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

Submission Title: [Focused Use Cases and Possible Timeline of Dependable Wireless M2M and BAN]
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Abstract: [Body area networks(BAN) should be more dependable for major life critical applications such as medicine, disaster, dependable sensing and controlling cars, buildings, smart grids, and smart city by extending BAN from human body to bodies of cars, buildings, and so on. That is so-called BAN of things like Internet of Things. While keeping advantages of IEEE802.15.6, specifications of MAC and PHY may be revised to make it much more reliable, secure, fault tolerant, robust against undesired factors. This slides may offier opportunity to discuss on use cases and applications of this standard.]

Purpose: [The discussion on use cases and applications will lead definition and requirement of current ongoing research and development on dependable wireless networks.]

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Use Cases and Possible Technologies for Dependable Wireless M2M and BAN

17th March, 2014 Beijing

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Agenda

1. Background and Demand of Dependable Wireless
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. Background

- IG-DEP started July 2012 but has not discuss on major use cases and applications yet although definition of Dependability has been discussed.
- Discussion on use cases and applications we should cover in IG-DEP may lead definition and requirement common with and different from IEEE802.15.6 BAN standard.
- Applications Matrix has been useful for developing a categorisation scheme and analysing technical requirements
  - However, insufficient by itself for proposal design and evaluation
- ITU-R has covered M2M in SG11 and others.
- IEEE802.15 SG-SRU and 802.11 other SGs may have relationship

2. Review of IG-DEP Sessions in July, Nov. 2012, March, May, July & Nov. 2013

- Doc. IEEE802.15-12-0370-00-wng0 : **Dependable Wireless M2M Network for Controlling - Applications for Cars, Energy, Medicine, Cities –**
- It was proposed to start **either a new IG on Dependable M2M** or **a IEEE802.15 TG6 amendment of BAN** in July. It could get about 40 supporting votes for this action.
- **It was asked Pat to postpone its opening** because a few could attend IR meeting in September due to several reasons.
- **Possible use cases and manners of** activities were discussed at sessions in Plenary in November 2012.
- **Two sessions of IG-DEP** in Orlando, March 2013 discussed with 12 attendees to **focus on amendment of TG15.6.**
- **Definition of dependability and its technical** feasibility were discussed in Hawaii, May 2013.
- **Use cases and applications** were discussed in Geneve, July 2013.
- **Focused use cases and action plan** were discussed in Dallas, Nov. 2013

Contents of IEEE802.15-13-0192-01-wng0 in March 2013

1. Recall of My Presentation in WNG Session in July 2012
2. Review of IEEE802.15.6 for Wireless BAN
3. Background for Amendment of IEEE802.15.6
4. Dependability of Wireless Networks
5. First Focus on Amendment of 15,6 for Dependable Medical BAN and Extend to BAN of Things
6. Possible Amendment of BAN
7. What to be documented
8. IEEE802.15.6 Deficiencies
9. Action Plan for TG6a(amendment of IEEE802.1.5.6)
10. Questions & comments

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.

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

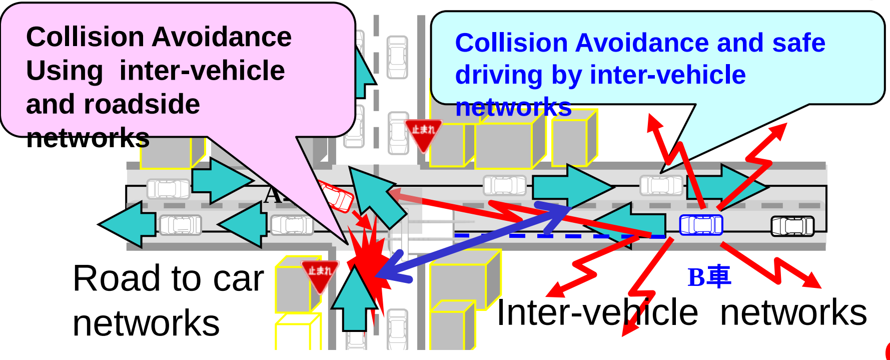
- **Meanings of Dependability:**
  - **For us, “Dependability in network” means to guarantee lowest performance enough high in a sense of highly reliable, safe, secure, fault tolerant, robust services in any predictable and even unpredictable worse environments.**

- **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.

