Submission Title: [Review of IG Dependability Activities for Cars and other IoT & M2M Use cases and Amendment of IEEE802.15.6 Wireless Medical BAN]

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Source: [Ryuji Kohno1,2,3] [1; Yokohama National University, 2; Centre for Wireless Communications (CWC), University of Oulu, 3; University of Oulu Research Institute Japan CWC-Nippon]

Address [1; 79-5 Tokiwadai, Hodogaya-ku, Yokohama, Japan 240-8501
2; Linnanmaa, P.O. Box 4500, FIN-90570 Oulu, Finland FI-90014
3; Yokohama Mitsui Bldg. 15F, 1-1-2 Takashima, Nishi-ku, Yokohama, Japan 220-0011]

Voice:[1; +81-45-339-4115, 2; +358-8-553-2849], FAX: [+81-45-338-1157],
Email:[1: kohno@ynu.ac.jp, 2: Ryuji.Kohno@oulu.fi, 3: ryuji.kohno@cwc-nippon.co.jp]

Abstract: [In order to reconsider IG-DEP, first its activities is reviewed. A demand of BAN-base medical platform with cloud and AI data mining server and repository is introduced. To include medical BAN-base platform, possibility of amendment of medical BAN standard IEEE802.15.6 is discussed.]

Purpose: [information]

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Review of IG Dependability Activities for Cars and other IoT & M2M Use cases and Amendment of IEEE802.15.6 Wireless Medical BAN
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. Focused Use case; Automotive Use Cases
6. Summary of Technical Requirement for Automotive
7. Technical Requirement for Automotive and UAV
8. Demand of Medical Infrastructure Platform of BAN, Cloud Networks and AI Data Mining Server and Repository
9. Review of IEEE802.15.6 for Medical WBAN
10. Discussion; Possible Amendment of IEEE802.15.6
Industry 4.0
Machine Centric Communications for Cyber Physical Systems

Dependability is the most important issue in Industry4.0.
Depends of Dependable IoT and M2M for Sustainable Social Services

- Population Ageing & Medical crisis
- Cost of energy ... fuel supply & demand
- Increasing environmental requirements
- Escalating security concerns
- Heightened investor demands

Healthcare Service (Medical ICT)
Energy Network (Smart Grid)
CO₂ Reduction, Green Innovation
Public Safety, National Defense
Global Borderless Economics

Ryuji Kohno (YNU, CWC, CWC-Nippon), July 2018
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.
- Since March, 2017, IoT in factory such as flexible factory project (FFPJ) has been discussed in joint session between IEEE802.1 and 802.15.
- in order to show up demand of car manufactures and electronics, IG-DEP is preparing for tutorial session at July, 2017 meeting in Berlin.
- IG-DEP requests IEEE802.15 TG-SRU, 802.24, 802.12, 15.4s, 15.1 and IETF 6TiSCH to commit this activities.
- Medical device industry requests a standard of overall platform of BAN, could network and AI data mining server and repository by integration of ICT and data science.
2. Discussion Items in Previous Meetings (1/3)

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 usable 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 audio/video, air condition etc. would greatly benefit from wireless dependable technologies.
   - The systems would be a one whole set however.

6. Car and car electronics factories need a new standard for maintaining their manufacturing lines in a dependable manner.
2. Discussion Items in Previous Meetings (2/3)

To pursue dependability in network may be possible to go beyond IEEE 802.15 scope. 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: Collect trending retransmissions and other info to prevent failures.

(2) Link Layer: 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: MIMO and multipath are friends of dependability with PHY layer redundant links.

• PHY layer can be adaptable to environment, by switching frequency particularly, if you are in a null.
• 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.
After long discussion of use case and applications, we decided to focus on internal car network, inter-vehicle network, and car and car electronics factory network.

According to interview of car and car electronics manufactures, technical requirement has been summarized.

Draft of PAR and CSD have been summarized.

The meanwhile, additional use cases such as dependable sensing and controlling UAVs and rehabilitation robotics have been come up.

Technical requirement has been updated corresponding to the additional use cases.

To increase participants of IG DEP, other groups taking care of related subjects and technologies have been invited for discussion and collaboration.

Lately medical device industry requests to make a standard of medical infrastructure platform by BAN, cloud networks, and AI data mining server and repository by integration of ICT and data science.

