JAIPUR ENGINEERING COLLEGE AND RESEARCH CENTRE

Year & Sem – IV year & VII Sem
Subject – Internet of Things
Unit – V

Course outcomes (CO)

CO1: Understand the revolution of internet in field of cloud, wireless network, embedded system and mobile devices.

CO2: Apply IOT design concepts in various dimensions implementing software and hardware.

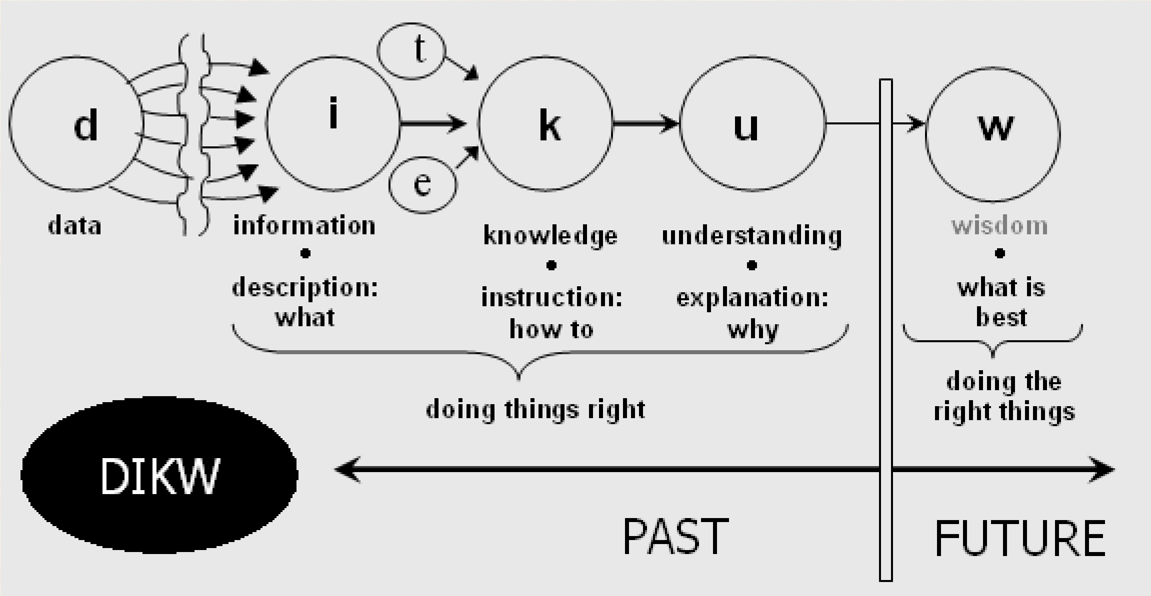
CO3: Analyze various M2M and IOT architectures.

CO4: Design and develop various applications in IOT.

Home Automation

Generate, collect, process and use acquired information to make decisions

- DIKW model
  - Information is inferred from data, in the process of answering interrogative questions (e.g., "who", "what", "where", "how many", "when"), thereby making the data useful for "decisions and/or action".
  - Knowledge as "synthesis of multiple sources of information over time"



Smart objects: Make things that weren't meant to talk to each other interact smartly

- Phone → Location detection, presence detection → Thermostat
- Doorbell activation → CCTV takes picture→ Email + SMS + Tweet
- Fire Alarm → Email + SMS
- Security System→ CCTV → Email + SMS
- Climate control → presence @ home & weather forecast
- Hot water tank 1 ← → Hot water tank 2 ← → our presence, weather forecast
- Dog→ CCTV + Email
- Weather notifications → email

Influence others to reduce their carbon footprint by sharing socially your metrics

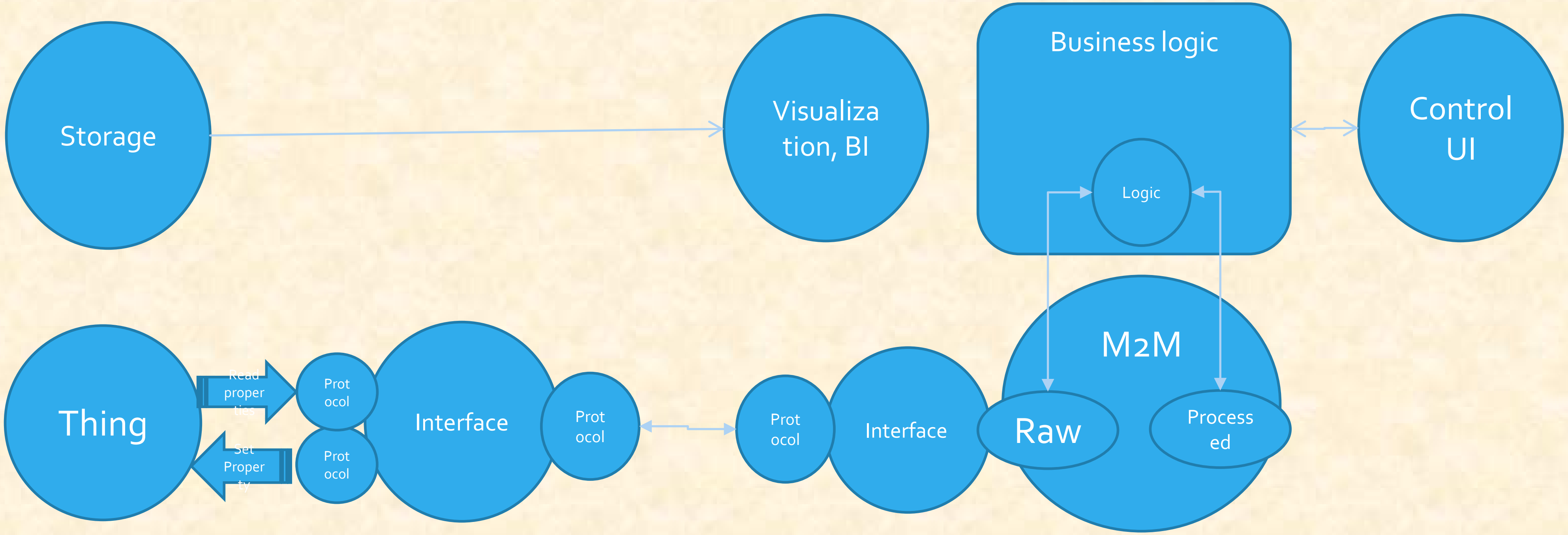
Alex Laskey: How behavioral science can lower your energy bill
https://www.youtube.com/watch?v=4cJo8wOqloc

- My @iot_house tweets power consumption statistics

Challenges

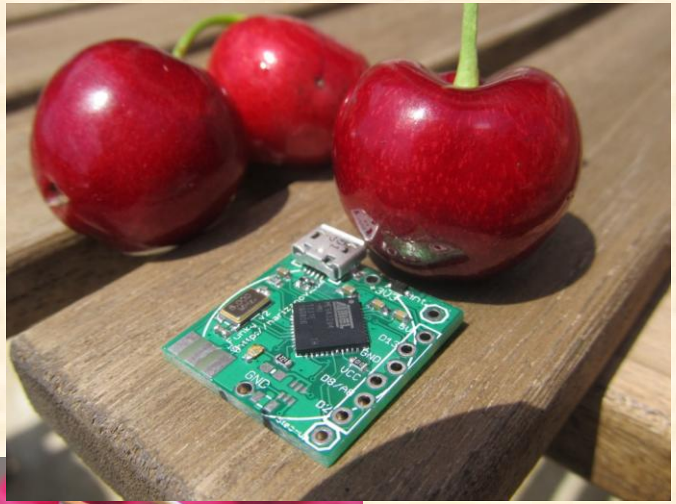
- Global cooperation
  - Proprietary and incompatible protocols
  - Lack of APIs
  - Example: Common external power supply
- Technological challenges
  - Power usage
  - Scalability
  - Security
  - Communication mechanisms
- Ethics, control society, surveillance, consent and data driven life

Overall Architecture



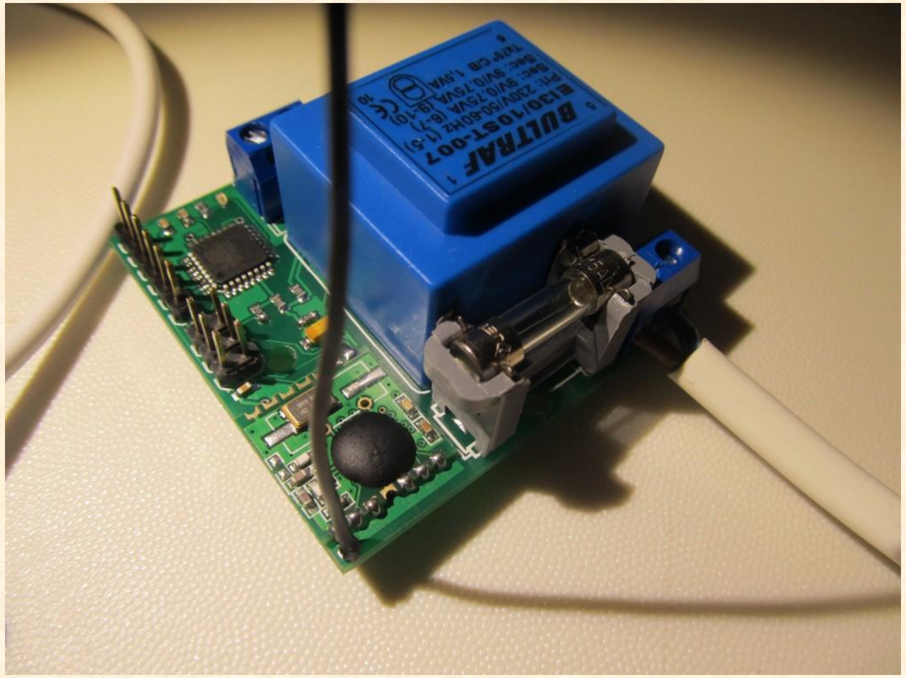
The hardware interface to “things”

- The ‘Funky’ project
- It is an Arduino-compatible multi purpose micro that is:
  - Very small: 20×21.2mm (0.78”x0.83”)
  - Very light: 3 grams
  - Low power (up to 1 year on coin cell battery)
  - Wireless capable (RFM12B transceiver)



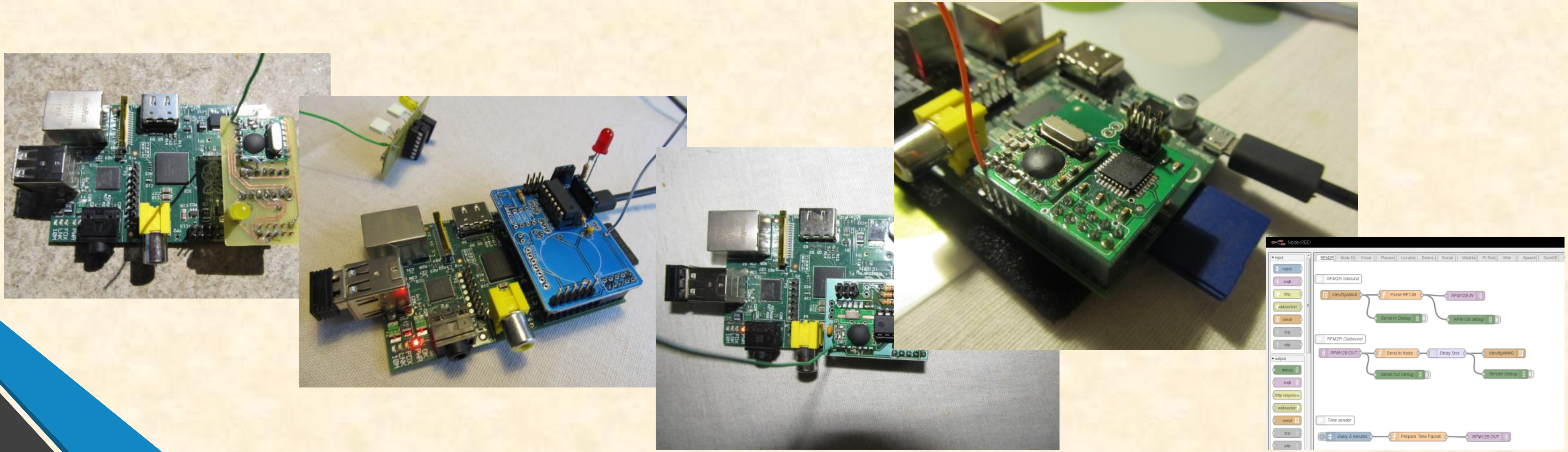
YAPM (Yet Another Power Monitor)