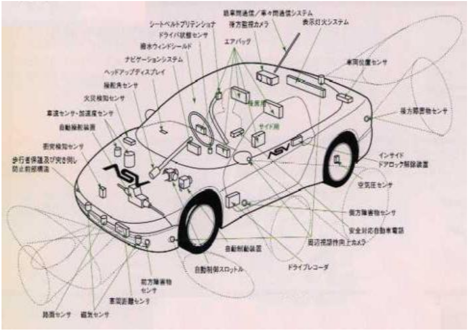
4. Focused Use Cases and Applications

- 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

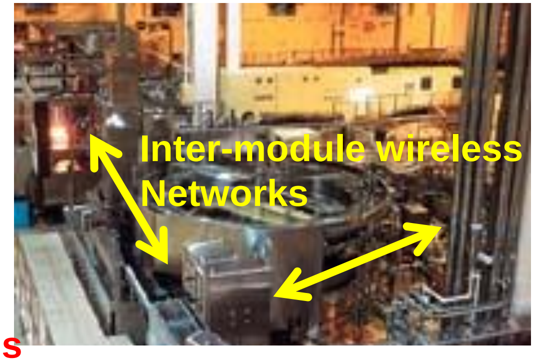
Possible Use Cases of Dependable M2M and BAN for Sensing and Controlling


Collision Avoidance Using inter-vehicle and roadside networks
Collision Avoidance and safe driving by inter-vehicle networks
止まれ
A
B車
Road to car networks
Inter-vehicle networks

Car Navigation & Collision Avoidance Radar



Car LAN & Wireless Harness



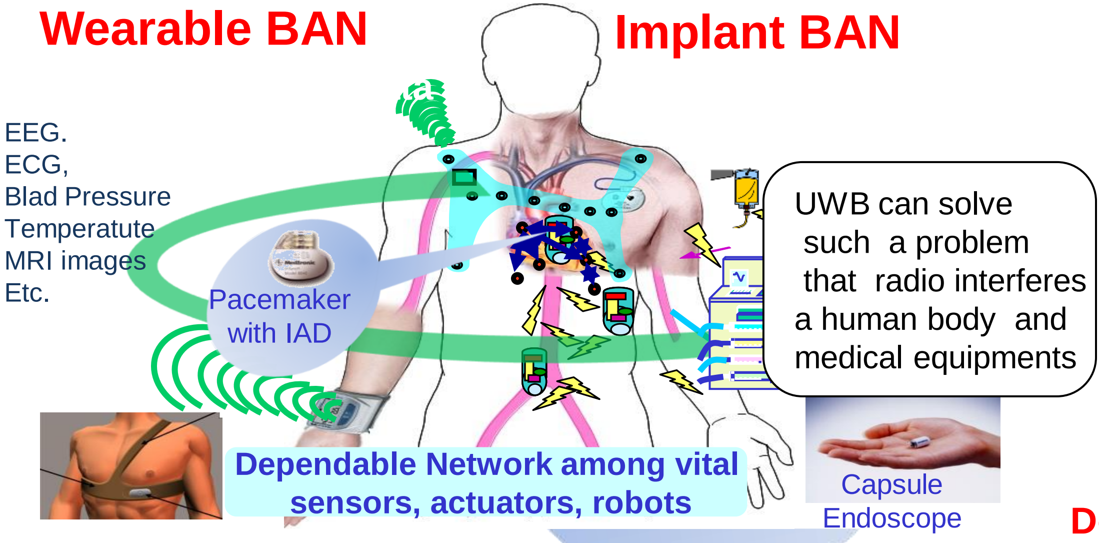
Factory Automation (FA)

Dependable Wireless Networks for Transportation

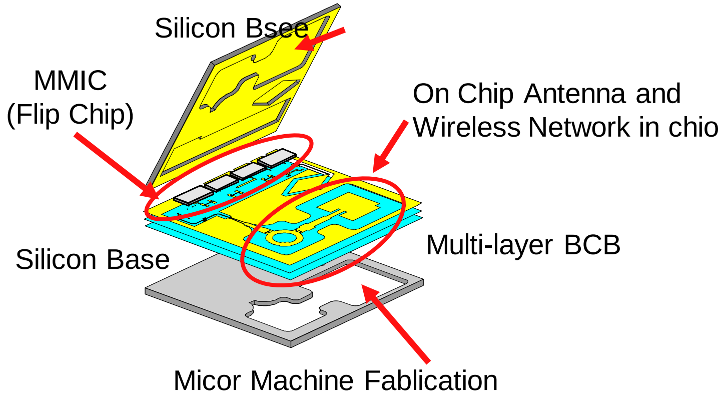
Dependable Wireless Sensing Controlling for Manufacturing (CIM)

