Ubiquitous Sensor Network

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USN Definition (1/3)

- WSN vs. USN
- WSN
  - Definition: a mesh network of small sensor nodes communicating among themselves using RF communication, and deployed in large scale (from tens to thousands) to sense the physical world. (Source: WIKIPEDIA)
  - Physical components: small MCU, limited memory, sensors (including specific conditioning circuitry), communication device (usually radio transceivers), battery, etc.
  - Characteristics: small-scale sensor nodes, limited power they can harvest or store, harsh environmental conditions, node failures, mobility of nodes, dynamic network topology, communication failures, heterogeneity of nodes, large scale of deployment, and unattended operation

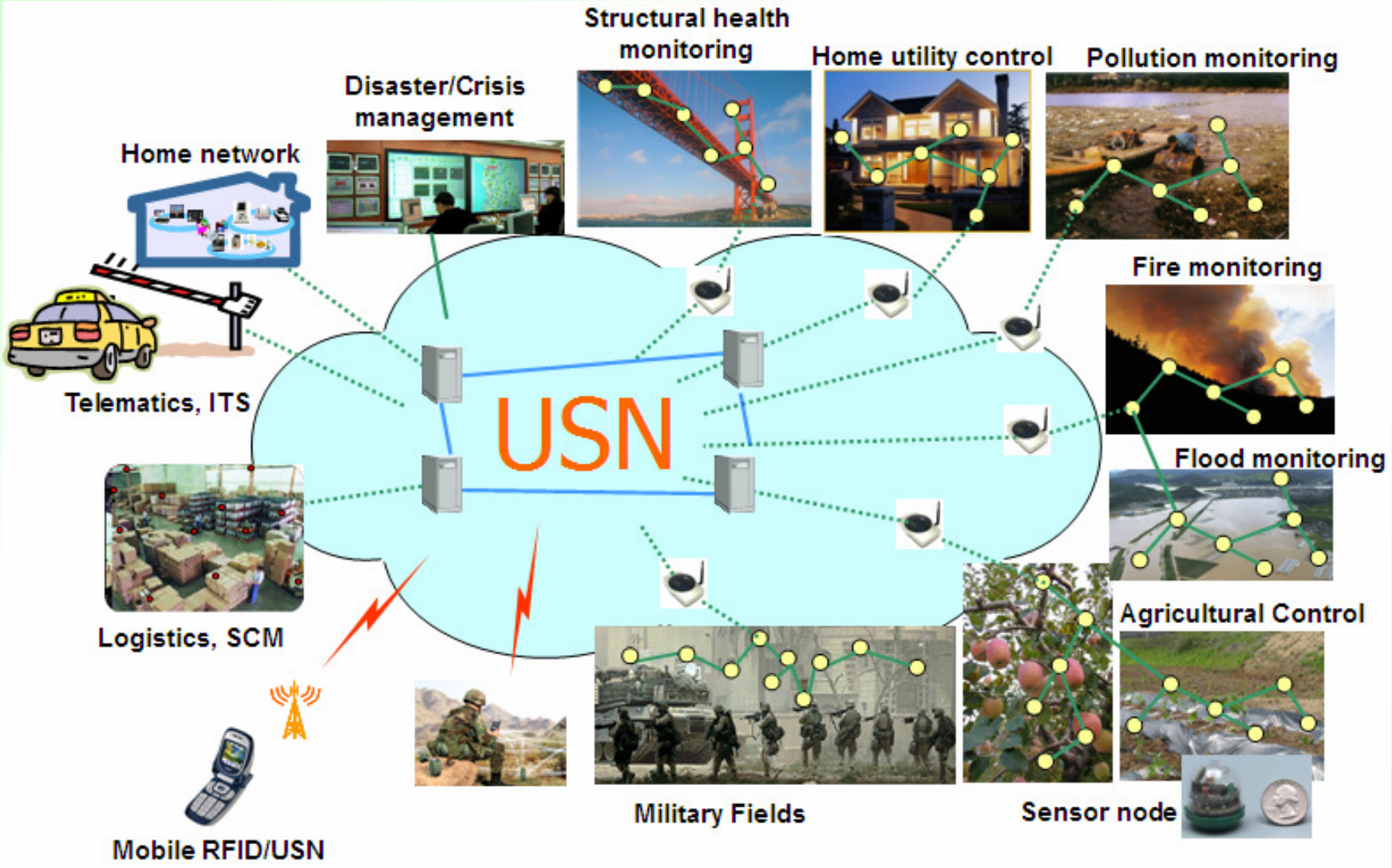
USN Definition (2/3)