So, again amendment of wireless medical BAN standard IEEE802.15.6 has been reconsidered.
3. Dependability in Wireless Networks

• Meanings of Dependability:
  – “Dependability in network” means to guarantee lowest performance enough high in a sense of highly reliable, safe, secure, fault tolerant, robust services by showing numerical worst and average performances with remained uncertainty in specific defined classes of environment.
  – This is based on the concept of “regulatory science.”

• Demand for Dependable Networks:
  – Highly dependable communications for IoT/M2M sensing and controlling medical healthcare, car, UAV, robotics and others is necessary in smart car, factory, and city as well as emergency environment such as natural disasters.
  – Numerical parameters to evaluate advantage and drawback of technologies are defined and their permissible ranges by showing remained uncertainty are agreed by all stakeholders such as users and manufactures, i.e. the concept of regulatory science.
Regulatory Science to Guarantee Dependability and Compliance in case of Medicine and Medical Devices

- Investigate Risk versus Benefit for New Medicine and Medical Devices
- Scientific Quantification of Risk vs Benefit by numerical evaluation
- Rule Making to balance between Risk and Benefit by consensus
- Decision & Action according to Regulation understanding uncertainty

To enhance dependability of wireless systems, Regulatory Science is useful while showing risk vs benefit with cost and remained uncertainty because it can protect not only users but also manufactures.
Human Impact vs BER according to Radio Emission Power

Pennes’s Thermal Propagation Equation

\[ c_p \frac{\partial T}{\partial t} = \nabla \cdot (\kappa \nabla T) + A_0 + Q_t - b(T - T_b) \]

1st term; Thermal Propagation
2nd Term; Thermal Radiation to keep proper temperature
3rd Term; Thermal Volume by Millimeter wave
4th term; Thermal Change due to Blood Stream

EIRP of Emission Power \( P_t \) and Antenna Gain \( G_t \) for a distance \( R \)

\[ E = \sqrt{\frac{49P_t G_t}{R}} \]

Then, radio emission power or SAR must be a numerical parameter to evaluate risk versus benefit of radio medical devices.
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
Possible Use Cases of Dependable M2M and BAN for Sensing and Controlling

- Car Navigation & Collision Avoidance Radar
- Dependable Wireless Networks for Transportation
- Wearable BAN
- Implant BAN
- Dependable BAN for Medical Healthcare
- Dependable Wireless System Clock in Micro Circuit & Network in Devices

- 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 LAN & Wireless Harness
- Inter-module wireless Networks
- Factory Automation (FA)
- Dependable Wireless Sensing Controlling for Manufacturing (CIM)

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

- On Chip Antenna and Wireless Network in chio
- Multi-layer BCB
- Silicon Base
- MMIC (Flip Chip)
- Capsule Endoscope
- Pacemaker with IAD
- EEG, ECG, Blad Pressure, Temperature, MRI images, Etc.

- Dependable Network among vital sensors, actuators, robots

- Ryuji Kohno (YNU, CWC, CWC-Nippon),
- Doc.: IEEE 802.15-18-0347-00-0dep
- Submission
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
Visualizing Portfolio of Focused Applications
Highly Life Critical Uses (High QoS)

QoS 1: Highest Priority of Dependability

Remote Diagnosis for Factory Automation
Home Medical Therapy
Hospital Emergency Service

QoS 2: Middle Priority of Dependability

Remote Sensing & Controlling Mobile Robots
Remote Well-being & Health Management
Home & Consumer Uses

QoS 3: Relatively Lower Priority of Dependability

Remote Diagnoses of Infra (bridge/bldg./train)
Visualizing Portfolio of Focused Applications
Industrial & Governmental Uses

Less Life Critical Uses (Low QoS)

Remote Diagnosis & Well-being
Disaster Analysis & Prevention
Government Infrastructure

Submission

YNU, CWC, CWC-Nippon,
Ryuji Kohno

July 2018
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
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

Automated Driving is leaving the Research Labs. Soon it will be in mass 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.
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.
Collision Avoidance Radar and Automatic Braking Using Wireless Dependable M2M/BAN

Wireless Feedback Sensing and Controlling Loop for Autonomous Driving

Controller $u[k]$ $\alpha[k]$ Car Axel/Brake Model and Radar System

Feedback Delay Loop Model with Motion Equation

Submission

July 2018

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Response to CFI: Case 6

Hiroshi Kobayashi, Nissan Automotive Co. Ltd.