Wearable BAN

Implant BAN


EEG.
ECG,
Blad Pressure
Temperatute
MRI images
Etc.
Pacemaker with IAD
UWB can solve such a problem that radio interferes a human body and medical equipments
Dependable Network among vital sensors, actuators, robots
Capsule Endoscope

Dependable BAN for Medical Healthcare


Silicon Bsee
MMIC (Flip Chip)
On Chip Antenna and Wireless Network in chio
Silicon Base
Multi-layer BCB
Micor Machine Fablication

Dependable Wireless System Clock in Micro Circuit & Network in Devices

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.

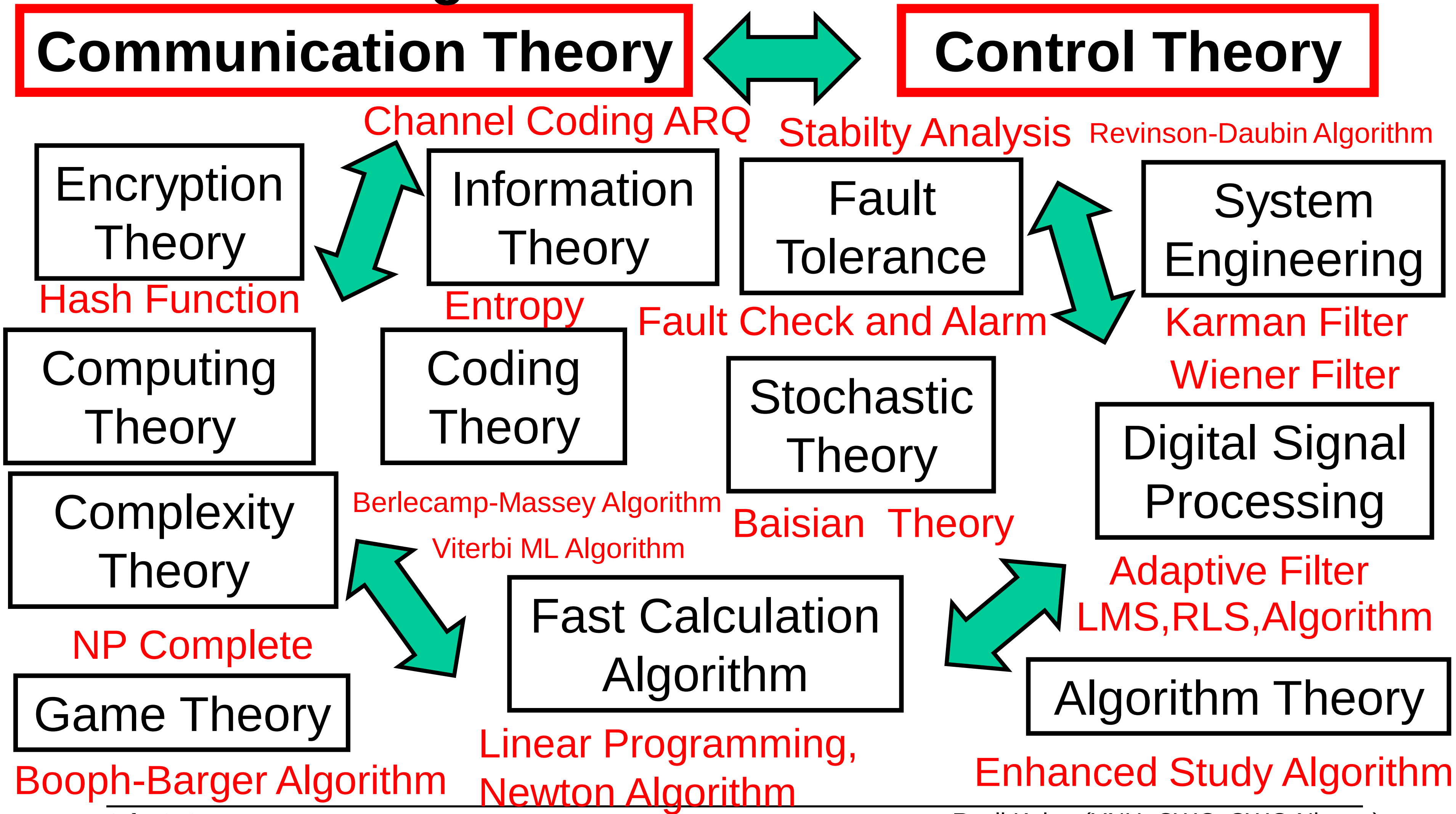
5.1 Research Subjects of Dependable Wireless