- USN
  - Not a simple network but an intelligent information infrastructure of advanced e-Life society, which means it is not a network technology term but a service infrastructure term
  - It delivers user-oriented information and knowledge services to anyone at anywhere and anytime where the information and knowledge is developed by using context awareness with detecting, storing, processing and integrating situational and environmental information gathered from sensor tags and/or sensor nodes affixed to anything.
  - Two viewpoints
    - Network installation view
    - Application/service view
  - USN deals with both viewpoints.

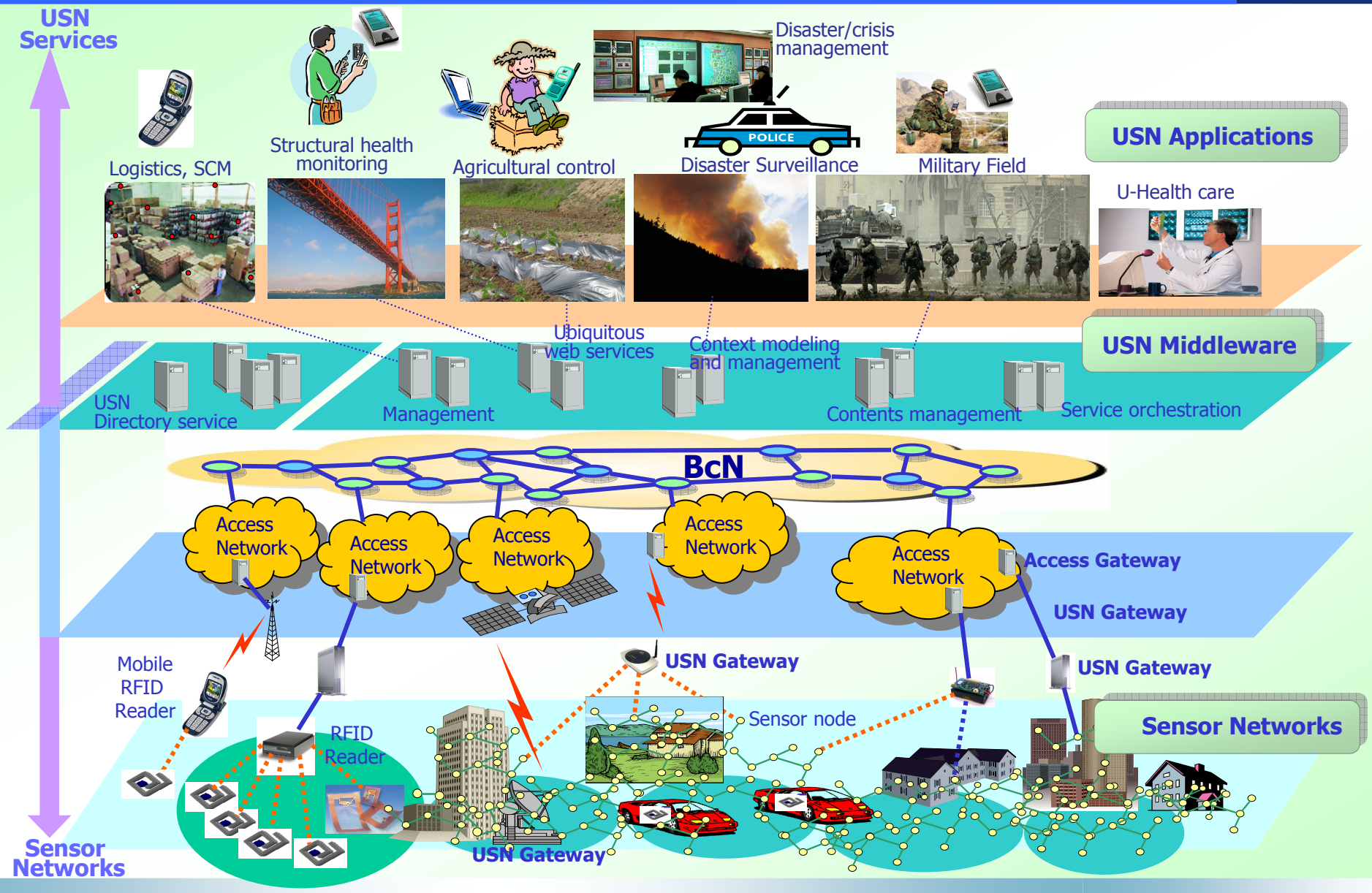
USN Definition (3/3)

