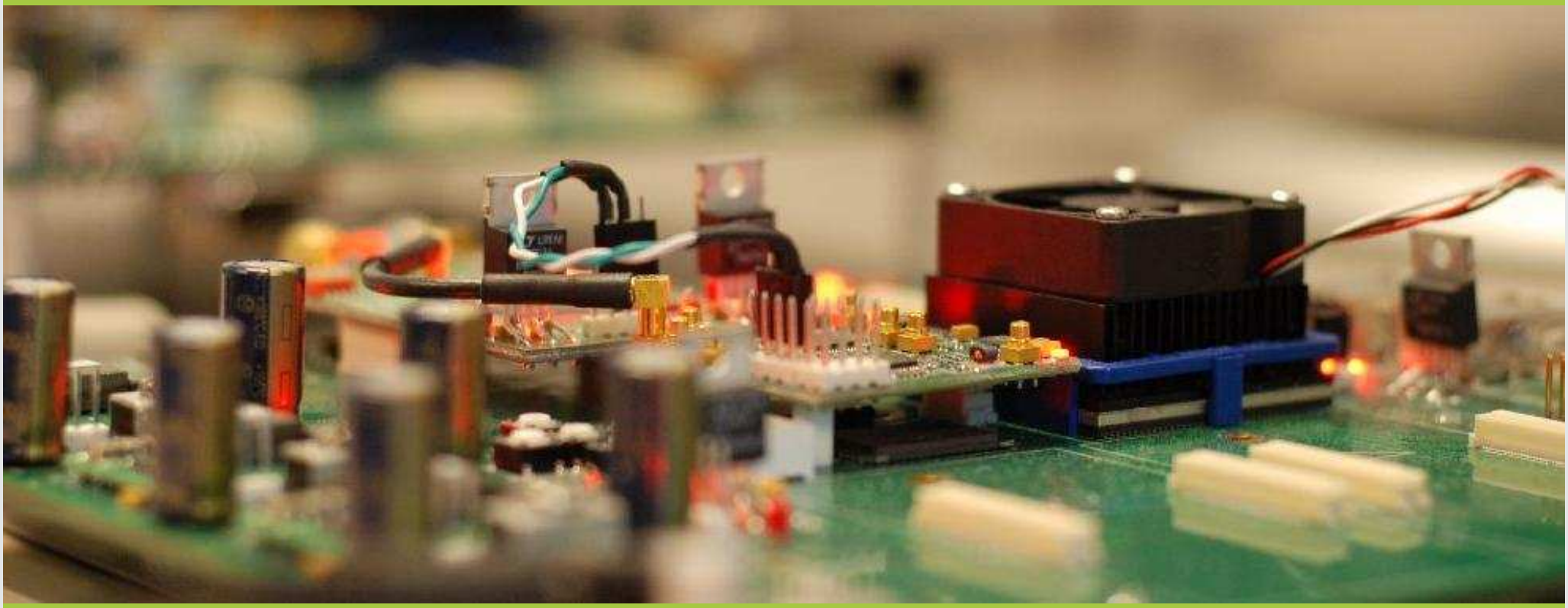

JAPANESE-FINNISH JOINT SYMPOSIUM
ICT and Technology in Medical and Health Research
Helsinki, Finland

On the Recent and Future Topics of Wireless Communications in Healthcare

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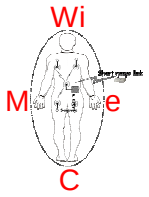
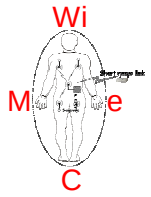
CWC Oulu CENTRE FOR WIRELESS COMMUNICATIONS University of Oulu

UNIVERSITY of OULU OULUN YLIOPISTO

Content

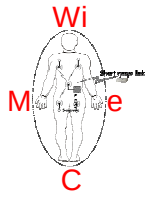


Introduction (1/2)