Update in Development of Wireless Sensing System for Factory
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.
Joint Japan and New Zealand Project for Search and Rescue in Disaster by Using Multipole UAVs (Drones)

- UAVs or drones which can…
  - be used indoor and outdoor
  - be operated by anyone
  - hover in mid air stably
  - be easy remote controllable

is suitable for search and rescue victims.

Subject: Dependable Sensing and Controlling Multiple Drones

After 311 (March 11, 2011) earthquake and Tsunami, Dependable Wireless has been more important for Disaster Prevision and Recovery.
2016-2017 New Zealand (UC)-Japan (YNU) Joint Project;
Dependable Wireless Body Area Networks to Support Search and Rescue and Medical Treatment in Disaster Scenarios Using Multiple UAVs

Step 1: Positioning for anchor node UAVs using GNSS
Step 2: Expanding ranging area by recursive process

Base station
Anchor nodes
Victim
Unexplored area episode
mobile’s base station
Remote Localization and Rescue of Missing Victims Using Wireless Dependable BAN of Things/M2M

Wireless Feedback Sensing and Controlling Loop for Rescue of Victims

Feedback Delay Loop Model with Motion Equation

For Remote Controlling UAVs

Navigation

By Using GNSS and Localization of UAVs/Drones

Missing Victims
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.
6. Focused Use Case: 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

In addition, UAV for disaster rescue and robotics for rehabilitation can be covered.
7. 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)
7. 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.
7. 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?
## 7. Technical Requirements (1/6)

<table>
<thead>
<tr>
<th></th>
<th>Car bus supplement</th>
<th>V2V</th>
<th>V2I</th>
<th>Factory automation</th>
<th>UAV(Drone) Remote Sensing and Controlling</th>
<th>Reference standard 802.15.6</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of sensors</strong></td>
<td>Up to ten per network</td>
<td>Up to Few tens</td>
<td>Less than ten</td>
<td>Up to ten per network</td>
<td>Up to ten (ex. camera, GPS etc.)</td>
<td>256</td>
</tr>
<tr>
<td><strong>Support for multiple network co-existence &amp; interoperability</strong></td>
<td>Less than 100</td>
<td>Up to Few tens</td>
<td>Less than 50</td>
<td>Up to 100</td>
<td>Up to ten (ex. at least 4 drones for relative localization)</td>
<td>0</td>
</tr>
<tr>
<td><strong>Topology</strong></td>
<td>Extended star</td>
<td>mesh</td>
<td>Star</td>
<td>Star + bus</td>
<td>Star (dynamic allocation changing a coordinator)</td>
<td>(extended) star+one hop</td>
</tr>
<tr>
<td><strong>Data rate</strong></td>
<td>Comparabile to CAN, RIM or FlexRay</td>
<td>Up to 2 Mbps/vehicle</td>
<td>Up to 2 Mbps/sensor</td>
<td>2 Mbps/sensor</td>
<td>Up to several ten Mbps/camera/drone</td>
<td>1 Mbps (mandatory rate)</td>
</tr>
<tr>
<td><strong>Aggregate data rate over interoperating networks</strong></td>
<td>Few hundred Mbps</td>
<td>Few hundred Mbps</td>
<td>Few hundred Mbps</td>
<td>Up to 1 Gbps</td>
<td>Up to several Mbps/drone</td>
<td>N/A</td>
</tr>
</tbody>
</table>

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**July 2018**

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Ryuji Kohno (YNU, CWC, CWC-Nippon)
## 7. Technical Requirements (2/6)

<table>
<thead>
<tr>
<th>Car bus supplement</th>
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<th>UAV(Drone) Remote Sensing and Controlling</th>
<th>Reference standard 802.15.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latency in normal operation</td>
<td>Comparable to CAN, RIM or Flex Ray</td>
<td>250 ms to 1s</td>
<td>250 ms to 1s</td>
<td>250 ms to 500 ms</td>
<td>Typical 50 to 100 ms Ref. 15.4e</td>
</tr>
<tr>
<td>Latency in critical situation</td>
<td>Comparable to CAN, RIM or Flex Ray</td>
<td>100 ms</td>
<td>100 ms</td>
<td>Few ms to 15 ms *</td>
<td>Several 10 ms</td>
</tr>
<tr>
<td>Association delay</td>
<td>N/A</td>
<td>Same direction &lt; 1 s</td>
<td>&lt; 500 ms</td>
<td>&lt; 1 s</td>
<td>&lt; 100ms</td>
</tr>
<tr>
<td>Authentication and security delay</td>
<td>N/A</td>
<td>Same direction &lt; 1 s</td>
<td>&lt; 500 ms</td>
<td>&lt; 1 s</td>
<td>N/A</td>
</tr>
</tbody>
</table>