- Wireless Power Monitor project



Receiver module

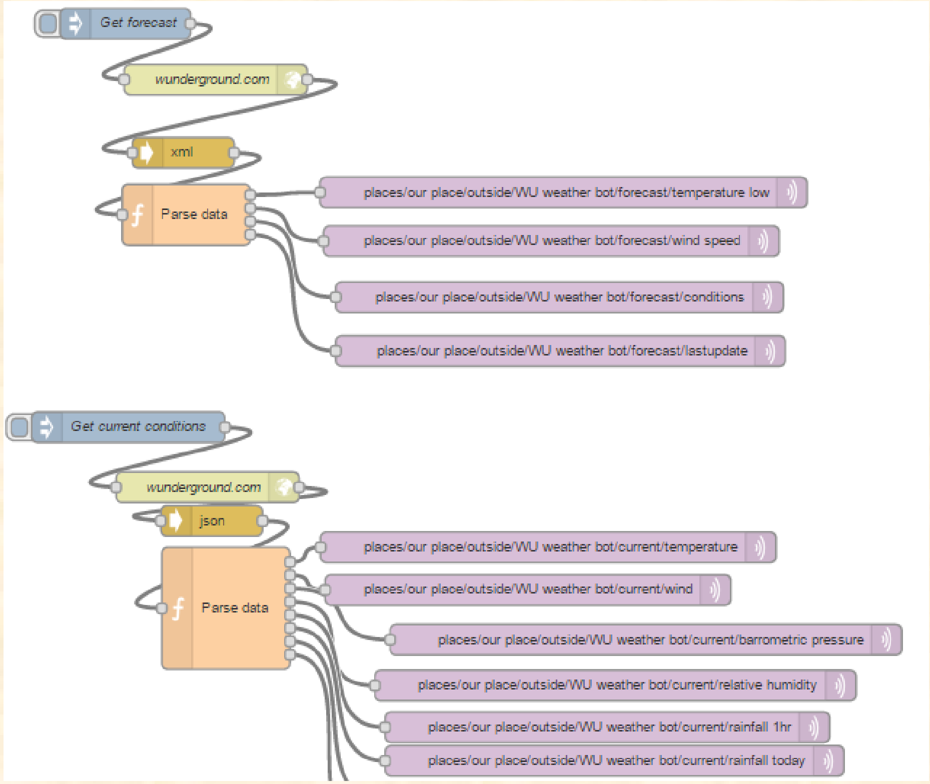
- The 'RFM2Pi' project
  - It is an Arduino-compatible board that acts as a wireless bridge between wireless remote nodes and the M2M layer



ESP8266 WiFi relay/thermostat project

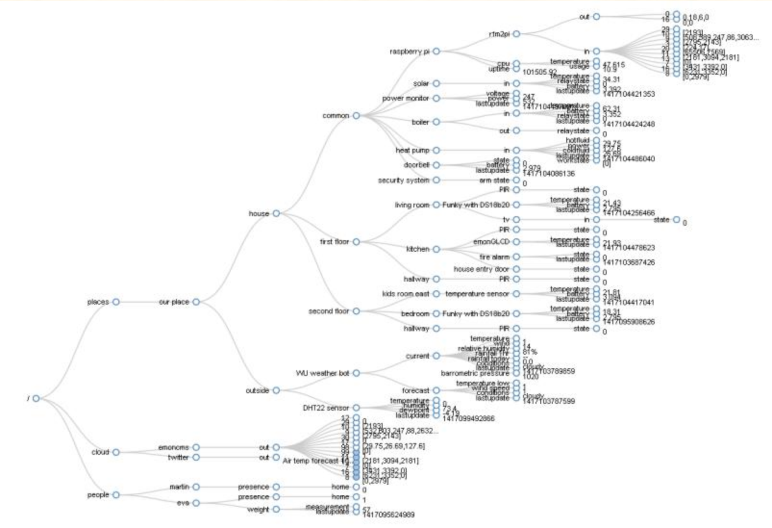
Software Interface example

- NodeRED weather forecast/current conditions



Machine to Machine

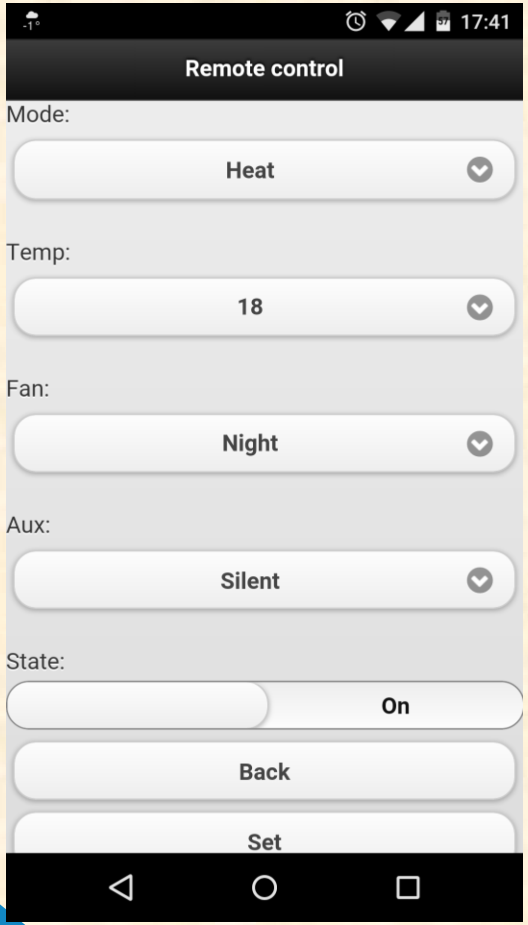
- Using mosquitto MQTT broker, extremely lightweight publish/subscribe messaging transport protocol
- My MQTT topic tree structure:

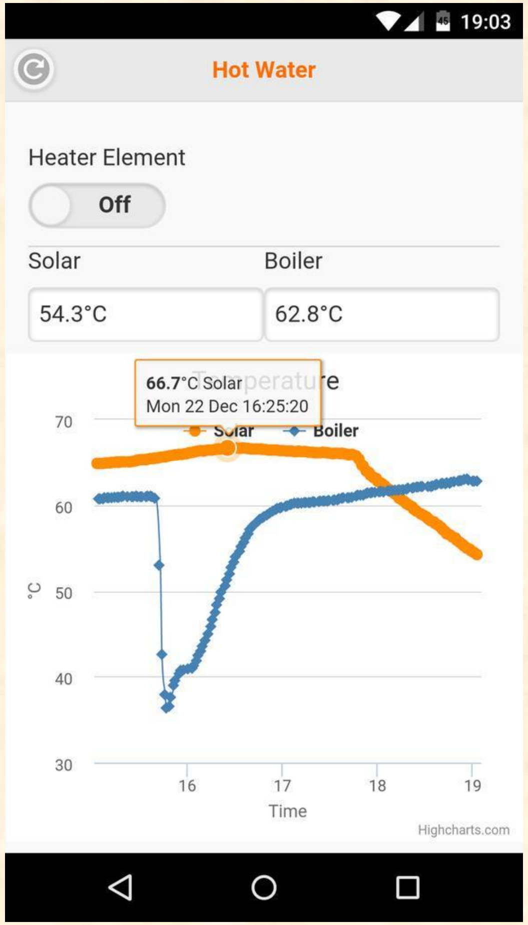


Business logic layer

- Using Node-RED
  - Very visual, drag-and-connect
  - Encapsulates all logic in single JSON file
  - Examples
    - Remote sensor data processing
    - Speech recognition/generation
    - Control UI
    - Dynamic DNS updater

Control UI


17:41
Remote control
Mode:
Heat
Temp:
18
Fan:
Night
Aux:
Silent
State:
On
Back
Set


19:03
Hot Water
Heater Element
Off
Solar
Boiler
54.3°C
62.8°C
66.7°C Solar
Mon 22 Dec 16:25:20
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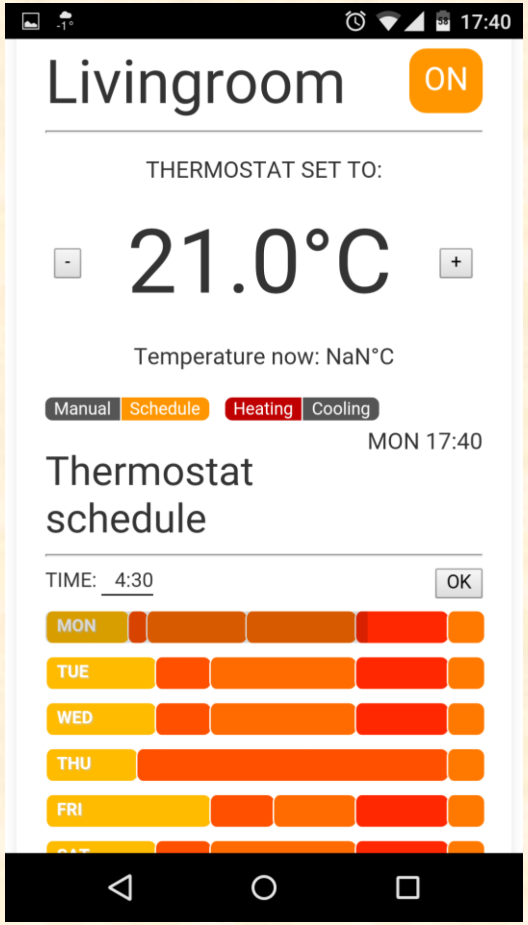
70
60
50
40
30
°C
16
17
18
19
Time
Highcharts.com


17:40
Livingroom
ON
THERMOSTAT SET TO:
-
21.0°C
+
Temperature now: NaN°C
Manual
Schedule
Heating
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Thermostat schedule
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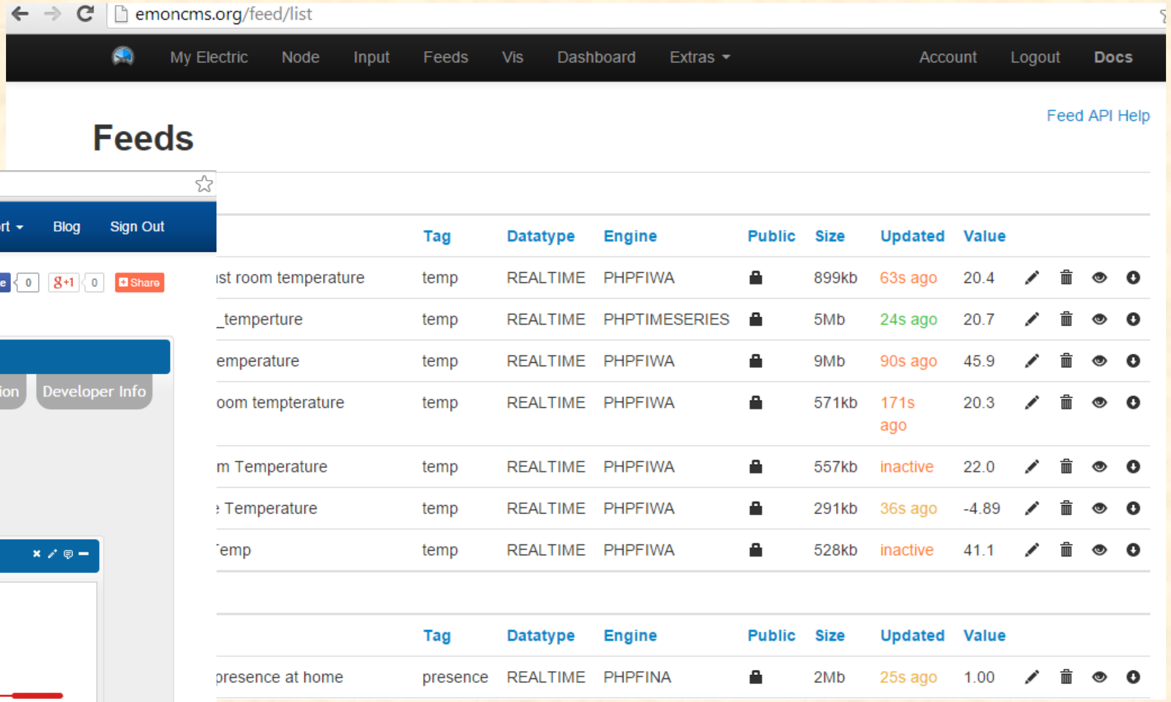
FRI