- Wireless communication is useful in several applications
  - medical and healthcare sector can benefit the success of wireless data transmission
  - a lot of benefits and cost savings are seen
- The ageing of the population is one growing field of research in this direction
- Big distances from home to healthcare facilities & scarcely populated countries & lack of resources bring needs:
  - to increase self-management of chronic conditions and
  - to introduce remote healthcare solutions
- Healthcare and medical sector allow no room for faults: requirements are
  - reliable, robust, secure and safety communication
  - demonstrations and test campaigns needed before real operational use
  - take care on possible harm, e.g. electromagnetic (EM) radiation
- Lots of wireless applications already in use in hospitals and other care units, still room for new research and innovations exist: for example
  - generic conceptual architecture, related channel models and safety protocols

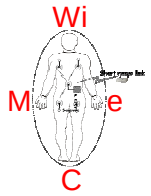
Introduction (2/2)



- Also, during the last few years, the standardization work of *Wireless Body Area Networks* (WBAN) for health and consumer related applications have been prepared by the study group IEEE802.15.6
  - does not end research; vice versa
- Medical ICT require different players and experts, e.g., end users, hospitals, physicians, economists and engineers
  - also differently oriented engineers should be included, i.e., for signal processing, data processing, communications and RF
- CWC plays in its own role in the whole concept: investigation and development of a link *within* wireless body area network and a link *from* WBAN access point *to* room/home access point
  - channel modeling for wireless body area networks;
  - performance evaluation of receivers for WBAN medical care applications;
  - system architecture of WBAN sensor network;
  - prototype development for medical parameters measurements and
  - end-user applications and services.

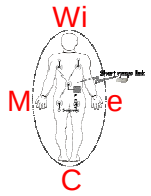
WBAN is the key element

General Architecture (1/1)



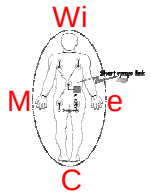
- A concept that can be effectively used for improving the existing working procedures and distribute the medical information processing have a huge and global market potential
  - provides wireless ICT and self-learning solutions in planning and developing a ‘wireless hospital’ or ‘distributed hospital’ with cognitive radios and smart components,
  - is based on collaboration between hospitals, patients and healthcare services and also service providers in the community, and benefits advantages of modern ICT
  - a smart and self adaptive environment will be enabled via a wireless sensor network, WBAN, under the control of a home/or other gateway
  - information processing can be distributed between the gateway and different sensor
- The general “virtual hospital“ system will provide
  - monitoring of physiological parameters
  - disease management system
  - adverse drug reaction
  - early detection of increased risk of falls, depression, sleep deprivation etc. and
  - alarm the human in the loop on a timely basis taking into account long term and short term analysis of behavioral and physiological data
- Cognitive evaluation using tests and automated remote behavior monitoring will enable, e.g., early detection of dementia or other diseases

Applications (1/1)



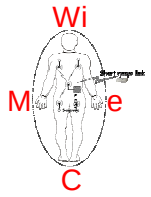
- The application defines how and how often clinical parameters are collected
  - to aggregate real time or buffered data and then transfer information to distant destination
  - the application and overall wireless system concept need to adapt to various requirements
- Applications requiring high data rates can be used occasionally, but most of the time, the transferred data consist of only few status or single value bits
  - this reflects not only to physical layer design of the protocol stack but also to higher layers of it
  - varying loads requires adaptive medium access to optimally share the radio spectrum with others
  - medical monitoring system cannot be based on the fixed spectrum utilization in time
- Similar approaches than used with humans can be exploited with animals
  - added value by remotely monitoring grazing cattle or install remote sensor to cow houses etc.
  - a wearable system modified for animal use: increase the market potential of the developed system
- Even thought the system architecture and algorithms are the same, the final manufacturing and implementation differs

Receivers (1/1)



- Different standardized solutions give a base to select proper signal structure to satisfy the given requirements
- The WBAN system concept study requires information on radio channel propagation characteristics: base for CWC's WBAN channel modeling work
  - CWC has carried out experimental channel modeling studies in different environments, including hospital
- CWC is focusing on UWB receivers (energy detector, Rake) using different measured channel models for wireless personal area networks (WPAN) and WBAN, as well as comparison with literature based WBAN channel models
- The channel model should be selected as realistic as possible because it can cause significant differences in the error rate performance
- "Low complexity" in such makes it possible to produce devices having long life time due to their low power consumptions
  - there is a drawback based on the computational capabilities and lower performance limits
- As a result of the receiver research, it is evident that some sort on intelligence and adaptive algorithms should be included to the receiver