（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



Communication Theory

Control Theory

Channel Coding ARQ

Stabilty Analysis

Revinson-Daubin Algorithm

Encryption Theory

Information Theory

Fault Tolerance

System Engineering

Hash Function

Entropy

Fault Check and Alarm

Karman Filter

Wiener Filter

Computing Theory

Coding Theory

Stochastic Theory

Digital Signal Processing

Complexity Theory

Berlecamp-Massey Algorithm

Viterbi ML Algorithm

Baisian Theory

Adaptive Filter

LMS,RLS,Algorithm

NP Complete

Fast Calculation Algorithm

Algorithm Theory

Game Theory

Booph-Barger Algorithm

Linear Programming,
Newton Algorithm

Enhanced Study Algorithm

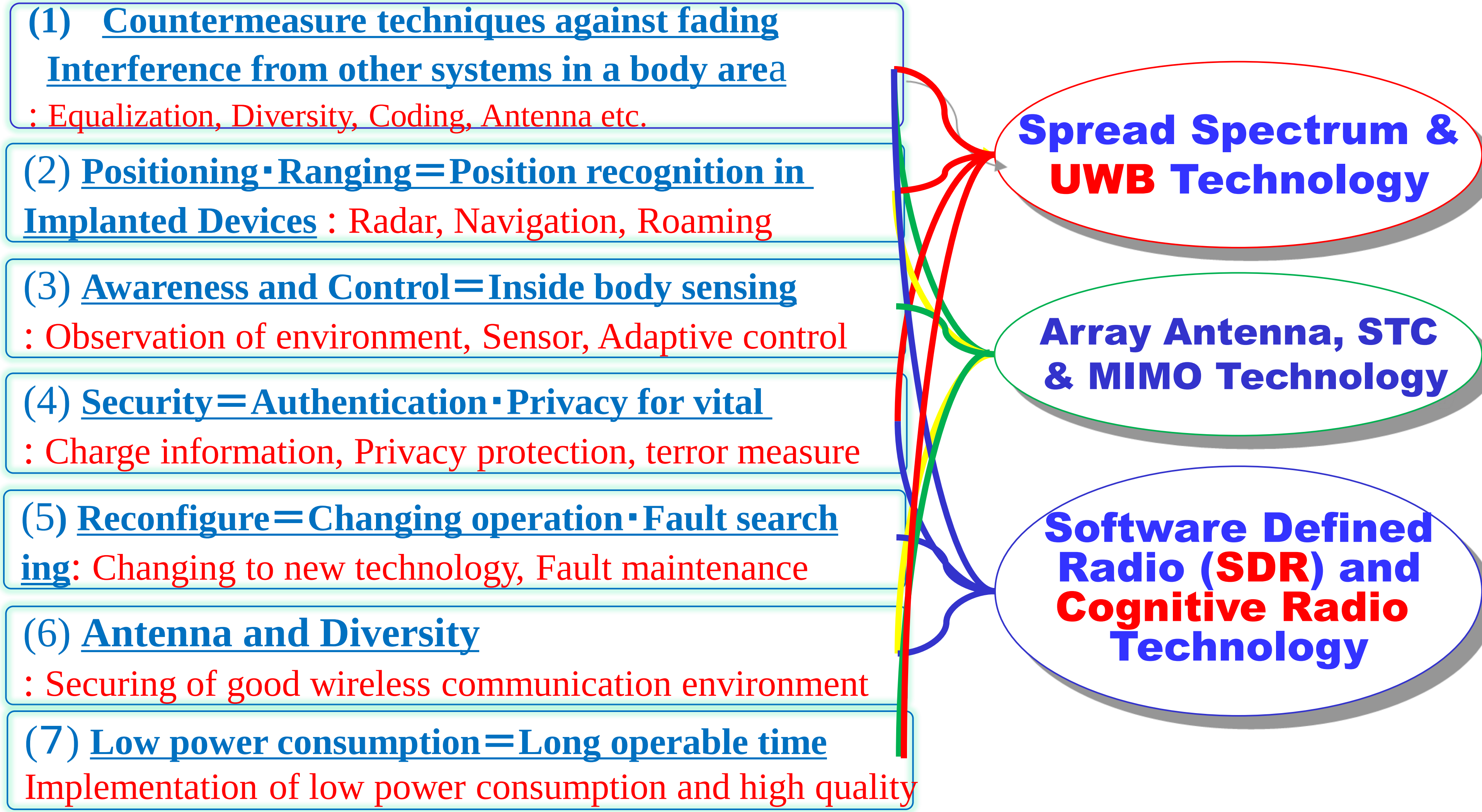
5.3 Basic Technical Requirements

- 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

Spread Spectrum & UWB Technology

Array Antenna, STC & MIMO Technology

Software Defined Radio (SDR) and Cognitive Radio Technology

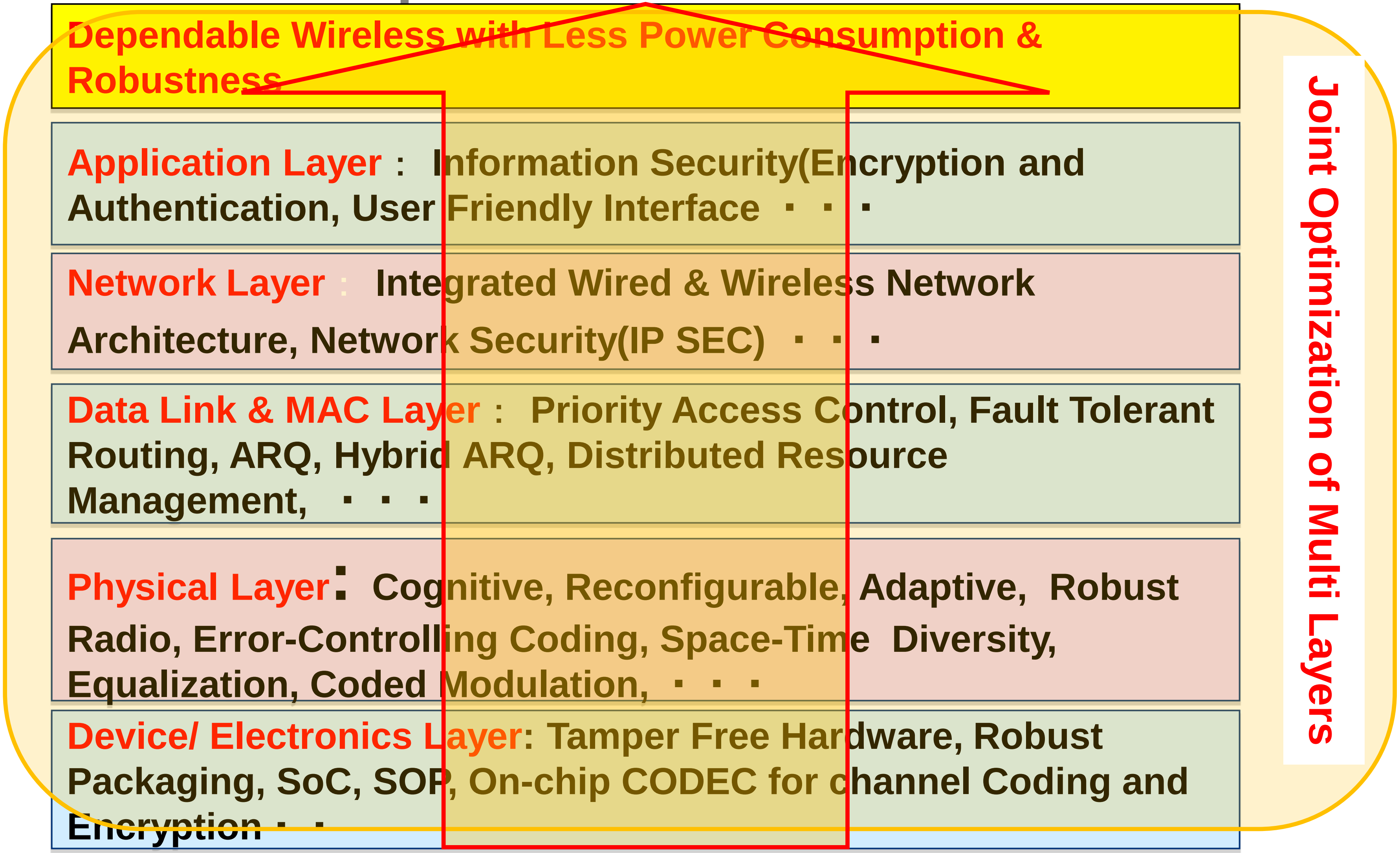
5.6 Communication Technologies in each Layer for Dependable M2M and BAN