Storage


emoncms.org/feed/list
My Electric
Node
Input
Feeds
Vis
Dashboard
Extras
Account
Logout
Docs
Feeds
Feed API Help
Tag
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Size
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ıst room temperature temp REALTIME PHPFIWA 899kb 63s ago 20.4
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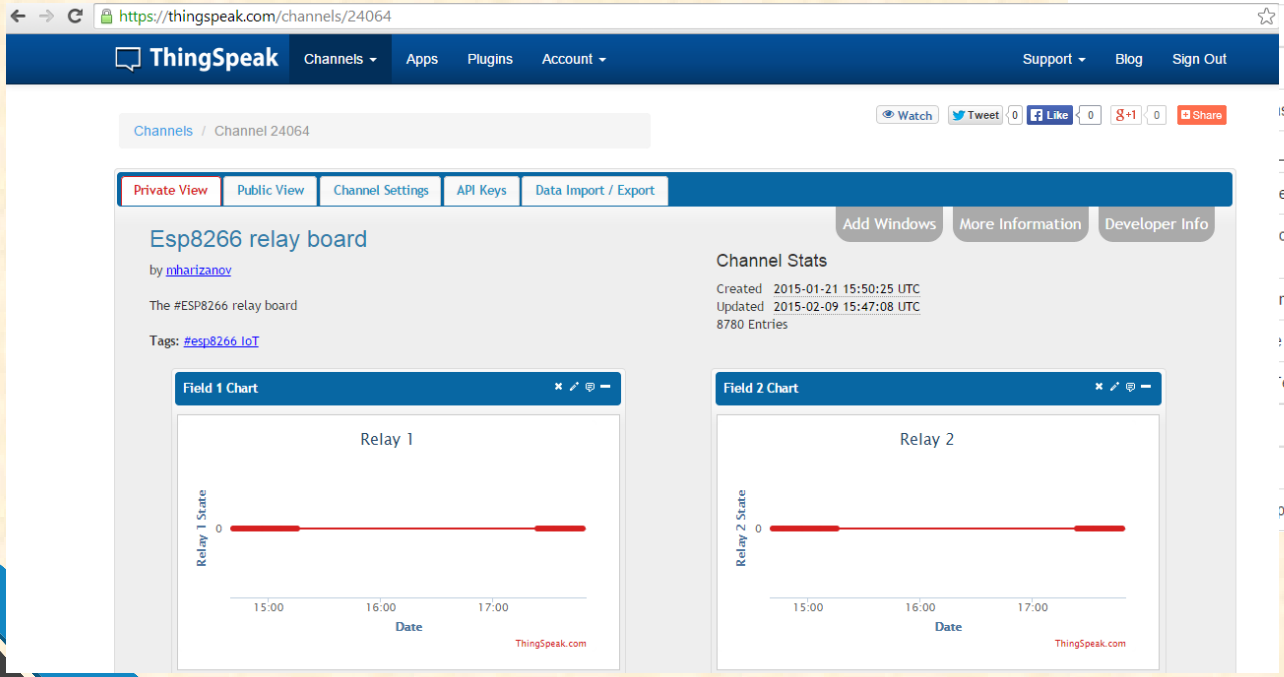
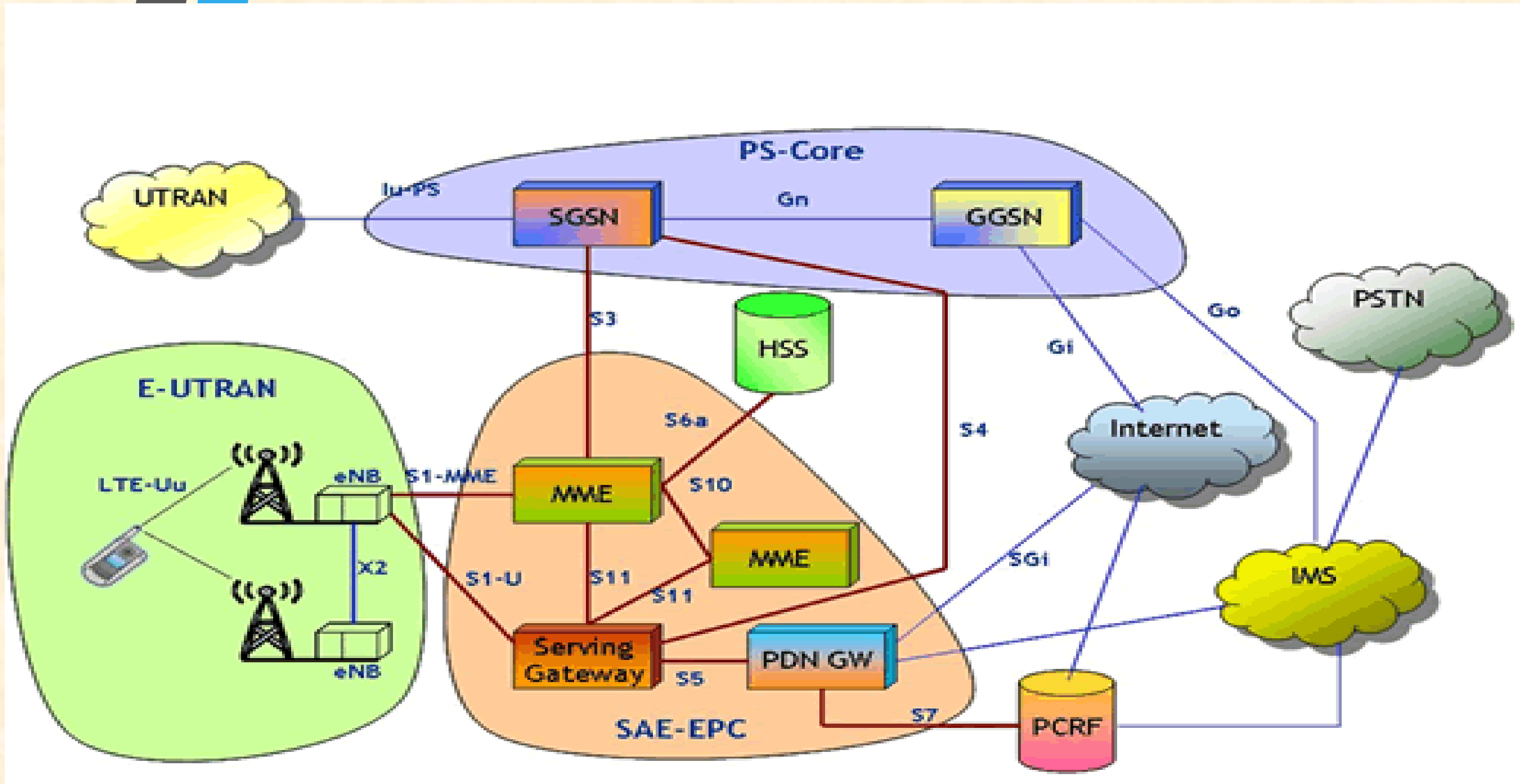
emperature temp REALTIME PHPFIWA 9Mb 90s ago 45.9
oom tempterature temp REALTIME PHPFIWA 571kb 171s ago 20.3
m Temperature temp REALTIME PHPFIWA 557kb inactive 22.0
Temperature temp REALTIME PHPFIWA 291kb 36s ago -4.89
emp temp REALTIME PHPFIWA 528kb inactive 41.1
presence at home presence REALTIME PHPFINA 2Mb 25s ago 1.00


https://thingspeak.com/channels/24064
ThingSpeak
Channels
Apps
Plugins
Account
Support
Blog
Sign Out
Channels / Channel 24064
Private View
Public View
Channel Settings
API Keys
Data Import / Export
Add Windows
More Information
Developer Info
Esp8266 relay board
by mharizanov
The #ESP8266 relay board
Tags: #esp8266 IoT
Channel Stats
Created 2015-01-21 15:50:25 UTC
Updated 2015-02-09 15:47:08 UTC
8780 Entries
Field 1 Chart
Relay 1
Relay 1 State
Date
Field 2 Chart
Relay 2
Relay 2 State
Date
ThingSpeak.com

Visualization

4G – Long Term Evolution (LTE) (2010's)



Data-centric Network

- Killer App = Facebook
- *Where is the clear voice path???*
- Broadband backhaul

WAP is crap and WOS is worse...

5G – The Vision

- Faster radio ~Gbps
- Low-latency wireless access ~ms
- Dynamic spectrum, multiple radio access technologies
- Next-gen network with improved support for emerging mobility services:


Mobile Data
(cellular, hetnet)


Vehicular Networks

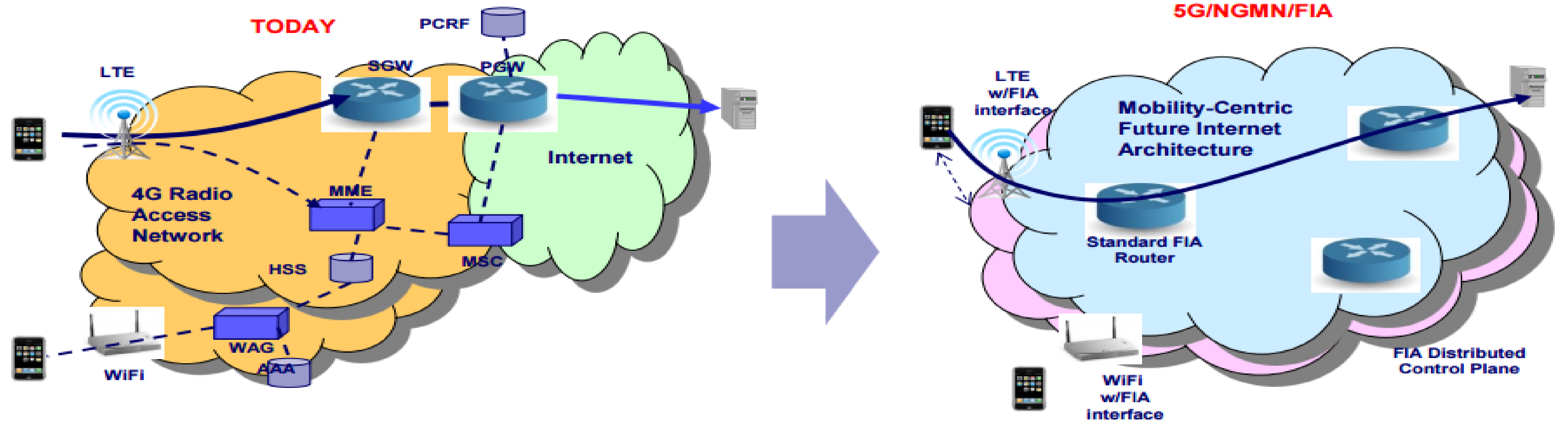

Emergency Networks


Content Delivery

Internet-of-Things


Cloud Services

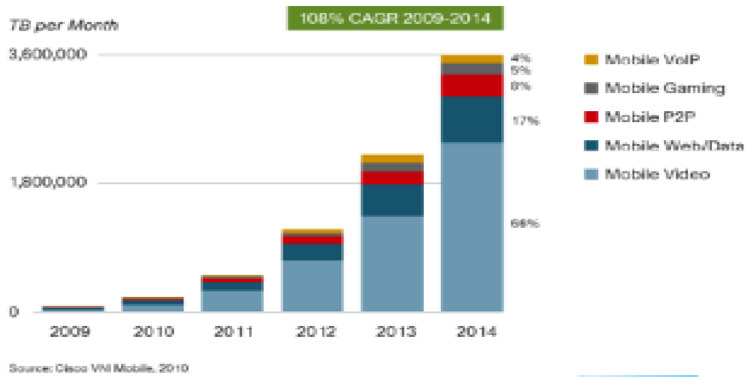
5G Network Architecture?



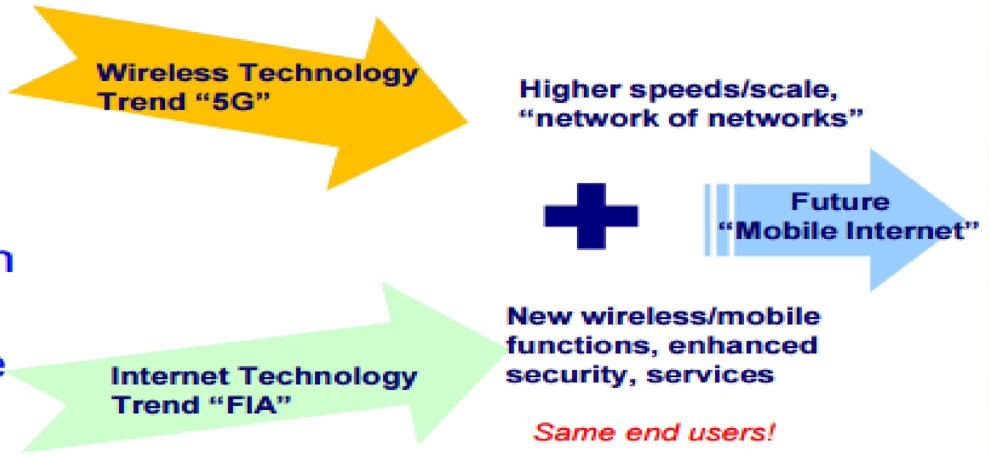
- Hybrid 3GPP & IP arch
- Complex control interfaces!
- Technology specific
- IP tunneling in data path
- Gateways (..bottlenecks, sub-optimum routing,..)