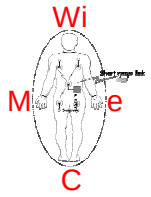
Future Trends (1/4): Continuating



- Wireless medical communications
  - by replacing assisting people's work and
  - replacing wired links by wireless connections in a hospital

  are applying new applications in a healthcare and welfare sector
- One example is wireless medical telemetry, which is a remote monitoring of a patient's health with the help of radio technology
  - gives patients a greater mobility and an increased comfort by freeing them from the need to be connected to medical or hospital equipments that would otherwise be required to monitor their condition.
  - improves quality of patient care but also the efficiency of hospital administration
  - reduces healthcare costs because it permits remote monitoring of several patients simultaneously
- Other examples

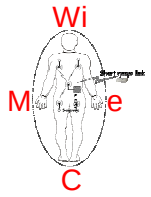
Future Trends (2/4): Boosting WBAN and UWB



- The development of this technology will lead to utilization of WBANs
  - sensors placed in-the-body (implantable sensors) and
  - on-the-body (wearable sensors)

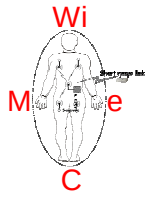
  can communicate with the outside world using wireless networks and provide medical information for further studies
- The measured physiological information can be forwarded to, e.g., a physician, in real-time
- The coming IEEE802.15.6 standard will give a boost for this development
- IEEE802.15.6 standard can also give a new boost for utilization of ultra wideband technology in general because UWB is selected the physical layer technology by the standard

Future Trends (3/4): Small Particles



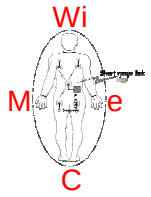
- What nanotechnology can provide for medical and healthcare sector?
  - extremely small and dedicated gadgets which are circulating, e.g., in a blood vessels
  - can take samples inside a body, operate as a diagnostic device, can deliver drugs
  - improve the patient's safety and save the patient from a possible surgical procedure
- Communication, sensing, measuring, and networking challenges of small and nano-scale wireless sensor networks is interesting, as well as realization of such nano-scale devices
  - the remarkable smaller node size and limited power resources make the problem very different in many respects compared to current communication and networking problems with WSN
  - antenna design for in-body nano-devices will provide room for new innovative solutions
- Nanogadgets should
  - be controlled wirelessly or
  - they can provide real time information from inside a body
- Taking a small sample of a tissue whose location is preliminary specified, or decision is based on the real time figure, set high demands for
  - positioning accuracy,
  - control signaling and
  - dependable data traffic

Future Trends (4/4): Large Networks



- Larger or dense network direction is due to facts that
  - a lot of WBANs (both in- and on-body) have to work in the close vicinity of each other
  - other networks, e.g., machine-to-machine (M2M) due to hospital equipments, can be used in the same area
  - all of there may be connected to the same backbone network, which can also be wireless
- All these lead to research on dependable wireless networks taking into account security in different levels (link level and networking level)
- When dealing with wireless connections, there can be multiple suitable networks available
  - this gives pressure for cognitive approach by providing tools to select network type based on the need
- There is also a tradeoff between
  - the computational capability,
  - memory amount, and
  - power consumption