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) ・・・

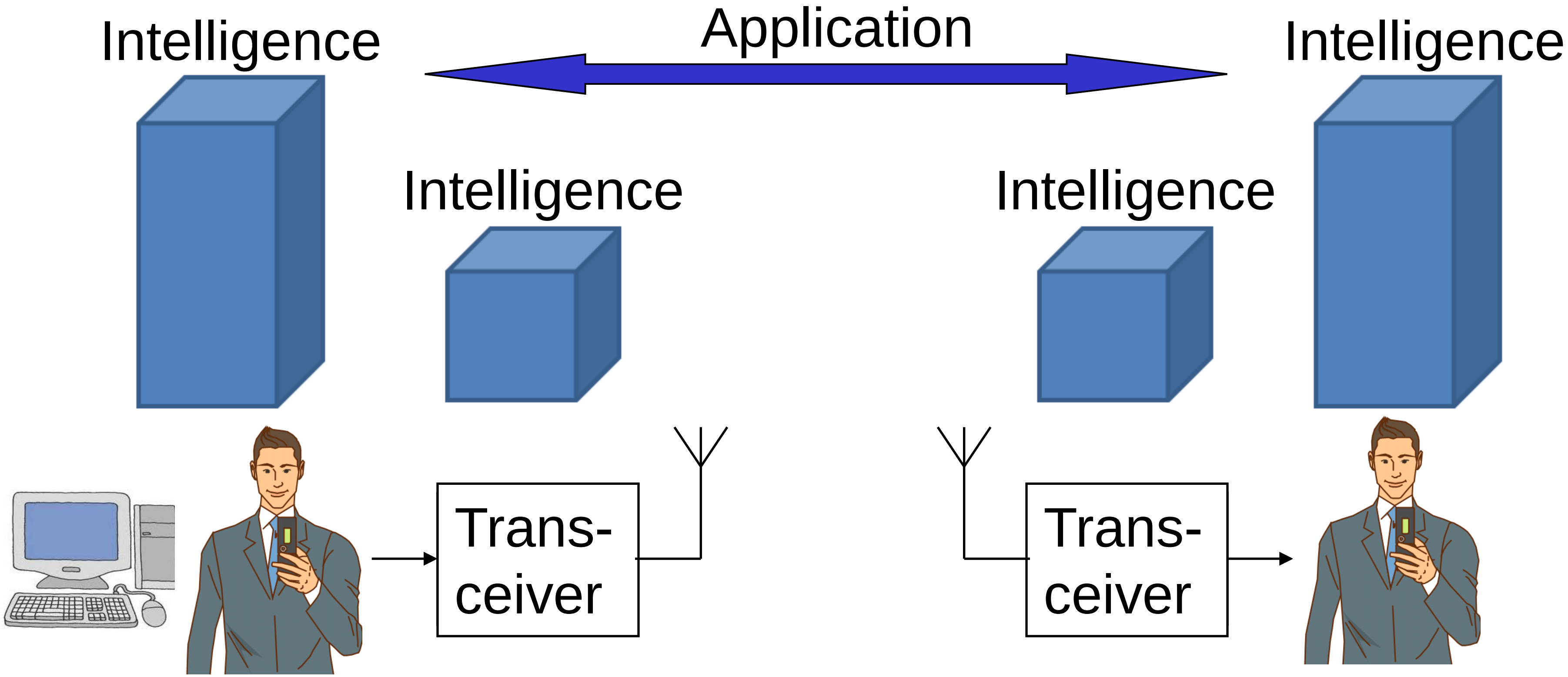
Data Link & MAC Layer： Priority Access Control, Fault Tolerant Routing, ARQ, Hybrid ARQ, Distributed Resource Management, ・・・