- WSN vs. USN
  - WSN is a networking technology term and focuses on sensor node networking and node system development.
  - USN is not a technology term but a user- and service-perspective term which shall cover lower-layer and higher-layer issues including PHY/MAC, networking aspects, application protocol and language issues, middleware functions, various management topics, context awareness services, and a variety of applications and services.

USN Applications



USN Problem Domains



USN Service Requirements (1/7)

- Sensor node is not general purpose device.
  - It has a specific purpose and limited usage.
  - Many application programs are not installed.
  - Application programs are not changed frequently.
  - Sensor-dedicated applications are installed.
  - Applications installed keep used for a long time.
- Each application has unique service and functionality requirements.
  - Fire monitoring
  - Intrusion detection
  - Military use cases
  - Weather information gathering
  - Body condition monitoring
  - Pollution monitoring

USN Service Requirements (2/7)

Virtual Market Characteristics

	Border guard	Weather information gathering	Bridge condition monitoring	Mountain fire monitoring	Health care	Home care
Heavy data volume				■		
Light data volume	■	■	■		■	■
Mobile node					■	
Stationary node	■	■	■	■		■
Mobile network					■	
Stationary network	■	■	■	■		■
Battery	■	■	■		■	
Power-line support				■		■
Streaming data				■		
Periodic data		■	■			
Event-driven data	■				■	■
Wire-line comm.				■		■
Wireless comm.	■	■	■		■	
Many nodes	■		■			
Several nodes		■		■	■	■
In-door					■	■
Out-door	■	■	■	■		

USN Service Requirements (3/7)

Virtual Market Characteristics

- Design spaces of WSN by ETH Zurich
  - Deployment
  - Mobility
  - Cost, size, resources and energy
  - Heterogeneity
  - Communication modality
  - Infrastructure
  - Network topology
  - Coverage
  - Connectivity
  - Network size
  - Lifetime
  - QoS requirements

USN Service Requirements (4/7)

- Functional requirements and design specification are possible to be limited for a specific use case.
  - Limited design specification can enable various technology solutions.
  - Even sensor-built-in RFID tag may be useful enough.
- Vender's proprietary solutions could be successful in limited purpose and various application environment.
  - A specific solution which meets customer requirements can be competitive against a general purpose solution.
  - Even a simple function can make customers happy even though many functions are not provided.

USN Service Requirements (5/7)

- Cost effectiveness is a vital factor for success because USN may handle a huge number of sensor nodes.
  - Cost effective design for S/W and H/W is very important technology and engineering target.
  - Maintenance and management cost should be considered.
    - Labor cost for sensor node and network maintenance/management
    - Labor cost for battery change
    - Battery cost
    - Troubleshooting cost
    - Opportunity cost by service failures; and so on
  - Maintenance/management cost >> installation cost

USN Service Requirements (6/7)

- Lots of applications have a formatted and tiny data size.
  - Size of raw data can be decreased by a sophisticated data structure design. Mapping or scaling can be a solution to do that.
  - A single message can be enough for data transmission. (Ex. Default payload size of TinyOS is 29 bytes.)
- USN isn't be established by personal interests but established by business purposes as well as turn-key basis.
  - So, non-standard solution is possible because the turn-key basis can enable a solution package with non-standard but well-functioning technology solutions.
- Sensor node shouldn't be open to the public for consumers' access due to security and management reasons.
  - Public information service is provided via a backend application system, not direct communication with sensor nodes.

USN Service Requirements (7/7)

- Wireless networking is not the only networking solution.
  - Wire-line networking can be more effective in some cases or could be mandatory.
  - But, wireless must be the promising solution for sensor networking.
- Sensor node and network is installed by installation experts and managed by management experts.
  - Consumers don't buy, install and manage sensor nodes and networks while they do so for television.
  - This property can enable automatic operation requirement to be excluded from functional requirements.
- Usually performance and throughput are not that important. But, availability and survivality are more important.