- Unified Internet/Mobile Net arch with integrated support for naming, authentication, mobility, etc.
- Simplified distributed control!
- Technology neutral –BS or AP plug-in
- Flat! No gateways or tunnels!
- Mobile devices as “first class” citizens

- **Historic shift from PC's to mobile computing and embedded devices…**
  - Mobile data growing exponentially – 3.6 Exabytes in 2014, >> wired Internet traffic
  - Sensor/IoT/V2V ~5-10B units by 2020
  - Internet in 2020 all about mobile platforms & services



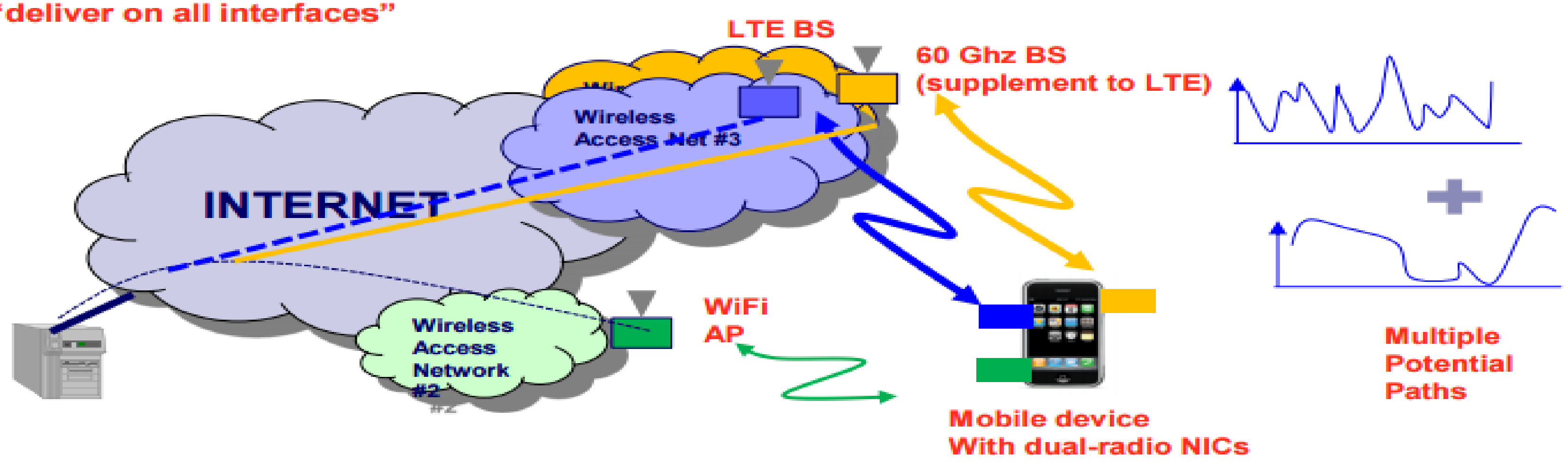
- **Inevitable convergence of mobile network and Internet industries**
  - Need to think beyond the "G"'s, associated with linear progression in mobile systems
  - Era of vertically integrated protocol stacks built on radio standards coming to an end
  - Single end-to-end protocol standard for the future mobile Internet!



Research Target of NSF Future Internet Architecture (FIA) MobilityFirst Project

- Multiple/heterogeneous radio access technologies (e.g. 4G/5G and WiFi) increasingly the norm
  - Improved service quality/capacity via opportunistic high BW access
  - Improved throughput in hetnet (WiFi/small cell + cellular) scenarios
  - Can also be used to realize ultra-high bit-rate services using multiple technologies, e.g. 60 Ghz supplement to LTE
  - Implications for naming and routing in the Internet

Multihomed devices may utilize two or more interfaces to improve communications quality/cost, with policies such as "deliver on best interface" or "deliver only on WiFi" or "deliver on all interfaces"



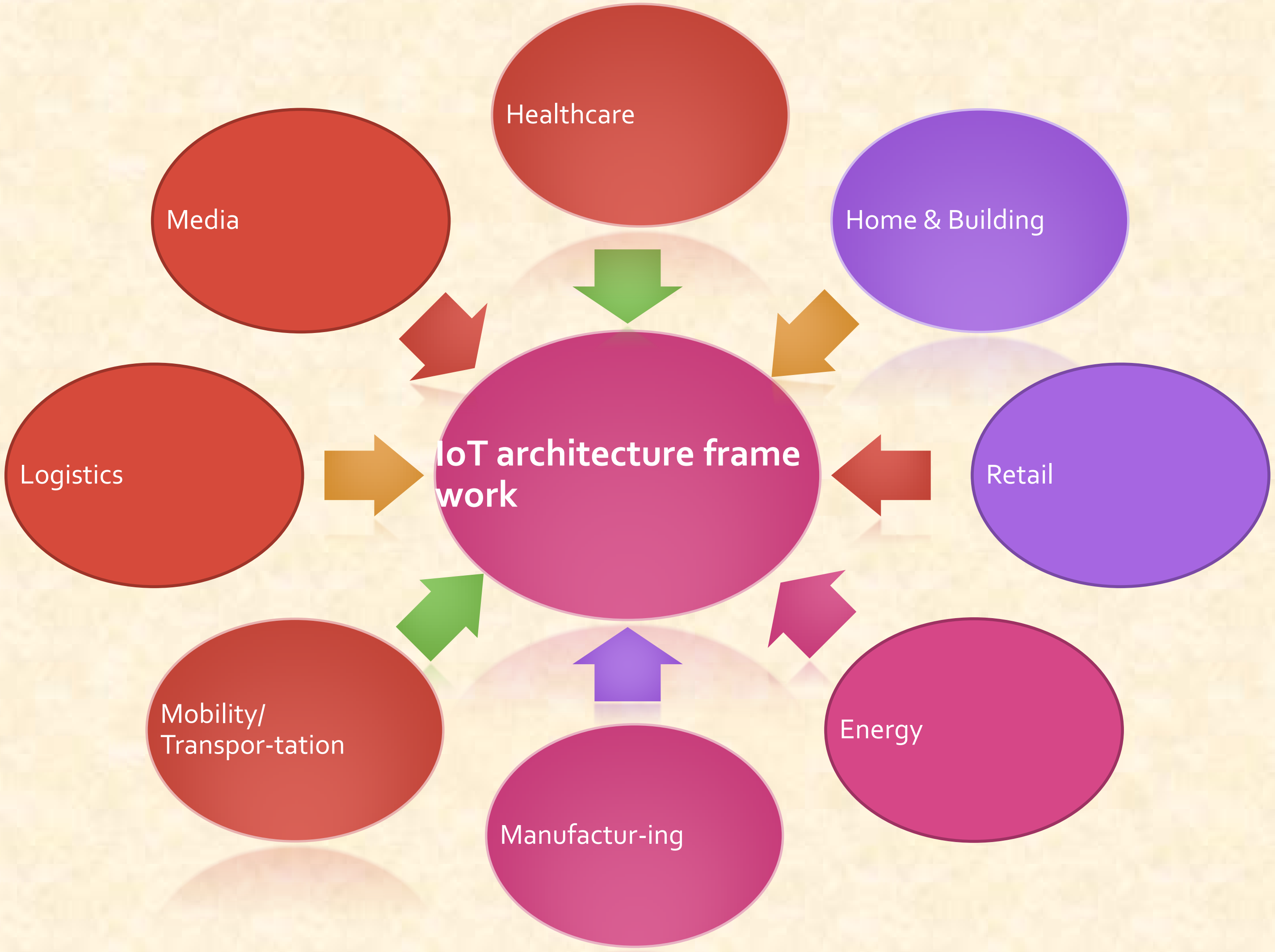
The Internet of Things (IoT)

- Sensors and Actuators
- Virtual Objects
- People
- Services
- Platforms
- Networks

- Low Bandwidth
- Possible high-volume
- 3GPP is considering GERAN
  - IoT over 2G technology

But what about Telematics?