## 7. Technical Requirements (3/6)

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Delivery ratio requirement</strong></td>
<td>&gt; 99.9%</td>
<td>&gt; 99.9%</td>
<td>&gt; 99%</td>
<td>&gt; 99%</td>
<td>&gt; 99.9%</td>
<td>95%</td>
</tr>
<tr>
<td><strong>Disconnection ratio (of time)</strong></td>
<td>&lt; 0.01%</td>
<td>&lt; 1%</td>
<td>&lt; 2%</td>
<td>&lt; 0.01%</td>
<td>&lt; 0.001%</td>
<td>?</td>
</tr>
<tr>
<td><strong>Synchronization recovery time</strong></td>
<td>&lt; 100 ms</td>
<td>&lt; 100 ms</td>
<td>N/A</td>
<td>&lt; 100 ms</td>
<td>&lt; 70 ms</td>
<td>Seconds</td>
</tr>
<tr>
<td><strong>Coverage range</strong></td>
<td>6 m</td>
<td>200 m (highway)</td>
<td>400 m (highway)</td>
<td>5 m</td>
<td>100m(among drones) Several km(with controller)</td>
<td>&lt; 10 m</td>
</tr>
<tr>
<td><strong>Feedback loop response time</strong></td>
<td>&lt; 10 ms</td>
<td>&lt; 1 s</td>
<td>N/A</td>
<td>&lt; 1 s</td>
<td>&lt; 10 ms</td>
<td>&lt; 500 ms</td>
</tr>
</tbody>
</table>
## 7. Technical Requirements (4/6)

<table>
<thead>
<tr>
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<th>Reference standard 802.15.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handover capability</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>&lt; 2 s</td>
<td>N/A</td>
<td>Not defined</td>
</tr>
<tr>
<td>Data packet size</td>
<td>CAN and RIM compatiblity</td>
<td>802.11 compatible</td>
<td>802.11 compatible</td>
<td>10 to 1000 bytes</td>
<td>802.11 compatible</td>
<td>Up to 255 octets</td>
</tr>
<tr>
<td>Jitter: typical max</td>
<td>5 ms</td>
<td>N/A</td>
<td>N/A</td>
<td>50 ms</td>
<td>N/A</td>
<td>QoS dependent</td>
</tr>
<tr>
<td>Jitter: critical max: 5% outliers acceptable</td>
<td>5 ms</td>
<td>N/A</td>
<td>N/A</td>
<td>5 ms</td>
<td>N/A</td>
<td>QoS dependent</td>
</tr>
</tbody>
</table>
7. Technical Requirements (5/6)

<table>
<thead>
<tr>
<th>Multiuser support (A) Intra network interference</th>
<th>Car bus supplement</th>
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<th>Factory automation</th>
<th>UAV(Drone) Remote Sensing and Controlling</th>
<th>Reference standard 802.15.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver/Passengers room: &lt;10</td>
<td>&lt;50 according to car cluster</td>
<td>&lt;20 according to car cluster</td>
<td>&lt;50 according to coverage range</td>
<td>&lt;10 according to no. of drones cluster</td>
<td>By a few use case models, worst interference can be defined</td>
<td></td>
</tr>
</tbody>
</table>

| Engine room: <10                                 | Engine room: <10 |

| (B) Inter network interference (number of coexisting networks) | Driver/Passengers room: < 5 | <10 according to car cluster | <10 according to car cluster | <10 according to factory condition | <5 according to no. of drones cluster | By a few use case models, worst interference can be defined. |

| Engine room: < 2 kinds | Engine room: < 2 kinds |
### 7. Technical Requirements (6/6)

<table>
<thead>
<tr>
<th>Channel model resilience</th>
<th>Car bus supplement</th>
<th>V2V</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Driver/Passengers room: Light multipath</td>
<td>Mostly line of sight with some shadowing</td>
<td>Mostly line of sight with some shadowing</td>
<td>Heavy multipath with shadowing</td>
<td>Line of sight</td>
<td>By a few use case models, worst interference can be defined</td>
<td></td>
</tr>
<tr>
<td>Engine room: Heavy multipath with shadowing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No Line of sight using camera</td>
<td></td>
</tr>
</tbody>
</table>

July 2018

Ryuji Kohno (YNU, CWC, CWC-Nippon)
8. Demand of Medical Infrastructure Platform of BAN, Cloud Networks and AI Data Mining Server and Repository
8.1 Wireless BAN: Body Area Network

Wearable BAN
Tele-metering or sensing vital signs with various sensors
- ECG
- EEG
- Blood Pressure
- Heart Beat
- Body temperature
- Sugar rate
- Medical images
- And video
- Etc.