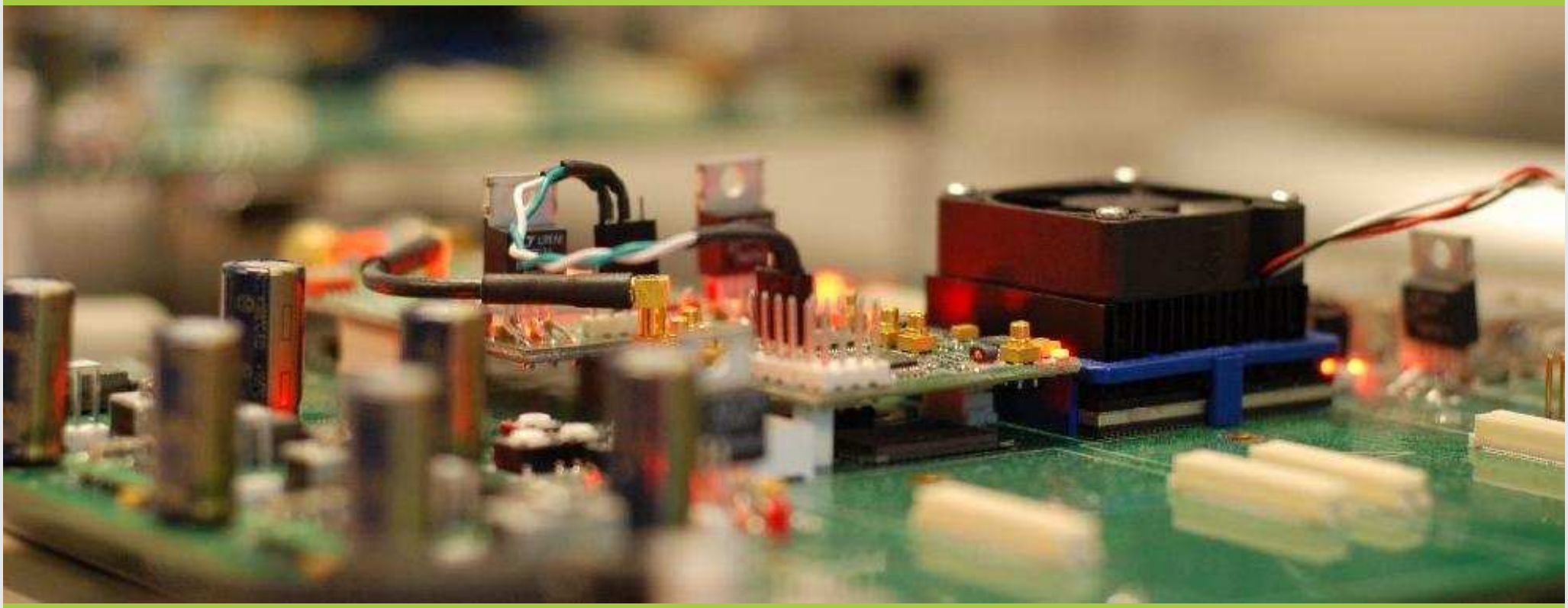
Conclusions (1/1)



- A lot has been done, is going on, but we still have a lot to do!

Remember!

http://www.ismict2012.org (dealine for paper submission tomorrow)



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Kiitos!