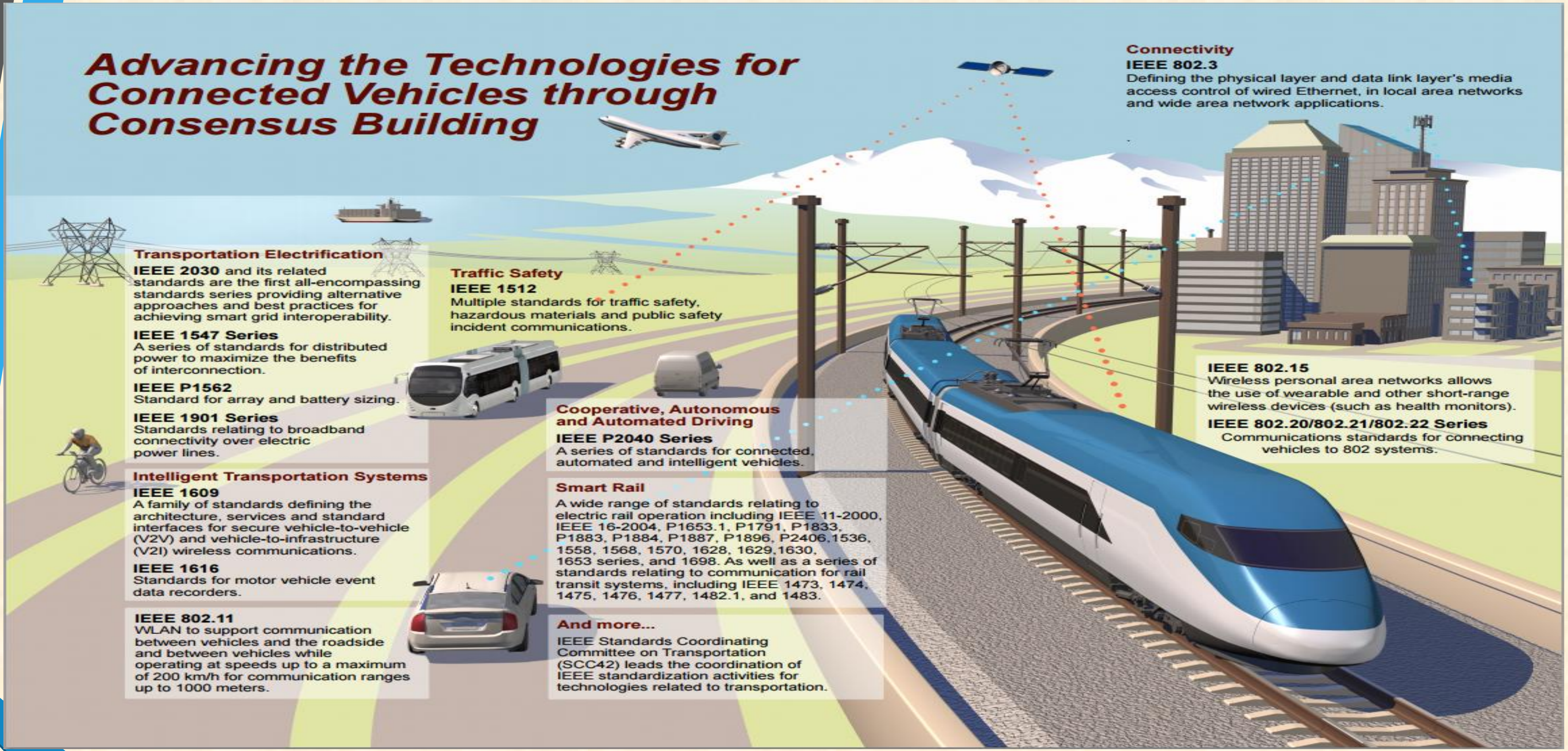
IoT Application Domains



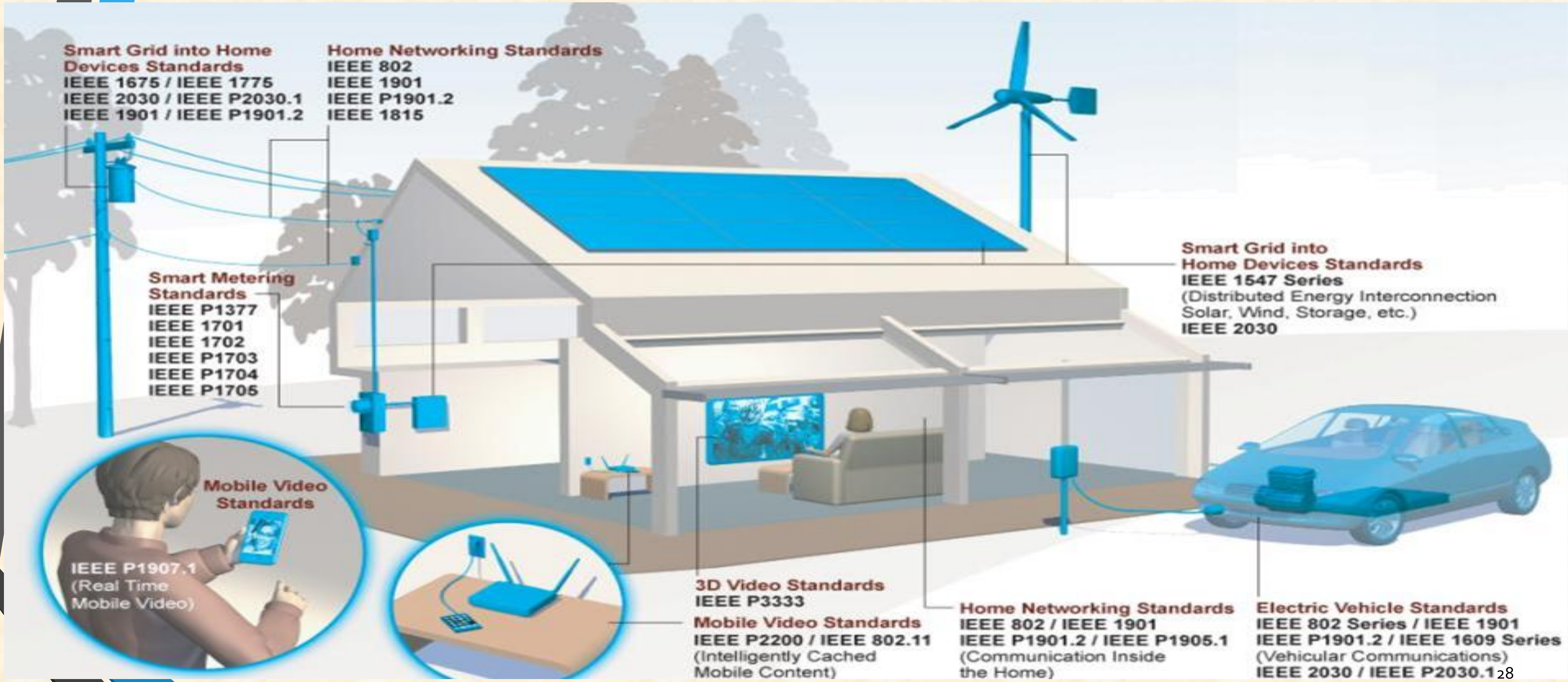
*due to the diversity of IoT application areas only selected domains and stakeholders are shown

eHealth and Wireless Monitoring

- **ISO/IEEE 11073 series** Health Informatics - Medical / Health Device Communication Standards


Advancing the Technologies for Connected Vehicles through Consensus Building
Connectivity
IEEE 802.3
Defining the physical layer and data link layer's media access control of wired Ethernet, in local area networks and wide area network applications.
Transportation Electrification
IEEE 2030 and its related standards are the first all-encompassing standards series providing alternative approaches and best practices for achieving smart grid interoperability.
IEEE 1547 Series
A series of standards for distributed power to maximize the benefits of interconnection.
IEEE P1562
Standard for array and battery sizing.
IEEE 1901 Series
Standards relating to broadband connectivity over electric power lines.
Traffic Safety
IEEE 1512
Multiple standards for traffic safety, hazardous materials and public safety incident communications.
Cooperative, Autonomous and Automated Driving
IEEE P2040 Series
A series of standards for connected, automated and intelligent vehicles.
IEEE 802.15
Wireless personal area networks allows the use of wearable and other short-range wireless devices (such as health monitors).
IEEE 802.20/802.21/802.22 Series
Communications standards for connecting vehicles to 802 systems.
Intelligent Transportation Systems
IEEE 1609
A family of standards defining the architecture, services and standard interfaces for secure vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) wireless communications.
IEEE 1616
Standards for motor vehicle event data recorders.
Smart Rail
A wide range of standards relating to electric rail operation including IEEE 11-2000, IEEE 16-2004, P1653.1, P1791, P1833, P1883, P1884, P1887, P1896, P2406,1536, 1558, 1568, 1570, 1628, 1629,1630, 1653 series, and 1698. As well as a series of standards relating to communication for rail transit systems, including IEEE 1473, 1474, 1475, 1476, 1477, 1482.1, and 1483.
IEEE 802.11
WLAN to support communication between vehicles and the roadside and between vehicles while operating at speeds up to a maximum of 200 km/h for communication ranges up to 1000 meters.
And more...
IEEE Standards Coordinating Committee on Transportation (SCC42) leads the coordination of IEEE standardization activities for technologies related to transportation.

The Smart Home Initiative



Institute of Electrical and Electronics Engineers (IEEE):
World's Largest Professional Association

Our Global Reach

430,000+
Members

45
Technical Societies

160
Countries

Our Technical Breadth

1,400
Annual Conferences

3,700,000+
Technical Documents

160+
Top-cited Periodicals

IEEE-SA Presence

- Globally recognized standards
- Clear IPR policy
- Approximately 1300 active standards
- More than 500 standards under development
- Over 7,000 individual members and 20,000 standards developers from every continent
- 200+ corporate members

- Leverages the breath of 40+ technical areas
- Smart Grid standards quoted in NIST
- Flagship transport layer standards in communications (IEEE 802)
- **Independent global community**
- Open standards process…

IEEE-SA Strengths

- Open membership, participation, and governance
- No restrictions
- Any individual or organization
- Includes academia
- Any industry or size of company

Different Paths: Standards Development

Individual Method

- Participants are individual technical experts
- Individuals represent themselves
- **Each individual participant has 1 vote**
- Ballot groups are made up of a minimum of 10 individuals
- Ballot group participants must be IEEE-SA individual members

Entity (Corporate) Method

- Participants are "entities," i.e., companies, universities, government bodies, etc.
- Designated representative and alternate represent the entity
- **Each entity has one vote**
- Requires 3 entities
- Entity sends representatives to meetings

The Market Challenge of Standards

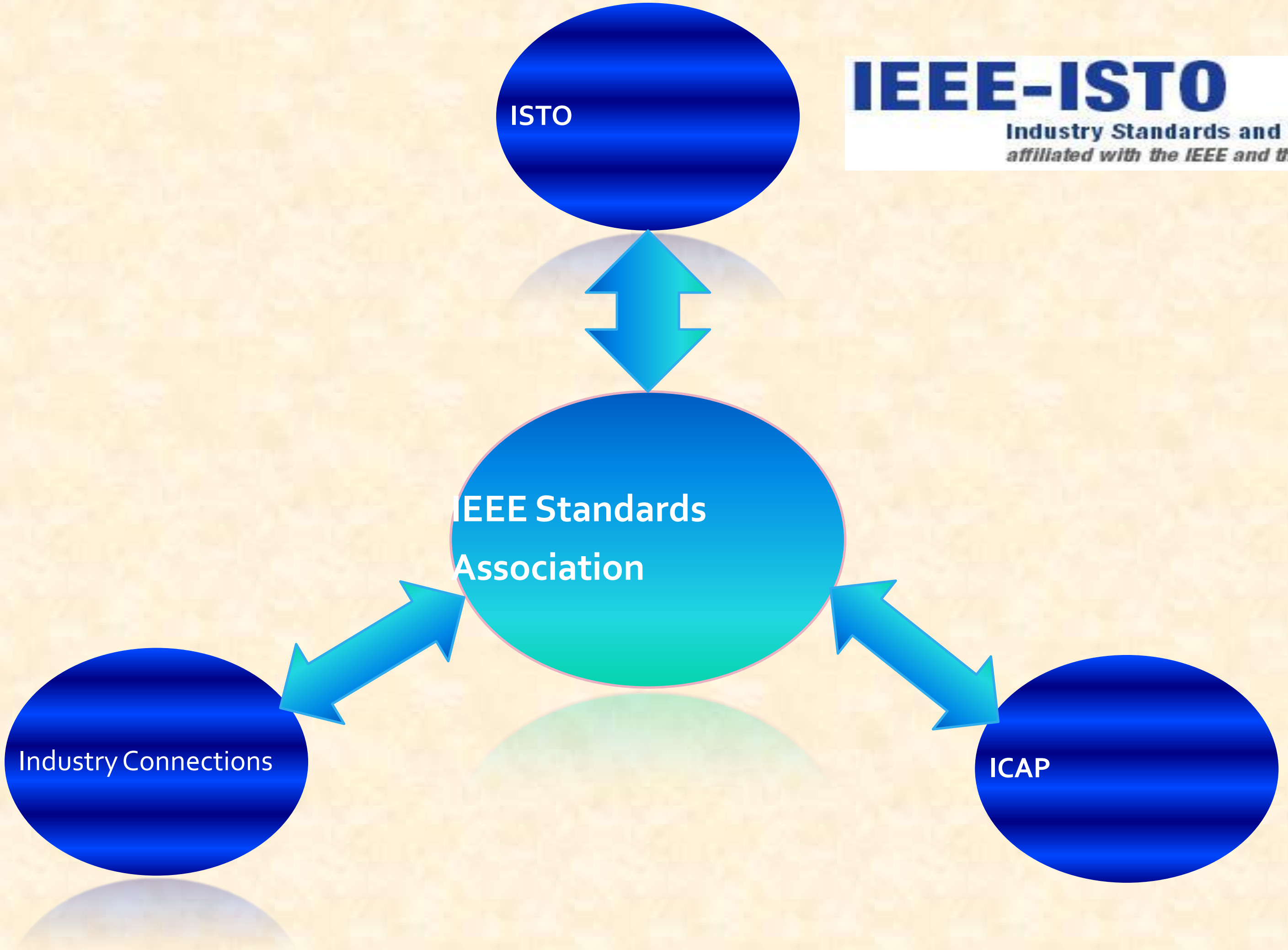
Benefits

- Establishes Developer Community
- Eliminates Customer Concerns with Sole-Sourcing
- Broadens Market Reach
    - Sole-source sales restricted to "must have"
- Reduces Production Costs
- Reduces R&D Costs
- Improves Interoperability
    - Affiliated Market Potential

Challenges

- IP Protection Issues
    - What do you protect/what do you expose?
- Competition
    - Must compete on:
        - Efficiency
        - Differentiation
- Cost/Resources
    - R&D Support
    - Standards delegate(s)

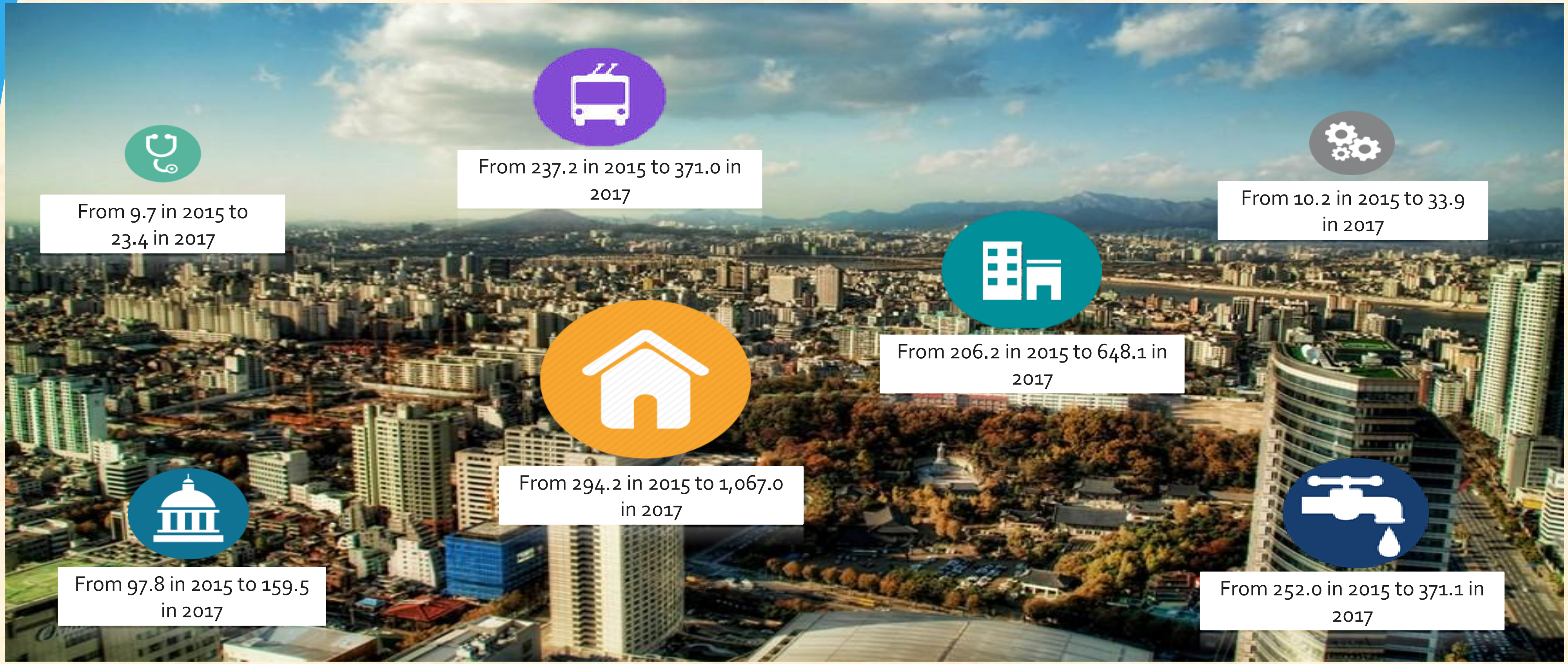
Tools for Collaboration



IEEE-ISTO
Industry Standards and Technology Organization
affiliated with the IEEE and the IEEE Standards Association