USN Technical Issues (1/4)

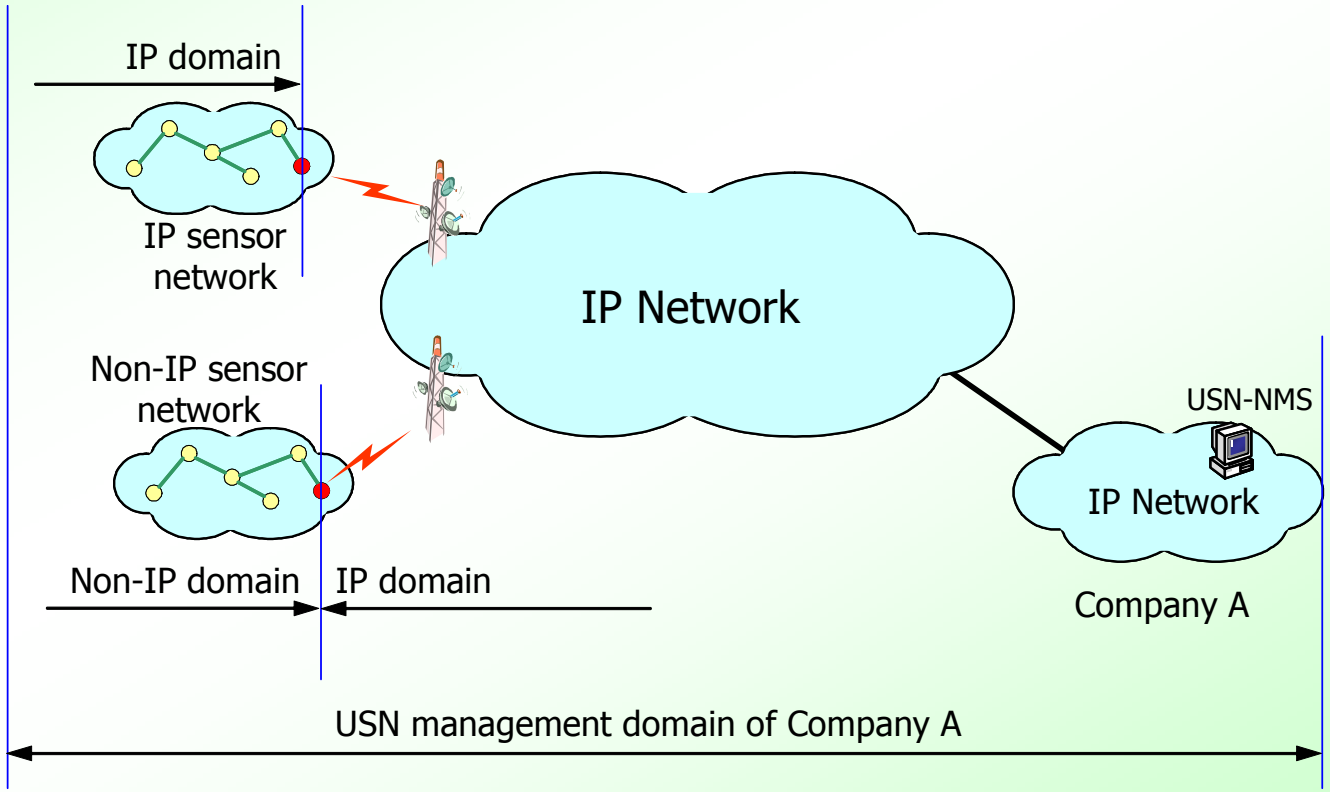
- Requirements analysis
  - Analysis of USN application models and scenarios;
  - Analysis of service requirements and functional capability requirements; and
  - Analysis of further development and relevant standardization items
- Non-IP sensor networking
  - ZigBee protocol stack
  - TinyOS-based sensor network
  - Proprietary sensor networking solutions
- IP sensor networking
  - Tiny TCP/IP networking stack
  - IETF 6LoWPAN

USN Technical Issues (2/4)

- Inter-networking between:
  - Non-IP sensor network and IP network
  - IPv4 or IPv6 sensor network and IPv4 or IPv6 network
- Mobility support
  - Intra-WPAN mobility
  - Inter-WPAN mobility
  - WPAN mobility
- Energy-saving routing protocol
- Energy-saving communication protocols
  - TCP/IP protocol family didn't care for energy saving.
  - Energy-saving communication protocols need to be developed.