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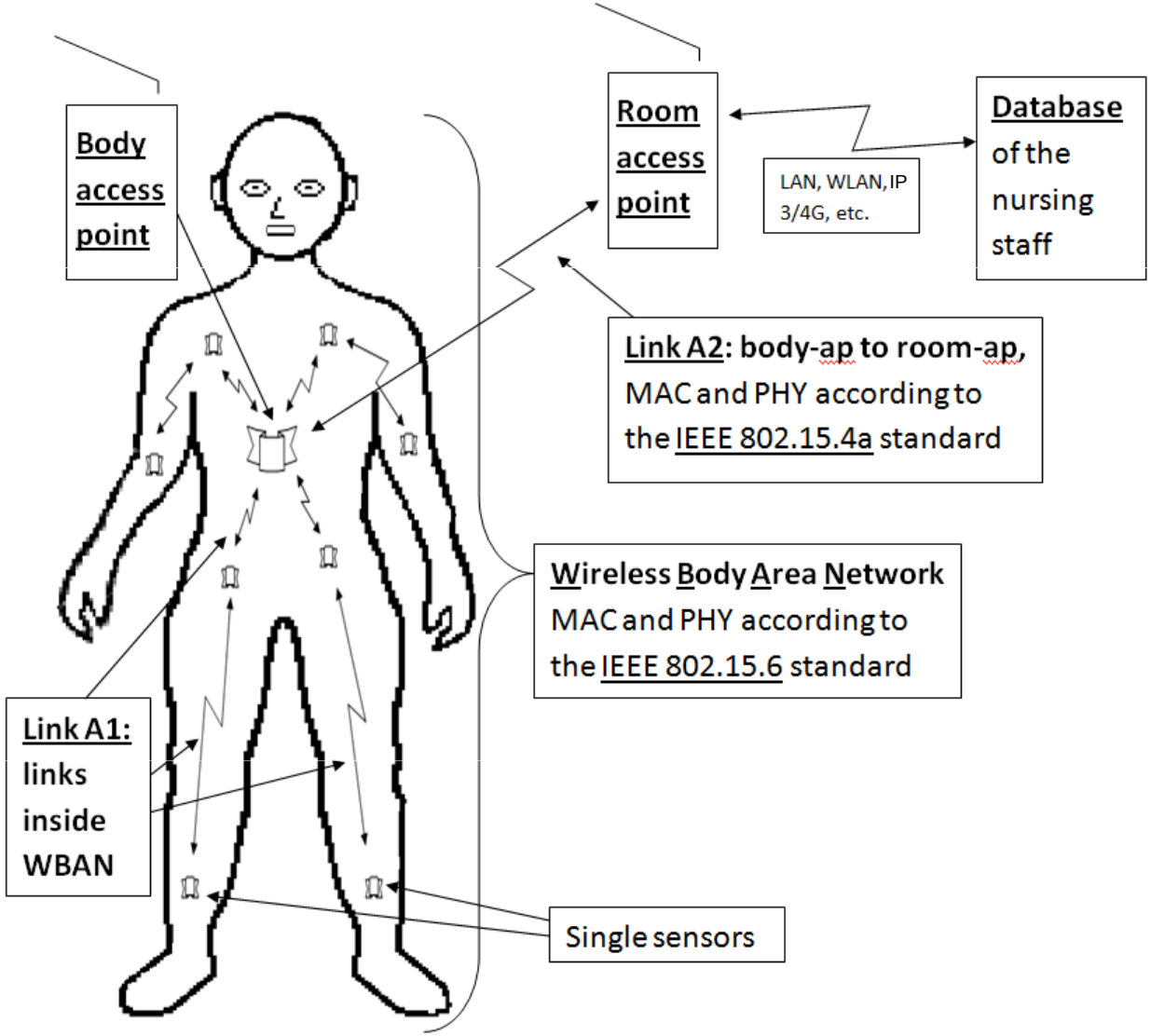