ICAP
IEEE CONFORMITY ASSESSMENT PROGRAM

IoT applications for smart sustainable cities and citizens

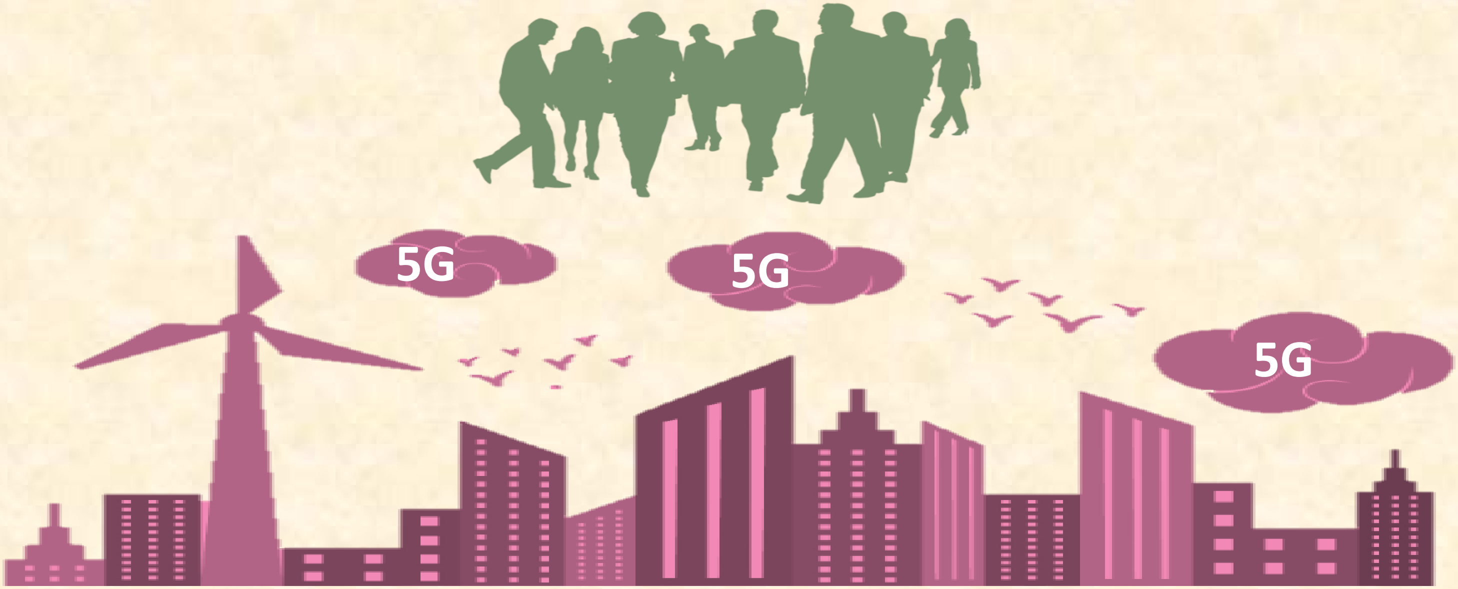


- Smart cities are projected to use 2.7 billion connected things in 2017

Source: Gartner (data in millions)

Building smart sustainable cities

IoT enabled services and infrastructure to improve and manage power, resources and urban planning.



First internationally agreed definition…

*"A **smart sustainable city** is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects"*

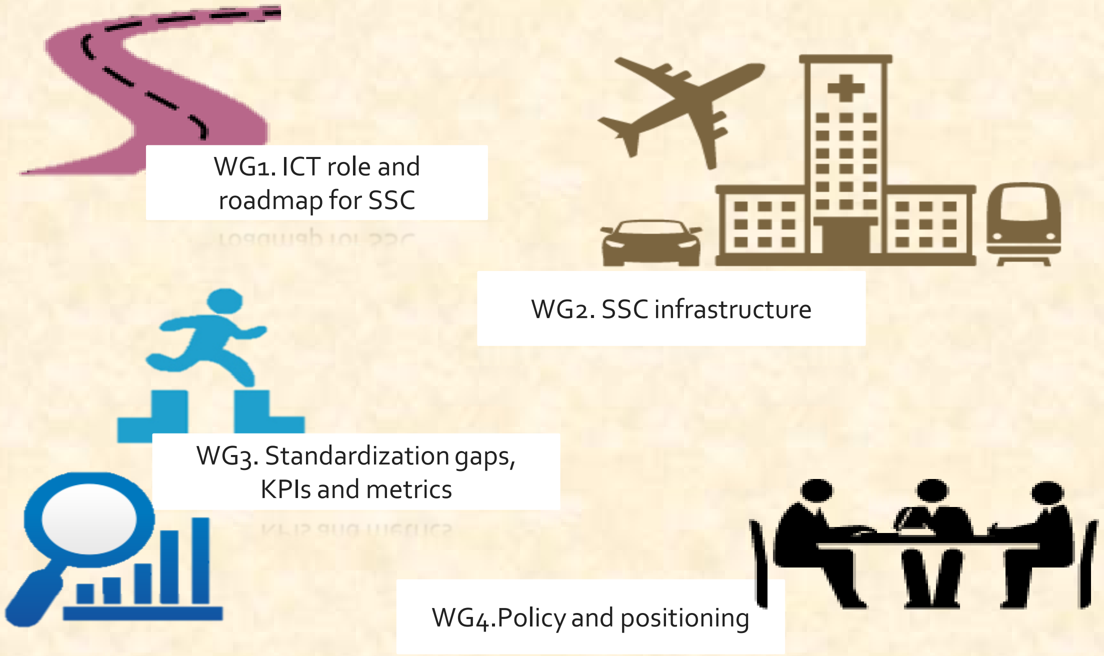
Source: ITU-T Focus Group on Smart Sustainable Cities

ITU-T Focus Group on Smart Sustainable Cities

Mandate and achievements

- Established in February 2013 and concluded in May 2015
- As an open platform for smart-city stakeholders
- Over 150 participants/collaborators from different stakeholders
- Liaison with other SDOs (ETSI, ISO, IEC etc) & IGOs (UNFCCC, UN-Habitat, etc)
- 21 technical specifications and reports approved

Working groups



FG-SSC technical reports and specifications

High Level and WG1 reports:

1. Smart sustainable cities: an analysis of definitions
2. An overview of smart sustainable cities and the role of ICTs
3. Smart sustainable cities: **a guide for city leaders**
4. **Master plan** for smart sustainable cities

WG3 reports:

1. Overview of KPIs in smart sustainable cities
2. KPIs definitions for smart sustainable cities
3. KPIs related to the **use of ICT** in smart sustainable cities
4. KPIs related to the **sustainability impacts of ICT** in smart sustainable cities
5. **Standardization roadmap** for smart sustainable cities
6. **Standardization activities** for smart sustainable cities

FG-SSC technical reports and specifications

WG2 reports:

1. Overview of smart sustainable cities **infrastructure**
2. Setting the **framework for an ICT architecture** of a smart sustainable city
3. **Multi-service infrastructure** for smart sustainable cities in new-development areas
4. **Anonymization infrastructure and open data** in smart sustainable cities
5. **Intelligent sustainable buildings** for smart sustainable cities
6. ICTs for **climate change adaptation** in cities
7. **Smart water management** in cities
8. **Cybersecurity**, data protection and cyber resilience in smart sustainable cities
9. **EMF** considerations in smart sustainable cities
10. **Integrated management** for smart sustainable cities

WG4 reports:

1. Setting the stage for stakeholders' engagement in smart sustaintable cities

Smart sustainable cities: a six step transition cycle

Six step transition cycle in details (1)

- Political priorities of the city
- Long-term development strategies
- Identify the relevant SSC stakeholders

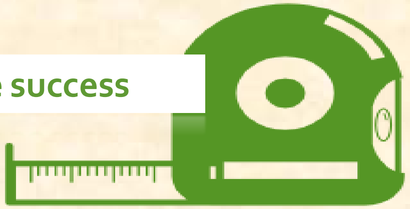
- Development of an appropriate SSC infrastructure
- Development of SSC service by integrating ICT into existing urban services

- Achievement of consensus and support for the implementation of the SSC vision and targets

Six step transition cycle in details (2)

4. Build your SSC

- Establishment of a feasible master plan for the SSC transition
- Ensure good operation and maintenance



5. Measure success

- Monitor, evaluation and assessment of the implementation of the master plan
- *Use the FG-SSC KPIs as baseline*

6. Ensure accountability

- Analysis and reporting of the progress achieved
- Identification and preparation of future plans


Openness


Privacy


Scalability

Building trust


Resilience

Data protection


Flexibility


Security


Cultural and age adaptation


Reliability

Pilot the ITU's SSC-KPIs in your city

Background

- A global project launched by ITU in cooperation with other UN agencies to support cities in the implementation and use of the ITU's SSC-KPIs developed by FG-SSC.
- Several cities are **testing** the ITU's SSC-KPIs and will get a **certificate** from ITU.
- ITU will also develop a **Global Smart Sustainable Cities Index**.

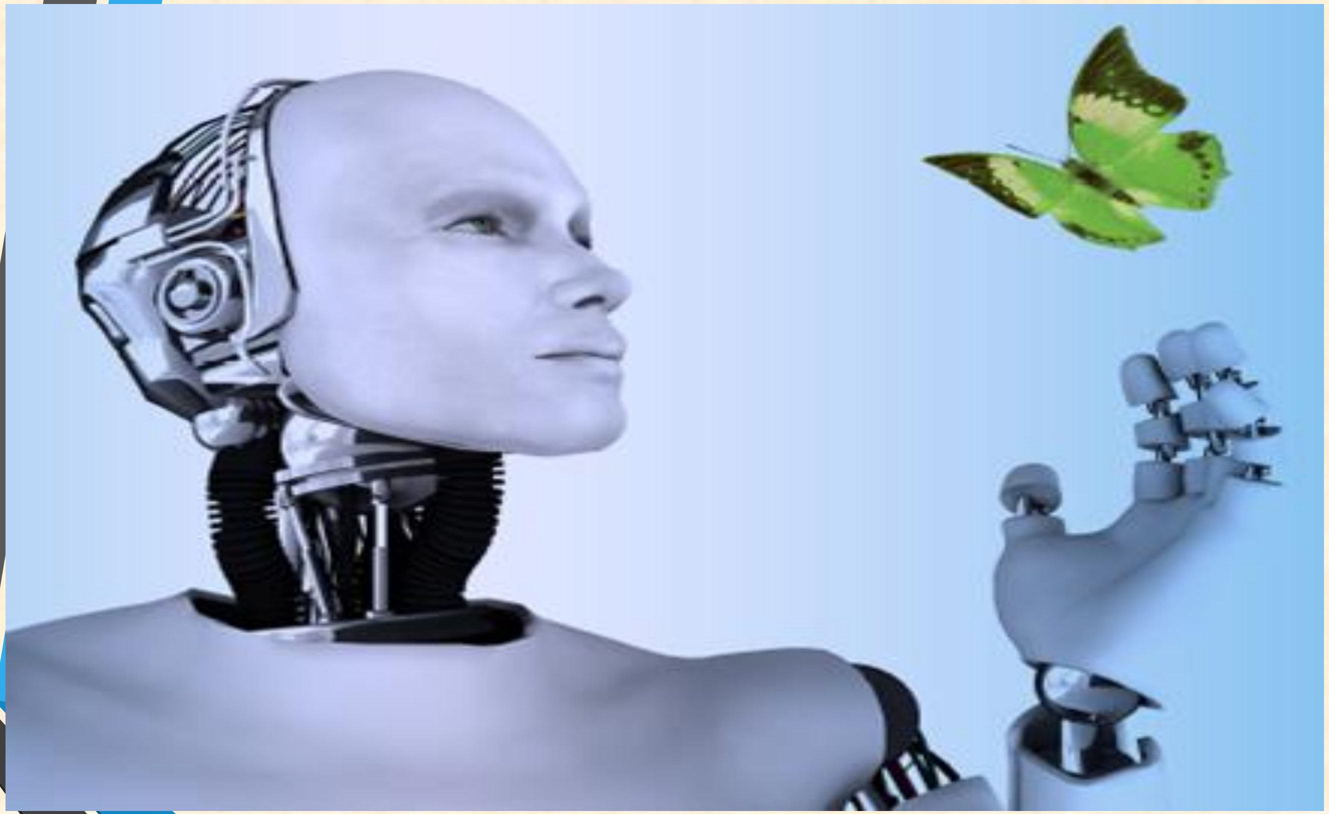
Benefits

- Cities will be able to **measure** current **performance** and identify opportunities to **improve** city services towards sustainability and operational eco-efficiency.