Implant BAN
Tele-control of Medical Equipment and Devices
- Pace Maker with ICD
- Wireless Capsule Endoscope

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

Ryuji Kohno (YNU, CWC, CWC-Nippon),
8.2 Standard of Medical Wireless Body Area Network (BAN); IEEE802.15.6

- 802.15.1 Bluetooth
  - 802.15.3a Alternative PHY of 15.3
  - 802.15.3b Maintenance of 15.3
- 802.15.2 Coexistence between WPAN and WLAN
  - 802.15.3c PHY in Millimeter wave band
- 802.15.3 PHY for High Rate WPAN
  - 802.15.4a Low rate UWB PAN Alternative PHY of 15.4
  - 802.15.4b Revision & Modification of 15.4 MAC
- 802.15.4 PHY for Low Rate WPAN
  - 802.15.4c Chinese WPAN
  - 802.15.4d Japanese WPAN
- 802.15.5 WPAN Mesh Network
  - 802.15.5 Chinese WPAN
  - 802.15.5 Japanese WPAN

IEEE802

IEEE802.11 Wireless LAN

IEEE802.15 Wireless PAN

IEEE802.16 Wireless MAN

802.15.6 Wireless Medical BAN

2012.2 Standard was Completed

2007.3 Standard Completed
8.3 BAN-base Medical Infrastructure Based on ICT and Data Science

Medical support for developing countries

University of Oulu & Yokohama National Univ. Medical ICT Center AI Data Mining Center: Watson

BAN

Satellite Link

WINDS

Big Data

Network Cloud

Internet

Cellular Network

Data mining

UoO & YCU Medical Center and Hospitals

Submission

Ryuji Kohno(YNU, CWC, CWC-Nippon)
Individual Wireless Connection for each sensor

Cloud Network

Cellular Wi-Fi Ether

BT Vital Sensor
BLE Vital Sensor
UWB-BAN Sensor

Coordinator

BT Vital Sensor
BLE Vital Sensor
UWB-BAN Sensor

Submission

Ryuji Kohno (YNU, CWC, CWC-Nippon),
8.5 Universal Platform by Wireless BAN, Network Cloud, Data Server with Data Mining for Medical Healthcare

Data mining or Analysis *like Watson*

Data storage server; DBMS

Network cloud

Gateway

Hospital, Rehabilitation center, or Clinicians

Body Area Network (BAN)

Coordinator

Node

Node

Node

physical assistant and surgery robots

Elderly people

Therapist, Nurses, Care givers
8.6 Medical Healthcare Data Mining and Networking Based on Universal Platform by Wireless BAN, Network Cloud, Data Server with AI Data Mining

Body Area Network; (BAN)
Machine Learning; Machine learning algorithms are data analysis methods which search data sets for patterns and characteristic structures. Typical tasks are the classification of data, automatic regression and unsupervised model fitting. Machine learning has emerged mainly from computer science and artificial intelligence, and draws on methods from a variety of related subjects including statistics, applied mathematics and more specialized fields, such as pattern recognition and neural computation.

**General Scheme for Machine Learning Methods**

![Diagram of machine learning process]
8.8 Applications of Deep Learning for Medical Big Data (1/3)

1. **Genome Analysis and Bioinformatics**: Current uses of machine learning in genomics focus on how clinicians provide patient care and making genomics more accessible to individuals.

2. **Disease Identification/Diagnosis**: Deep learning has been applied to diagnostics and treatments in multiple areas such as dosage trials for intravenous tumor treatment etc.

3. **Personalized Treatment/Behavioral Modification**: More effective treatment based on individual health data paired with predictive analytics is hot.

4. **Drug Discovery/Manufacturing**: Machine learning in drug discovery has the potential for various uses, first screening of drug compounds to predicted success rate.
8.8 Applications of Deep Learning for Medical Big Data (2/3)

5. **Epidemic Outbreak Prediction**: Deep learning has been applied to monitoring and predicting epidemic outbreaks around the world, based on data collected from satellites, historical information on the web, real-time social media.