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 ・・

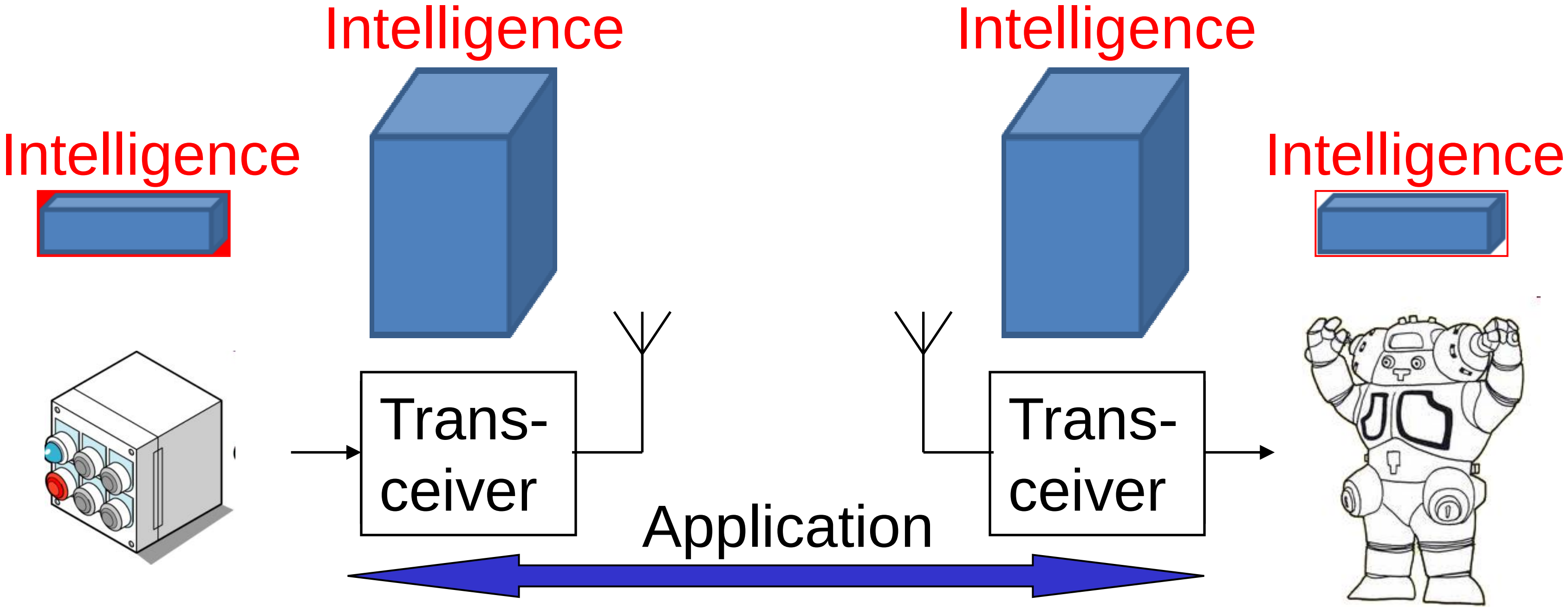
Joint Optimization of Multi Layers

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.

Discussion

Scope of project:

- Address PHY and MAC layer functionality
- Possibility to create management plane 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

6. Procedure of Promotion to Next Steps

- We tried to proceed establishing IG, SG, and TG on Wireless Dependable M2M Network since the plenary session of July 2012. However, due to some restriction procedure was not speeded up.
- There are two major approaches to procedure IG to SG and TG.