USN Technical Issues (3/4)

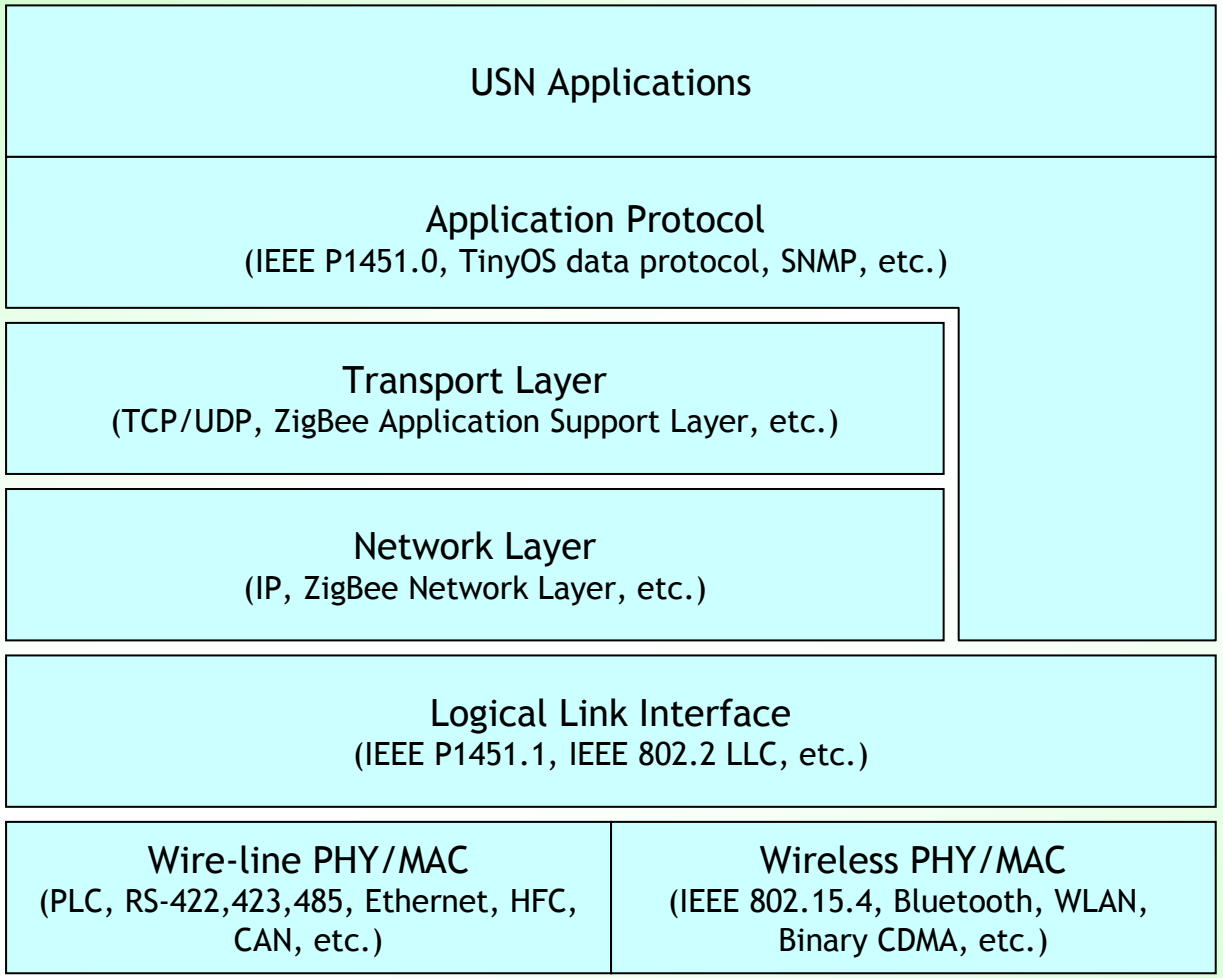
- USN management
  - Commissioning
  - Network management