First pilot project, May 2015

Join ITU' Smart Sustainable Cities Initiative!

Forum on "Internet of things: empowering the new urban agenda "



This forum will provide a platform to discuss why the Internet of things will be at the heart of smart city transformation.

When: 19 October 2015

Where: ITU Headquarters, Geneva, Switzerland

A win-win way forward for the future of IoT

IoT involves many manufacturers, spans multiple industries, and differs widely in application scenarios and user requirements.

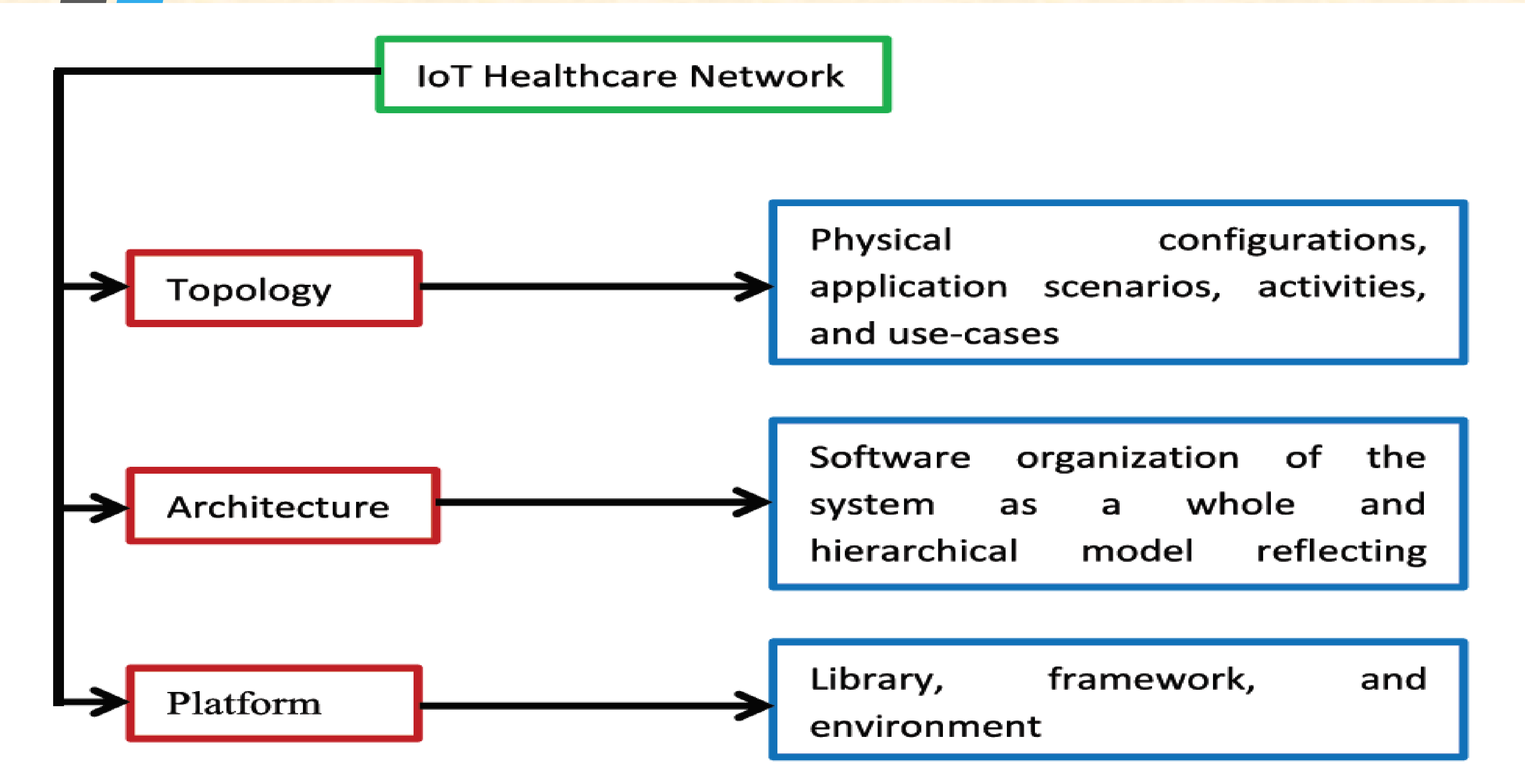
Standardization can create the necessary framework for any large-scale IoT deployment and ensure commercial revenues in future.

IoT in Healthcare

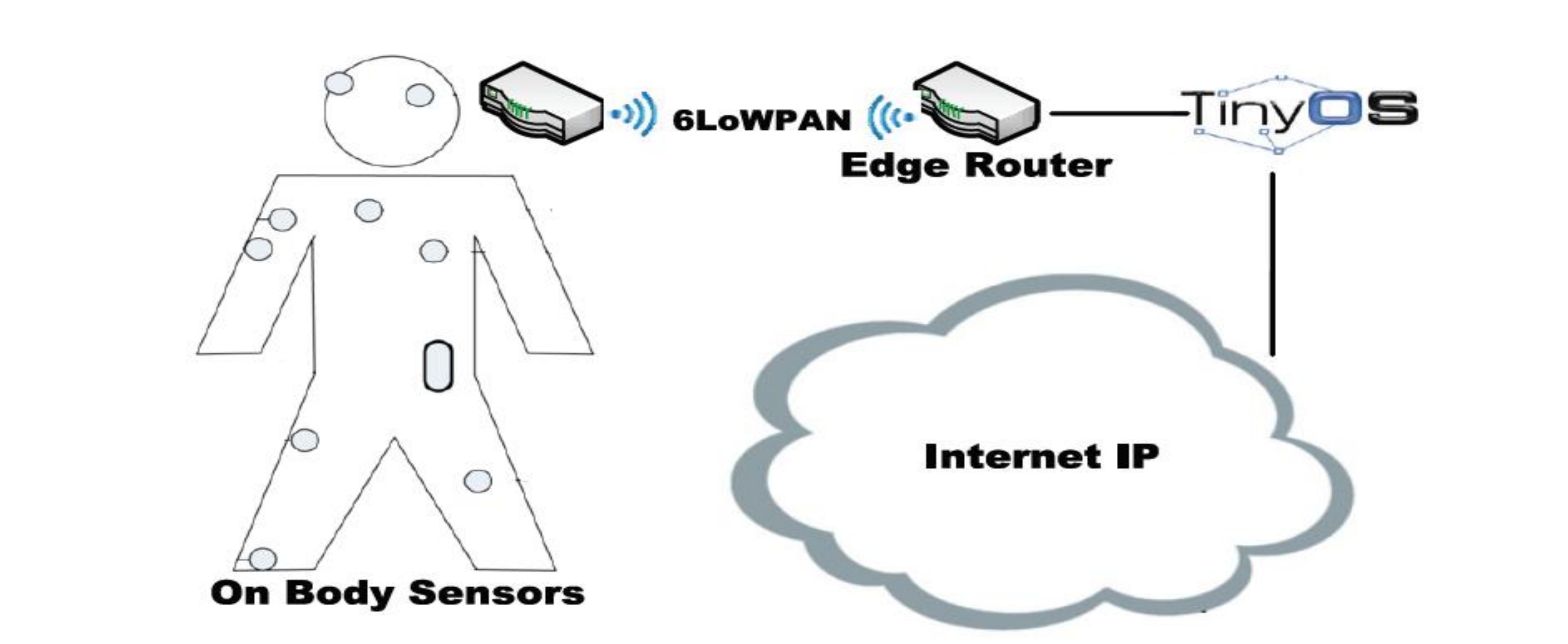
- Compliance with treatment and medication at home and by healthcare providers

- Various medical devices, sensors, and diagnostic and imaging devices can be viewed as smart devices or objects constituting a core part of the IoT.