(1) focus on amendment of BAN 802.15.6

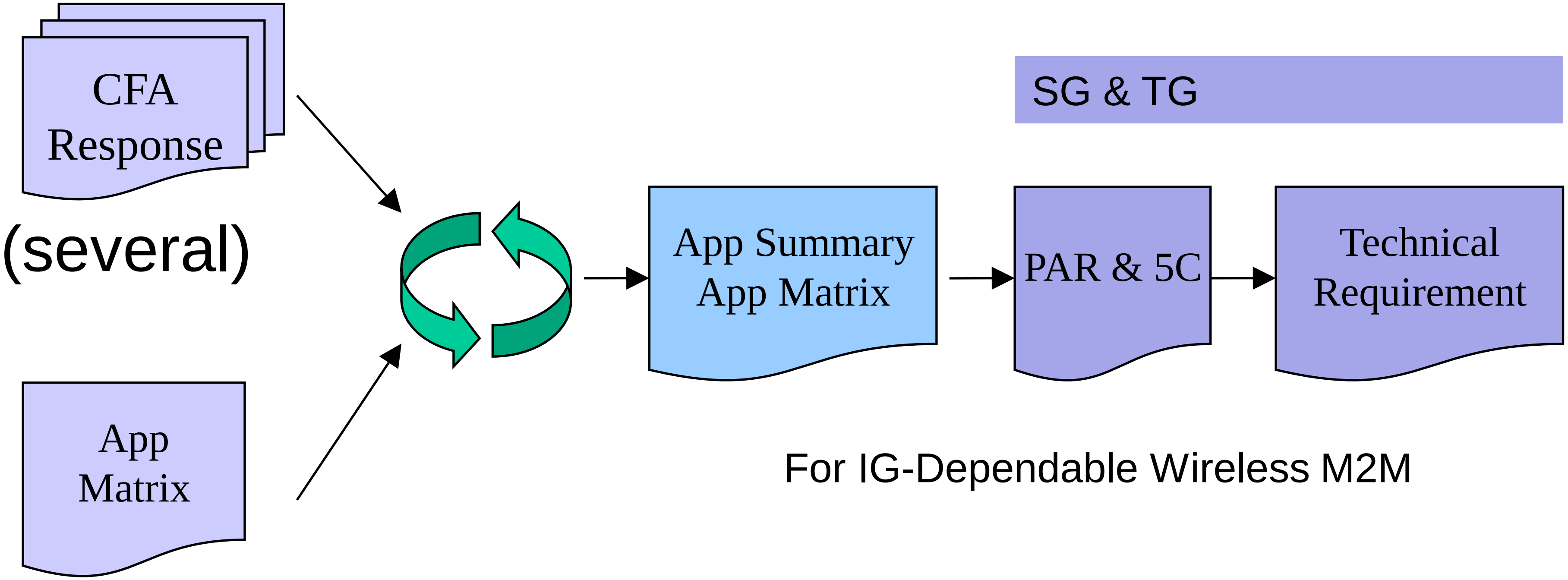
(2) focus on different PHY and MAC for dependable M2M

- An amendment of IEEE802.15.6 must be more realistic while keeping advantages of the BAN standard as IEEE802.15.6a (?)

7. Possible Time Line

- IG → WG → SG → TG → Standard
- Technical Requirement
- 5C and PAR
- Proposals
- Down selection
- Letter Ballots
- Sponsor Ballots
- Rev Com Approval

Development process



CFA Response

(several)

App Matrix

App Summary App Matrix

SG & TG

PAR & 5C

Technical Requirement

For IG-Dependable Wireless M2M

Amendment of 802.15.6

New use cases of dependable M2M

Document structure

- Table of contents
- Use Cases & Applications, categorized
  - Parameters
  - Free text description
  - CFA slide extracts
- Acknowledgements

Contributions

- Not all applications may be comprehensively described but major applications must be covered.
- If you can offer further details, either updated parameters or free text, please contribute
- Send content contributions to
- Jussi Haapola <jussi.haapola@ee.oulu.fi> and Ryuji Kohno <kohno@ynu.ac.jp>

Reference documents

- Applications Summary Document of IEEE802.15.6 BAN
  - 15-08-0407-00-0006-tg6-applications-summary.doc
- TG6 Applications Matrix
  - 15-08-0406-00-0006-tg6-applications-matrix.xls
- IG-DEP kick-off documents
  - IEEE802.15-12-0370-00-wng0 in July 2012
  - IEEE802.15-13-0192-01-wng0 in March 2013
- IG-DEP agenda documents
  - Closing Minutes IEEE802.15-13-0454-00-0dep in July 2013
  - Dependable Tech. IEEE802.15-13-0440-00-0dep in July 2013
  - Use case IEEE802.15-13-0416-00-0dep 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