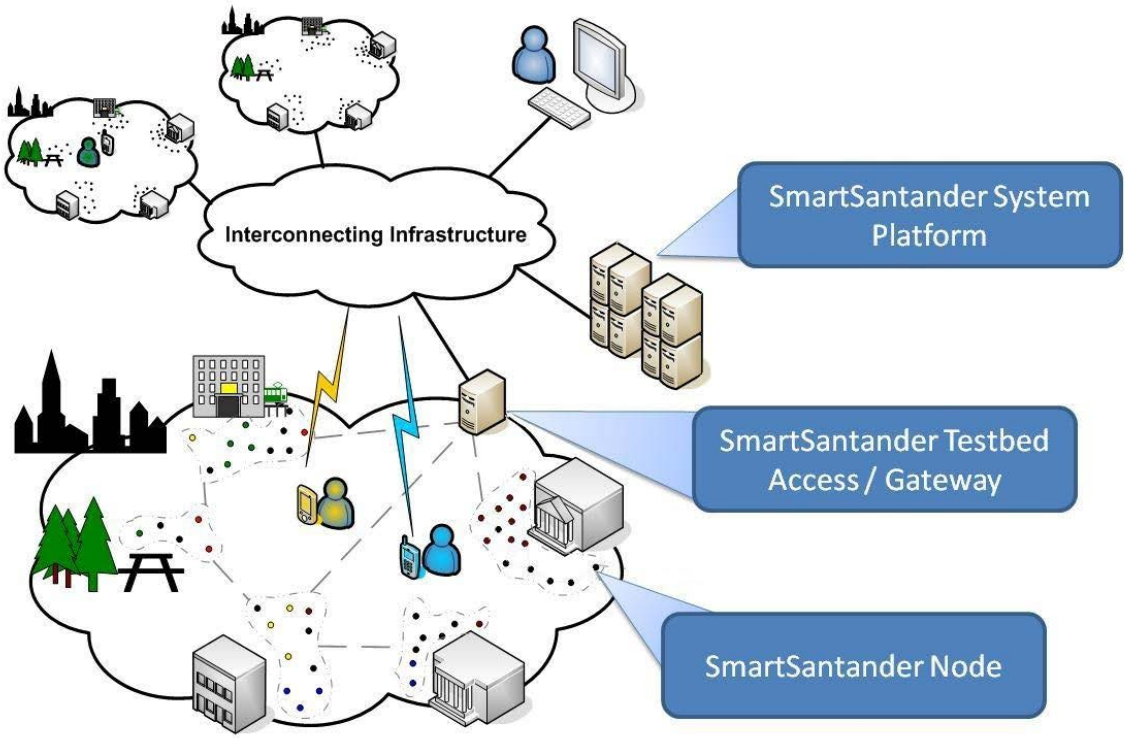
Water Pipeline Maintenance System



Public Wastes Collection System

Social Facility of Smart City Santander in Spain

The Santander testbed is composed currently of around 2000 IEEE 802.15.4 devices deployed in a 3-tiered architecture.



Refereed from http://www.smartsantander.eu

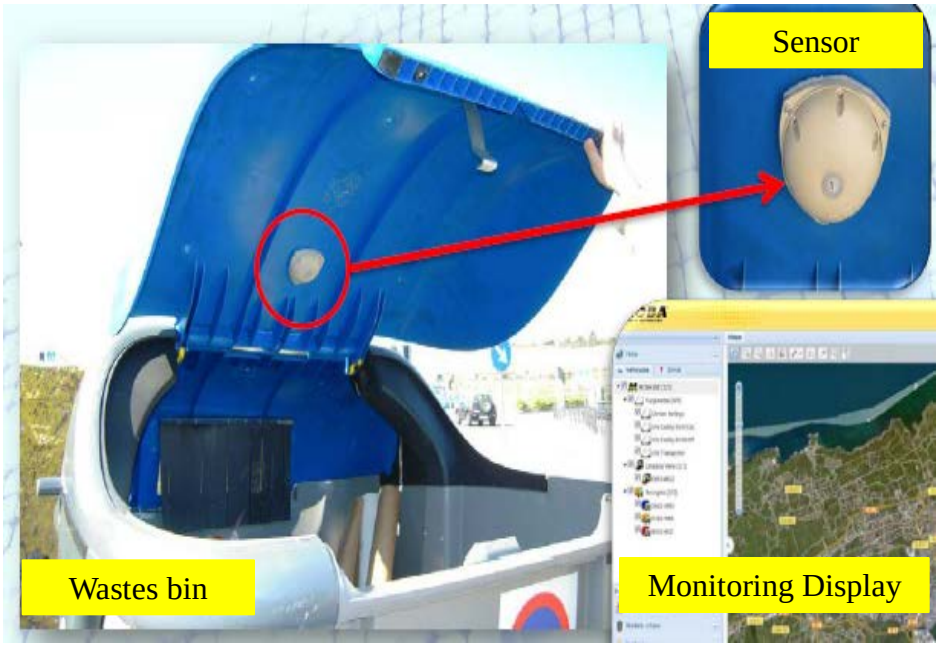
Key Functions

Validation of approaches to the architectural model of the IoT.
Evaluation of the key building blocks of the IoT architecture, in particular, IoT interaction & management protocols and mechanisms; device technologies; and key support services such as discovery, identity management and security.
Evaluation of social acceptance of IoT technologies and services.

Wireless Sensor Network for Public Wastes Collection

•Optimization of wastes collection by utilizing sensor and M2M network has been operated since 2014 with ASCAN as the first practical application of Smart City.

http://www.nec.com/en/press/201410/global_20141007_03.html



- Transmit volume of wastes with its location information via M2M network in real time.
- Analyze above information and display the optimized route and timing on onboard monitor in collection vehicles.
- NEC and ASCAN to launch pioneering smart waste collection service in Santander
- Real-time data on bin levels enables city to optimise collection intervals and routes and reduce refuse vehicle emissions and running costs

Combination of sensor, M2M network and big data analytics

Efficient collection	Cost reduction	CO2 reduction	Relaxation of traffic jam	Improved community environment

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?

Join in International Standardization of a New Standard of Dependable IoT/M2M in IEEE802.15IG-Dep

- **Amendment of Existing Standard of Medical BAN IEEE802.15.6 to Dependable IoT/M2M or BAN of Things**
  - An international standard of medical wireless Body Area Network(BAN) **IEEE802.15.6** was established in 2012.
  - However, demand for higher reliability and security, so-called "dependability" increases in medical and other life-critical applications.
  - So, **Medical Device Regulatory Science (MDRS) Consortium and Automotive Industry** have been promoting a new standard of **Dependable Wireless Network** in **IEEE802.15 IG-DEP**.
  - **Please join us this new standard promotion!**

Contacts and Conference call

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