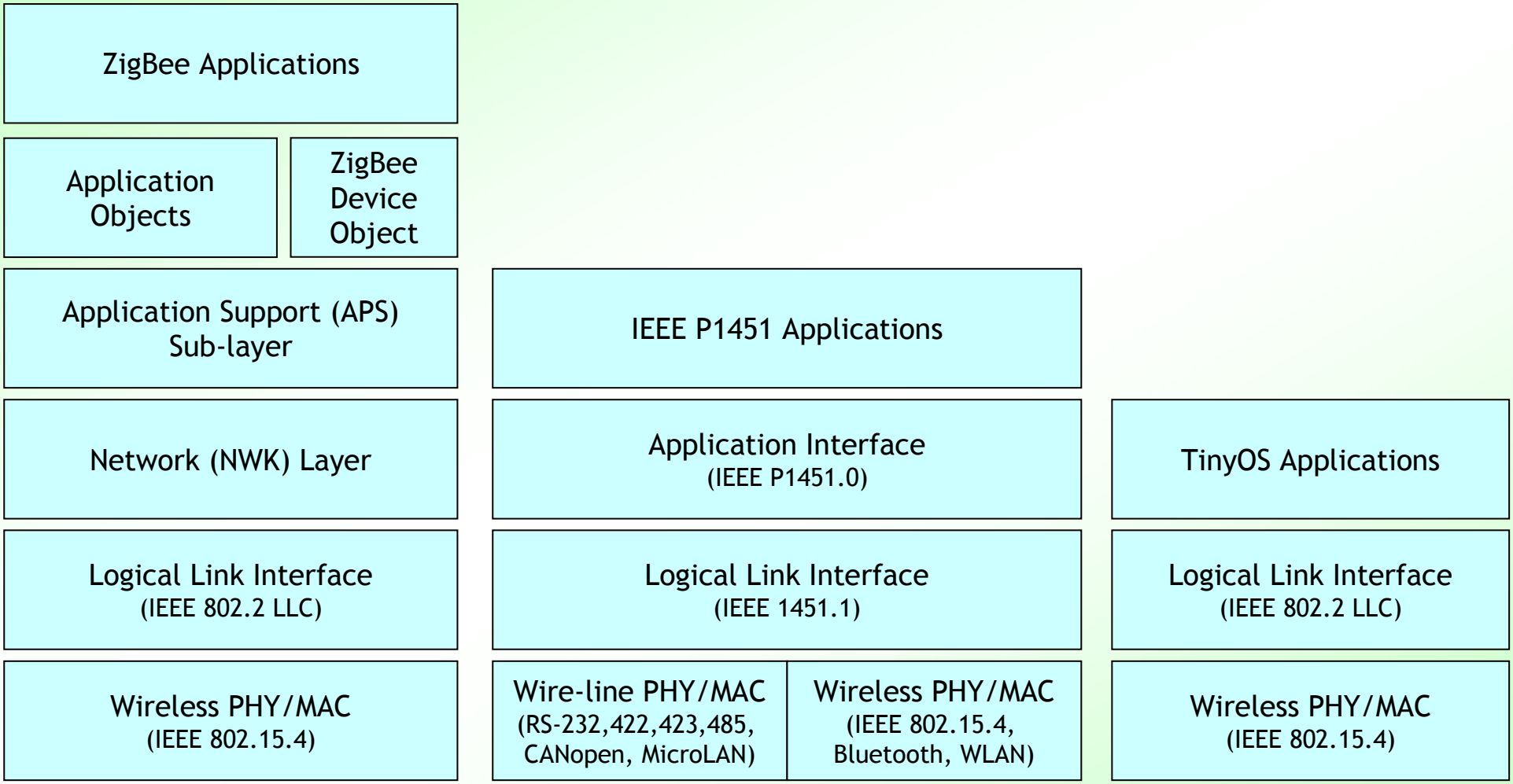
USN Technical Issues (4/4)

- Security
  - Telco-provided security capabilities could be a good solution for sensor node protection and other security requirements.
- Directory service
  - Sensor node identification for management
  - Public USN information service
- Middleware functions
  - Context awareness support
- Open service environment
  - value-added information resources should be integrated with other information contents or services.