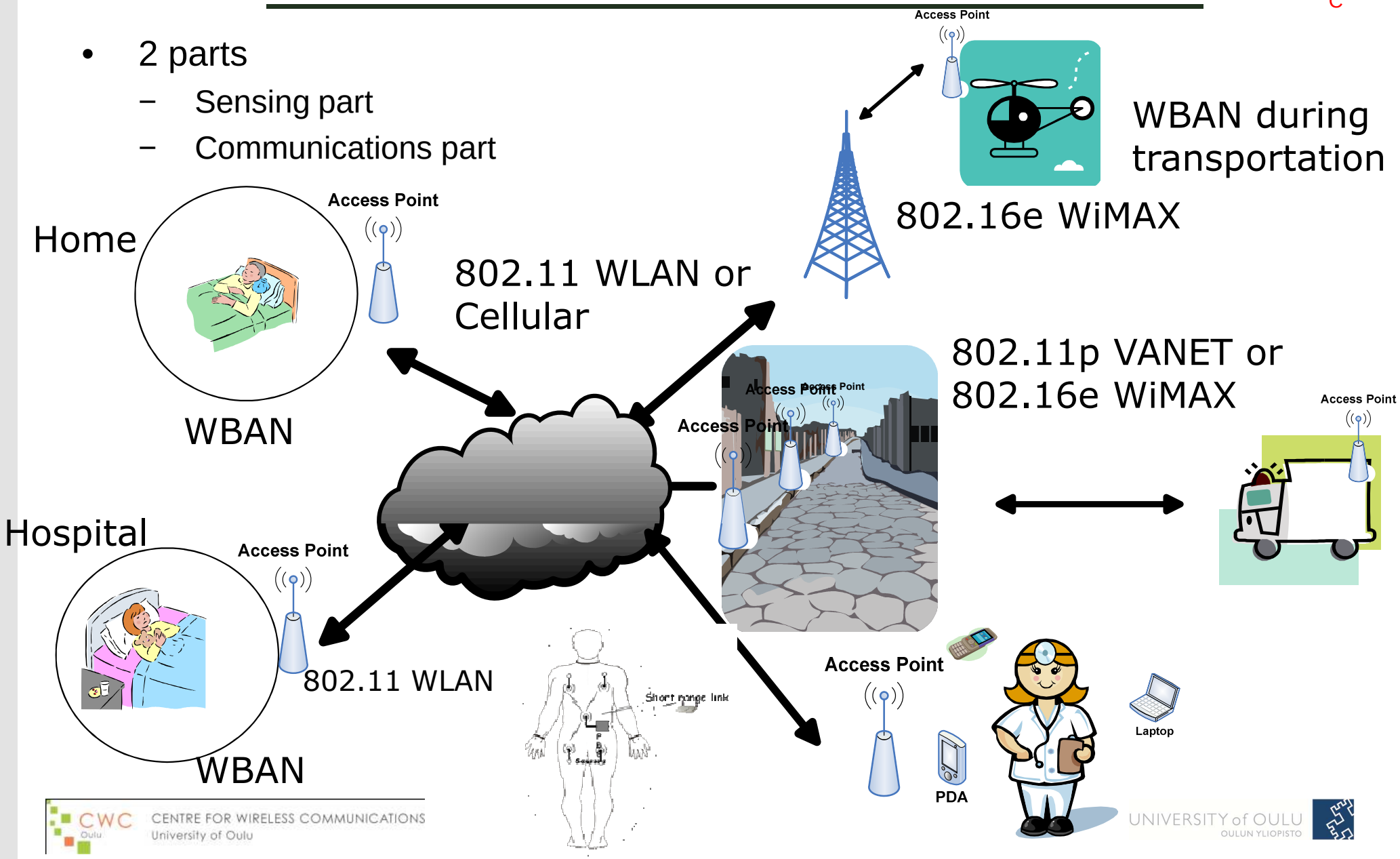
UNIVERSITY of OULU OULUN YLIOPISTO