7. **Smart Electronic Health Records**: Document classification e.g. sorting patient queries using support vector machines, and optical character recognition are helping advance the collection and digitization of eHR, eMR.
8.8 Applications of Deep Learning for Medical Big Data (3/3)

8. **Clinical Trial Research;** Applying advanced predictive analytics in identifying candidates for clinical trials could draw on a much wider range of data than at present.

9. **Validation and Certification of Drug & Medical Devices;** Regulatory compliance examination of new drugs and medical devices and robotics and their certification before market can be speed up to analyse critical use cases by deep learning.

10. **Validation Tracking and Surveillance After Market;** Even after market of certificated drugs and medical devices, deep learning can be applied for searching adverse drug reactions and malfunction detection by updating in real time monitoring.
8.9 Security and Dependability of Medical Healthcare Big Data
Healthcare-specific Security Standards

Authentication
• Identification
• Signature
• Non-repudiation

Data Integrity
• Encryption
• Data Integrity Process
• Permanence

System Security
• Communication
• Processing
• Storage
• Permanence

Internet Security
• Personal Health Records
• Secure Internet Services

General Security Standards
200+ Standards for Internet and General Information Systems
Major Usecases of Medical Healthcare Big Data

1. Primary Uses
   (UseCase1.1) Diagnosis and Treatment;
   • Disease Identification, Personalized Treatment/Behavioral Modification,
     Drug Discovery/Manufacturing, Epidemic Outbreak Prediction
   (UseCase1.2) Validation and Regulatory Compliance Test

2. Secondary Uses
   (UseCase2.1) Business Promotion of Drugs and Medical Devices
   • Marketing commercial products related with customers’ health.
   (UseCase2.2) Promotion of non-medical business and social service
   • Applying anonymized medical data as open public data to improve social
     services with other open public data.
9. Review of IEEE Std 802.15.6


IEEE 802.15.6

Narrow band PHY on-body & in-body
- Modulation: GMSK & DPSK
- TX range: ~3m
- Bands: MICS, WMTS, ISM
- Data rate: ~ some Mbps

UWB PHY on-body
- Modulation: IR-UWB & FM-UWB
- TX range: ~3m
- Band: UWB band
- Data rate: ~10Mbps

HBC PHY on-body
- Frequency Selective
- 10-50MHz
- 125kbps-2Mbps
- Beacon-base-TDMA
- Group Superframe
- Priority support
- Non-beacon mode

Common MAC (for all PHY)

UWB: Ultra-wideband
HBC: Human body communication
## 9.1 15.6 User Priority Mapping

<table>
<thead>
<tr>
<th>Priority level</th>
<th>Traffic designation</th>
<th>Data type</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Emergency or medical event report</td>
<td>Data</td>
</tr>
<tr>
<td>6</td>
<td>High priority medical data or network control</td>
<td>Data or management</td>
</tr>
<tr>
<td>5</td>
<td>Medical data or network control</td>
<td>Data or management</td>
</tr>
<tr>
<td>4</td>
<td>Voice</td>
<td>Data</td>
</tr>
<tr>
<td>3</td>
<td>Video</td>
<td>Data</td>
</tr>
<tr>
<td>2</td>
<td>Excellent effort</td>
<td>Data</td>
</tr>
<tr>
<td>1</td>
<td>Best effort</td>
<td>Data</td>
</tr>
<tr>
<td>0</td>
<td>Background</td>
<td>Data</td>
</tr>
</tbody>
</table>
## 9.2 Three Channel Access Modes

<table>
<thead>
<tr>
<th>Channel access mode</th>
<th>Time reference-based (superframe structure)</th>
<th>Beacon</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Yes</td>
<td>Yes</td>
<td>Coordinator sends beacon in each superframe except for inactive superframes.</td>
</tr>
<tr>
<td>II</td>
<td>Yes</td>
<td>No</td>
<td>Coordinator establishes time reference but doesn’t send beacon.</td>
</tr>
<tr>
<td>III</td>
<td>No</td>
<td>No</td>
<td>There is not time reference.</td>
</tr>
</tbody>
</table>
9.3 Time-referenced Superframe w/ Beacon

Clock and position of each access phase

May obtain contended allocation for highest priority

EAP: exclusive access phase
RAP: random access phase
MAP: managed access phase
CAP: contention access phase