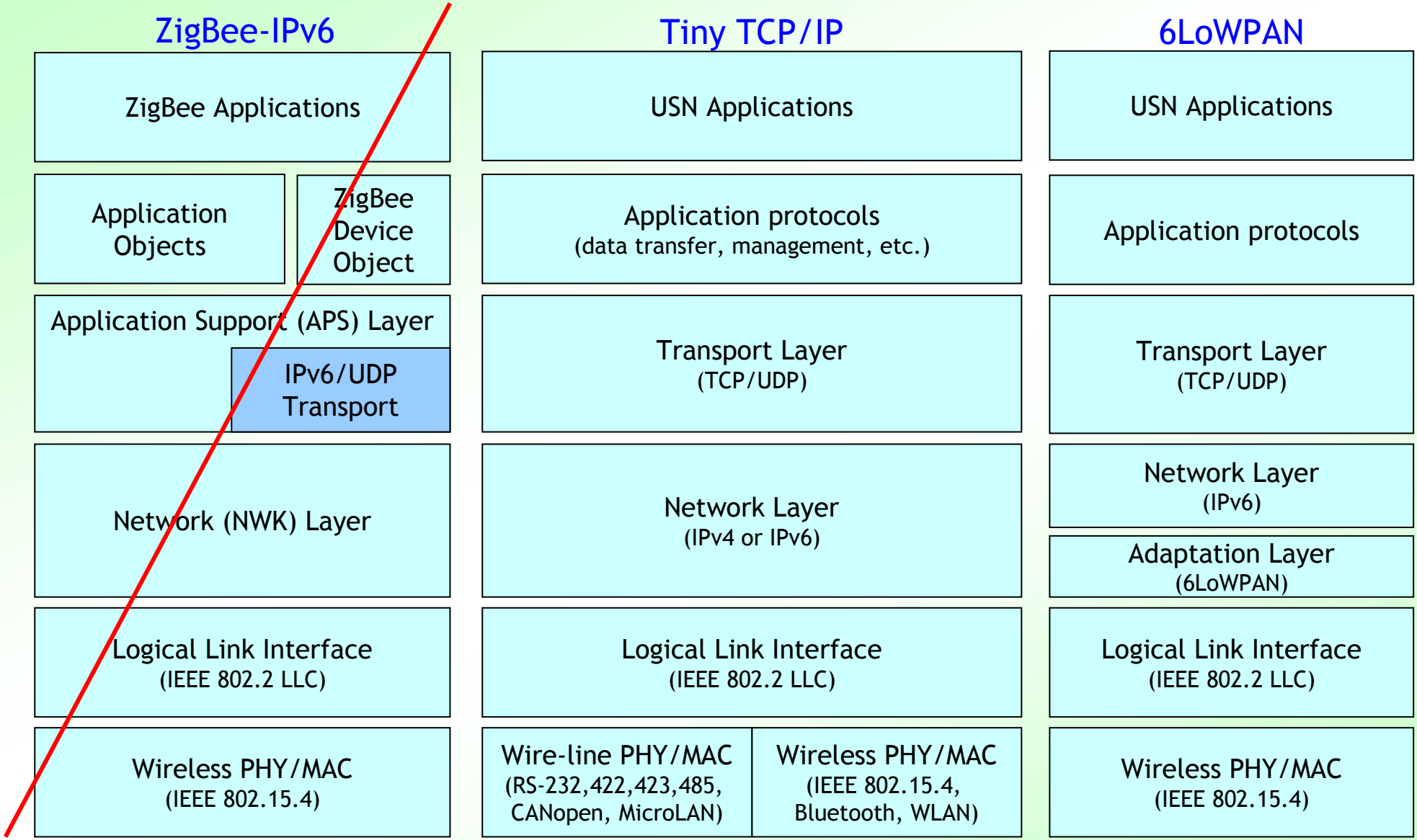
USN Technology Layer Model



Non-IP USN Networking Solutions



IP-USN Networking Solutions



Conclusions

- USN is information service infrastructure to cover low layers to higher layers.
- USN has various problem domains to be tackled.
- USN service requirements cause new challenging functionality requirements.
- So, future Internet architecture should care for USN.

Q/A