Research items

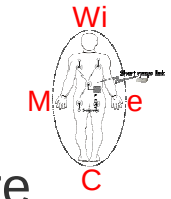


CWC: Architectural Overview of WBAN Sensor Network and Communications

- 2 parts
  - Sensing part
  - Communications part

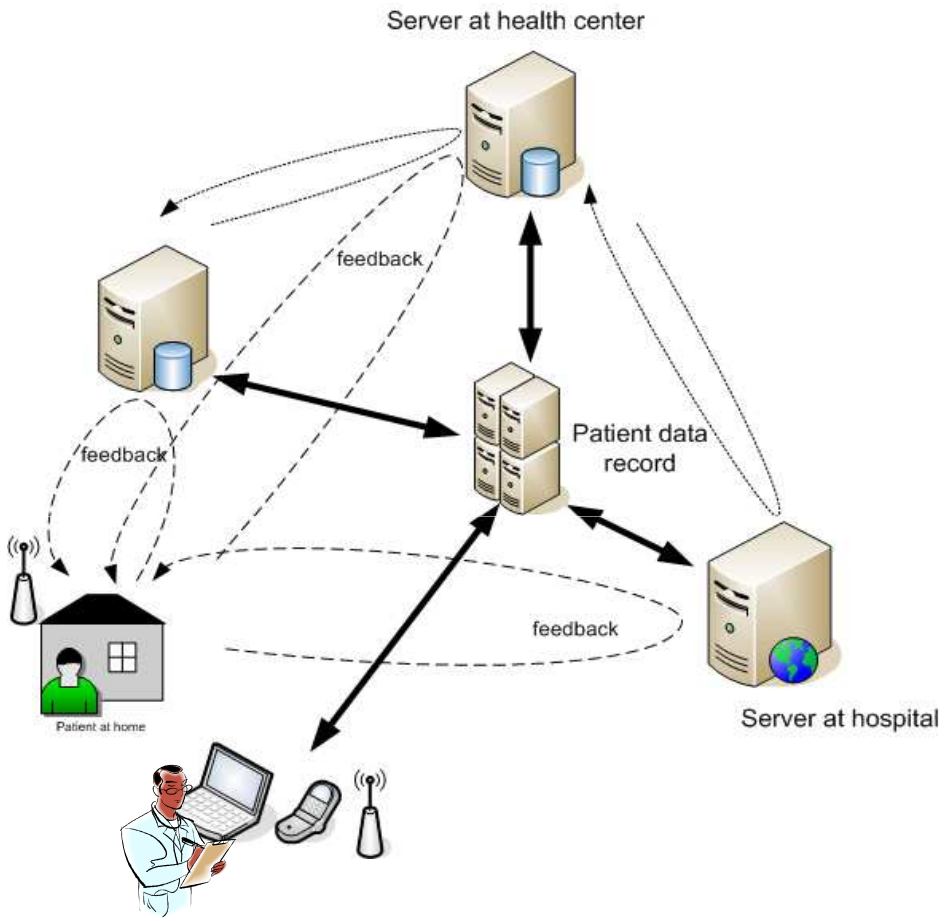


Distributed (virtual) hospital

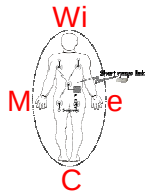


- Is based on the collaboration between hospitals, patients and health care services, and
- is benefiting from advantages of modern ICT technologies.

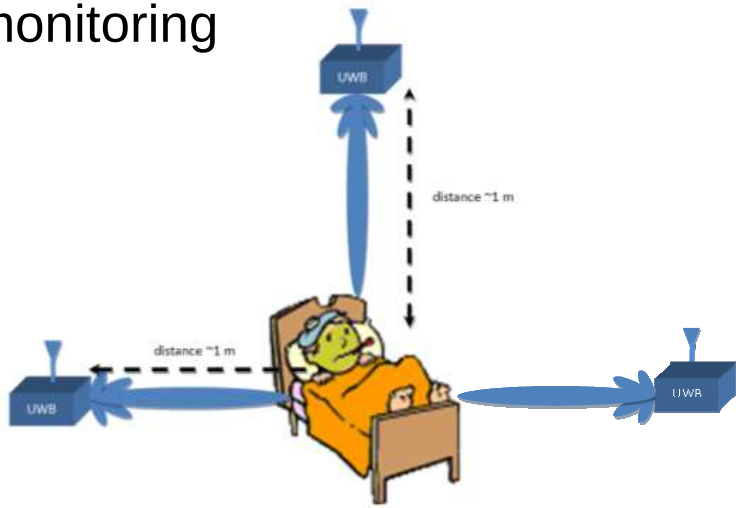
1. Patients will first make vital parameter measurements according to their prescription.
2. Measurement data is transferred to the home health server.
3. The home health server sends data to the hospital's health server or to the health care centre's health server.
4. Data is then processed in a hospital and feedback is sent from the hospital's health server back to the patient's home server and patient itself.



Possible application based research items

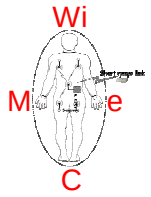


- Sensoring and data transferring related to stress and cardiovascular diseases
- Sensoring and data transferring related to behavioral and physiological data analysis, and detection of early symptoms
- Sleep apnea monitoring



- Future dependable wireless hospital concept

Research items (application based)