One superframe
## 9.4 Main Features of the Three PHYs

<table>
<thead>
<tr>
<th></th>
<th>Frequency band (MHz)</th>
<th>Data rate (kbps)</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>NW-PHY</td>
<td>400, 600, 800, 900, 2400</td>
<td>75.9 --- 971.4</td>
<td>Interference with other systems operate at the same bands</td>
</tr>
<tr>
<td>UWB-PHY</td>
<td>6000-10600 3100-4800</td>
<td>390 --- 12600</td>
<td>Worldwide common band is 7.25 – 8.5 GHz</td>
</tr>
<tr>
<td>HBC-PHY</td>
<td>21</td>
<td>164 --- 1312.5</td>
<td>Strong concern on the effect to implant devices</td>
</tr>
</tbody>
</table>
9.5 Summary of IEEE802.15.6

- Body area network (BAN) is considered as an core technology in supporting automatic medical monitoring and healthcare agilence services as well as consumer centric electronics.

- A new standard, IEEE Std 802.15.6™ was completed and published in Feb. 2012. In which, Unified MAC and three PHY specifications are defined to support different applications.

- Commercial BAN products have been sold for medical healthcare for a human body in a world.

- In PHY, UWB-BAN is appropriate for high QoS use case.

- In MAC, hybrid contention base and free protocols is reliable to guarantee delay and throughput flexibly.
9.6 Demands for BAN Extension

1. BAN for Car and Other Bodies beyond Human Body
   • Reliable performance of medical BAN for human body could be widely applicable for remote maintenance of car body and other bodies in IoT/M2M use cases.
   • Demands for More flexible and widely applicable BAN in cars, robotics, UAVs and others are increasing for autonomous remote sensing and controlling.

2. BAN-base Infrastructure Platform for Medical Healthcare
   • BANs in end users are connected through Cloud Network and Edge Computer with AI Data Mining Server and Repository for medical healthcare platform by integration between ICT and data science.
   • Enhanced dependability is required for end-to-end reliability and security.

3. BAN-base Universal Platform for Medical and beyond Medical Infrastructures
   • Emergency for natural disasters and terrorism, smart city with reliable maintenance of cars, buildings etc. need common dependable platform,
10. Discussion

Covering Use cases of project:
1. Primarily, automotive use cases; internal car, intervehicle communications, car and car electronics factory manufacturing
2. Additionally, UAV and robotics feedback loop sensing and controlling
3. Medical BAN, Cloud and AI Data Mining Server Platform; Ban-Base Platform

Q Shall we extend to the BAN-base medical Platform?

Scope of project:
Q IG Dependability keeps promoting a new standard of PHY and MAC layers only for 1 and 2, or including 3 as well?

• Technical requirement may change more difficult if including 3 although dependability is commonly primarily important for all 1,2 and 3 and a size of market increases.
• To guarantee overall dependability in networks, a BAN-base platform with cloud and AI data mining server and repository can provide more enable technologies in network and application layers of ICT and machine learning technology in data science.
• In particular, network security can be guaranteed as well as security in PHY and MAC layers
• New and current ongoing projects can increase participants and contribution much more such as EU-Japan Medial ICT and Data Science Project, ETSI Smart Ban project, Flexible Factor Project in Japan (FFP) as well as collaboration with IEICE Study Group of Reliable Controlling Communications status.
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 Jussi Haapola <jussi.haapola@ee.oulu.fi> and Ryuji Kohno <kohno@ynu.ac.jp>
Major Reference documents (1/3)

- 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.
  - 15-17-0399-01-IG-DEP-On the way to Industry4.0
Major Reference documents (2/3)

- 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
  - 15-16-0557-06-0dep-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
Major Reference documents(3/3)

- IG-DEP Enable Dependable Technologies
  - Dependable Tech. IEEE802.15-13-0440-00-0dep
  - Dependability-Tech.-at-communications-layers IEEE802. 15-13-0440-00-0dep
  - Dependable wireless feedback controlling schemes considering errors and delay in sensing data and controlling command packets IEEE802.15-18-0116-00-0dep
  - A dependable MAC protocol matched to bi-directional transmission in WBAN IEEE802.15-18-0115-01-0dep

- Related Activities for Enhanced Dependability in Wireless Networks
  - IEEE802.1., 3. & 15 Joint Activities 15-17-0394-00-0dep
  - IEICE TC RCC & TC MICT
    - 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