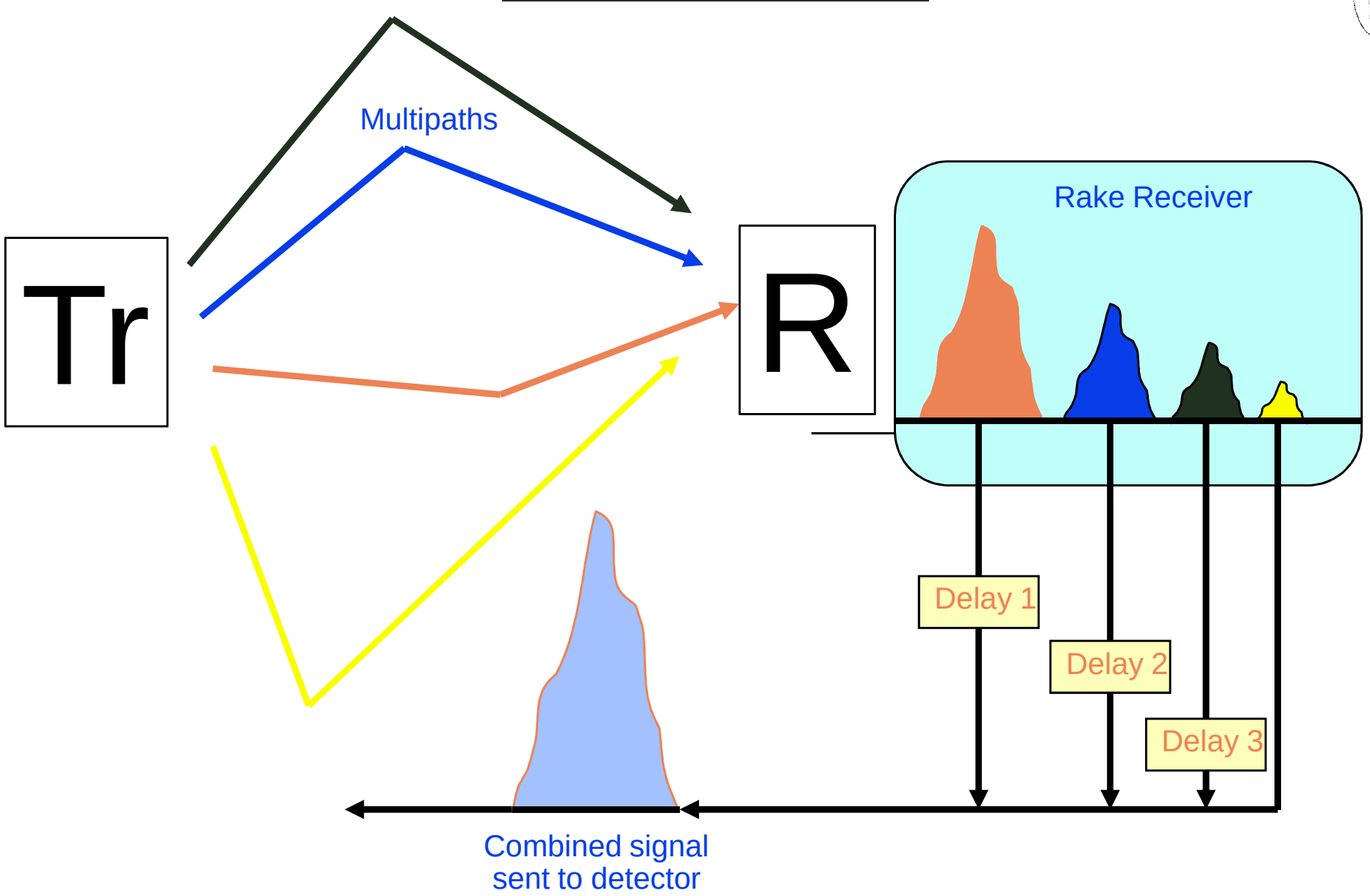


- General requirements for delay, data rate etc. based on what physiological parameter to measure:

Medical Condition	WBAN sensors
Cardiac Arrhythmias/Heart Failure	Heart rate/ECG, blood pressure, activity
Asthma	Respiration rate, peak flow, oxygen saturation
Cardiac Rehabilitation	Heart rate/ECG, activity, environmental sensors
Post-operative Rehabilitation	Heart rate/ECG, temperature, activity
Diabetes	Blood glucose level, activity, temperature
Obesity/Weight loss programs	Heart rate, smart scale, activity (accelerometers)
Epilepsy	EEG, gait (gyroscope, accelerometers)
Parkinson's Disease	Gait, tremor, activity (gyroscope, accelerometers)

Vital and healthcare data	Data rate
Heartbeat	< 1 00 bps
Blood pressure	< 100 bps
Electrocardiogram (ECG)	~ 2500 bps
Electroencephalography (EEG)	~ 540 bps
Body temperature	< 100 bps
Blood sugar rate	< 100 bps

Rake receiver



Channel model

- The channel models used are based on the measurements carried out at the premises of Oulu University Hospital and a model by IEEE802.15.6 - CM3
  - “body surface to body surface” channel models