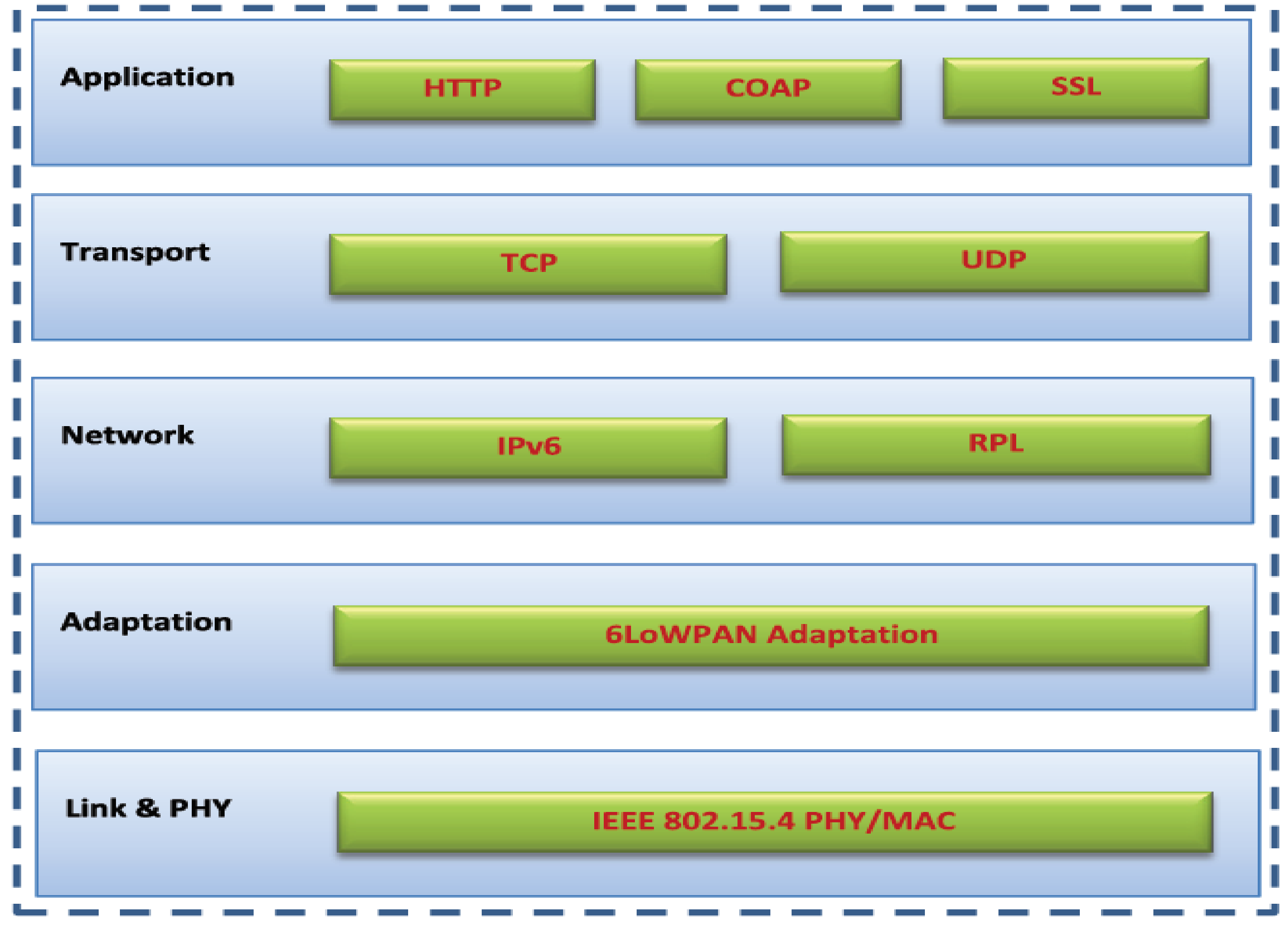
IOT Healthcare Networks



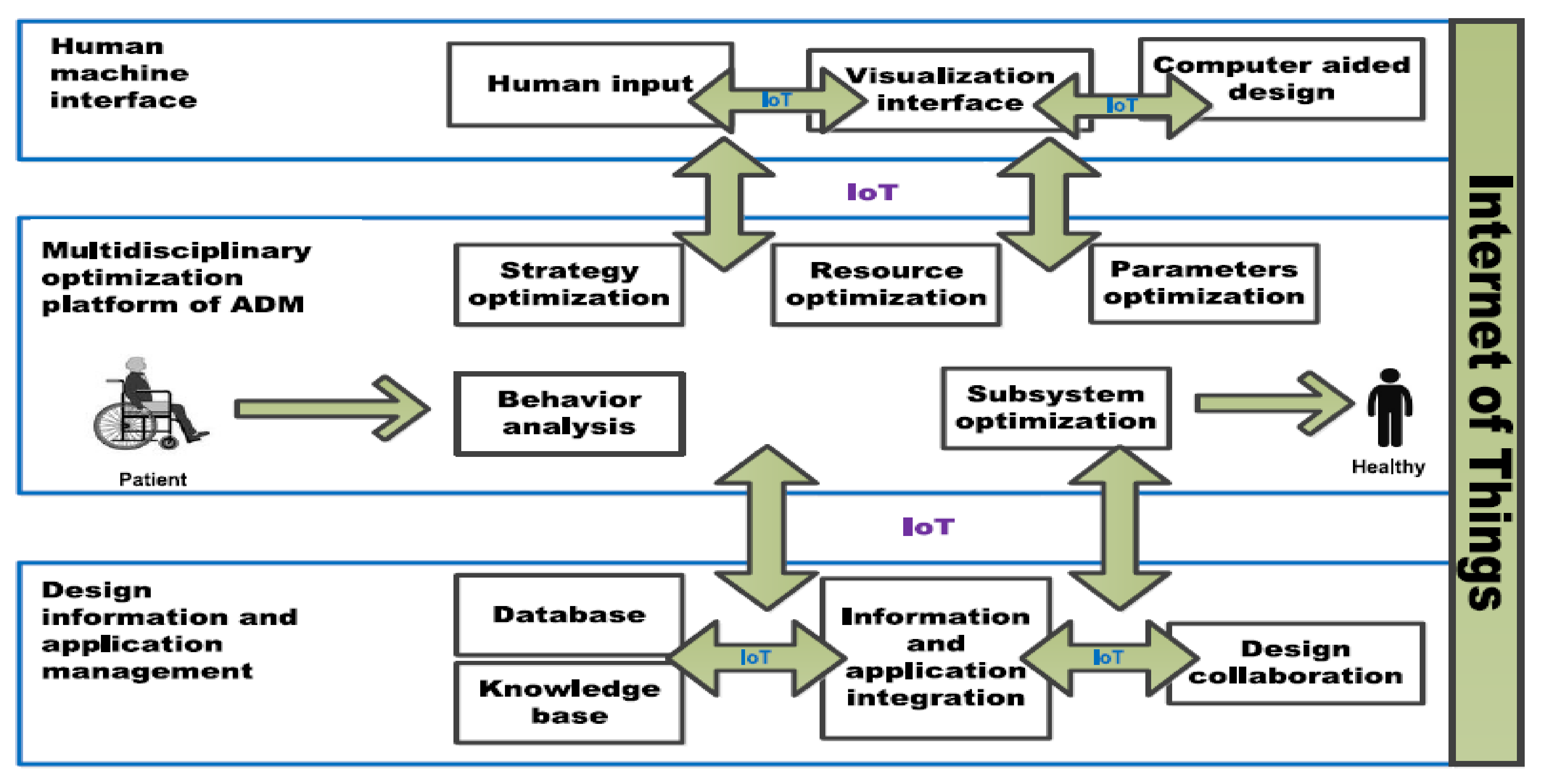
The IoThNet Topology



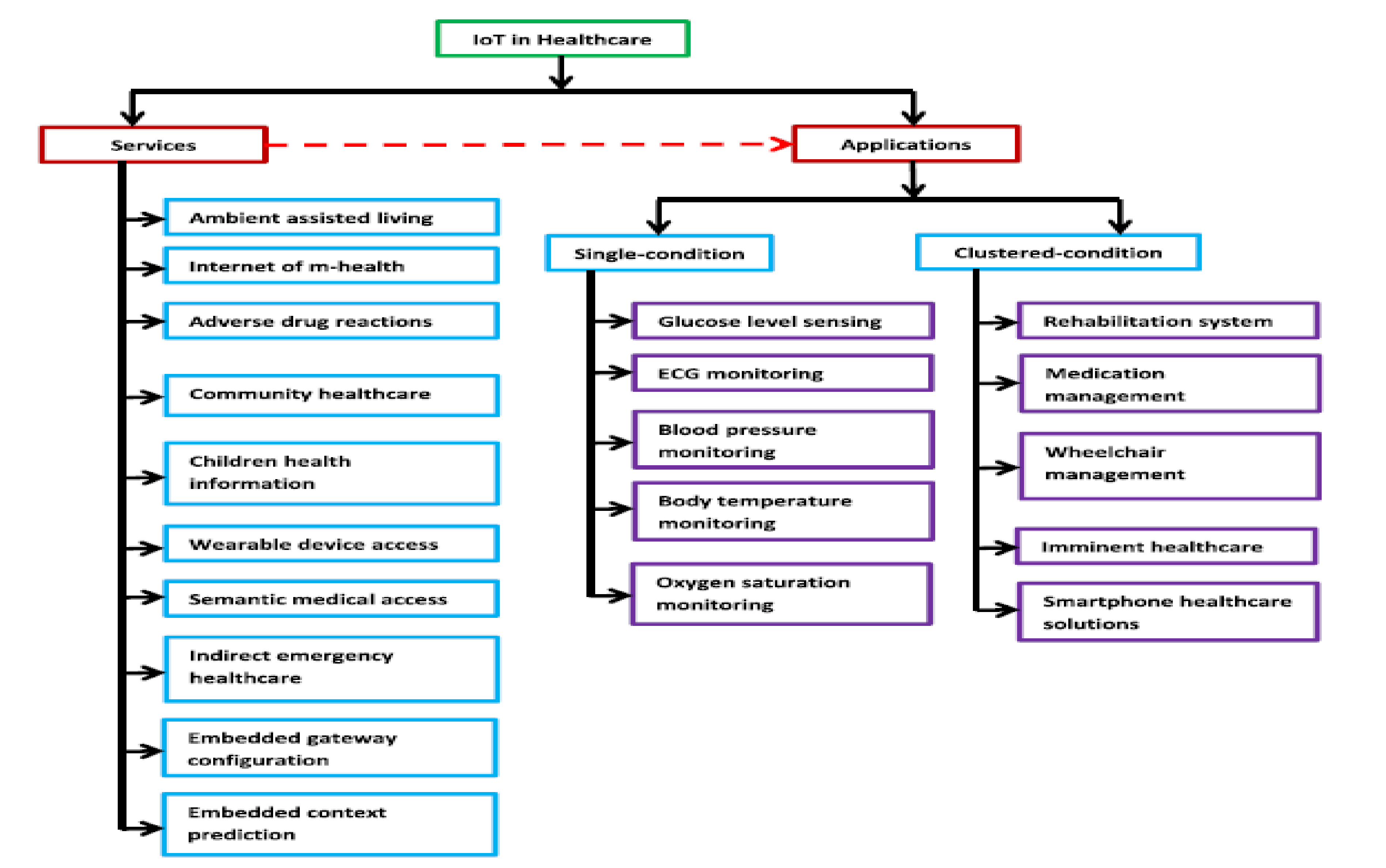
Protocol stack of 6LoWPAN



IoTNet Platform



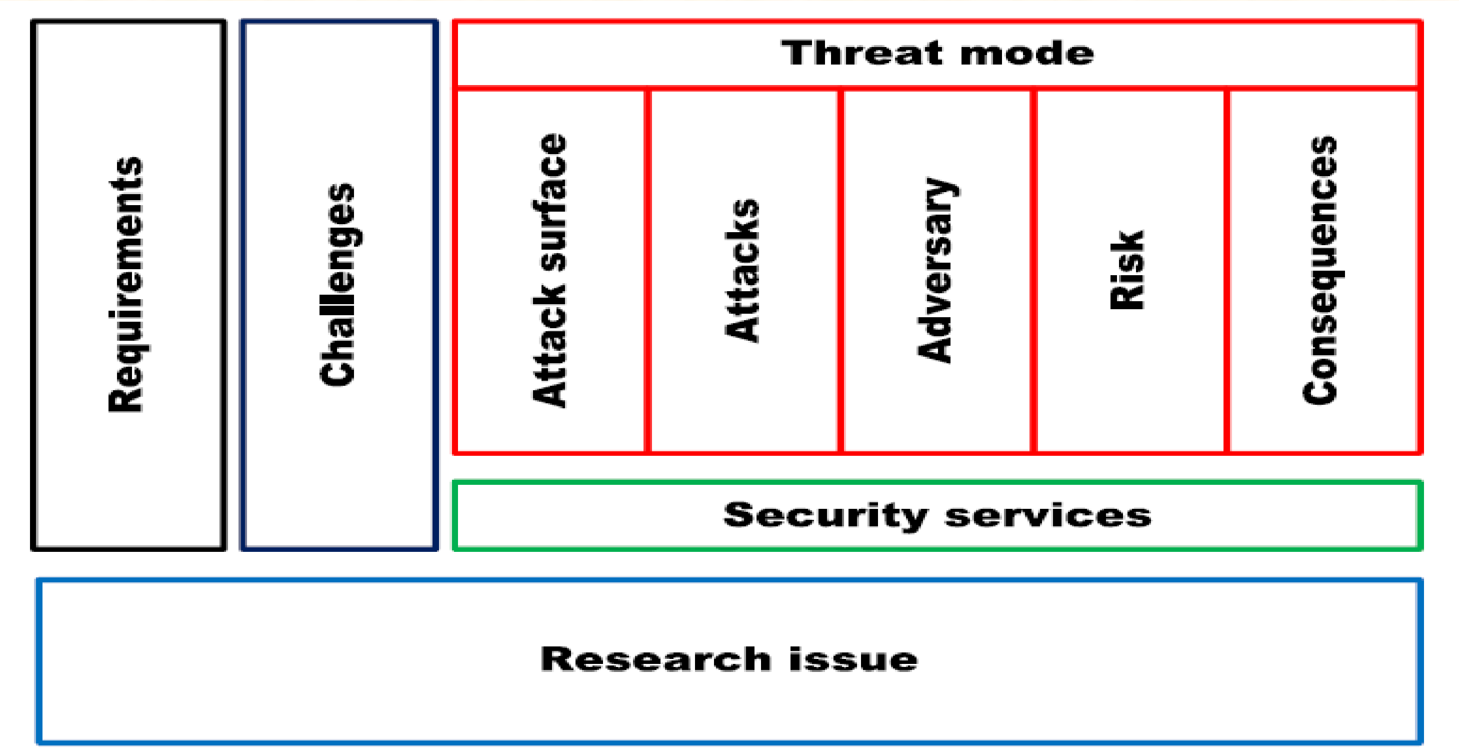
IoT healthcare services and applications



Security Issues with IoT in Healthcare

- Healthcare devices deal with private information
- This information needs to be protected from been revealed, modified or forged
- Critical to identify and analyze distinct features of IoT security and privacy

Security Issues with IoT in Healthcare



Security Requirements

- Confidentiality
- Integrity
- Authentication
- Availability
- Data Freshness
- Non – Repudiation
- Authorization
- Resiliency
- Fault Tolerance
- Self – Healing

Security Challenges

- Computational Limitation
- Memory Limitation
- Energy Limitation
- Mobility
- Scalability
- Communications Media
- The Multiplicity of Devices
- A Dynamic Network Topology
- A Multi – Protocol Network
- Dynamic Security
- Tamper – Resistant Packages

Attack Taxonomy

- Attacks based on Information Disruption
- Attacks based on Host properties
- Attacks based on Network properties

Attacks based on Information Disruption

- Interruption
  - Denial – Of – Service attack.
  - Communication links lost or made unavailable
- Interception
  - Eavesdrop on the information to threaten data privacy and confidentiality
- Modification
  - Tamper medical information
- Fabrication
  - Forge or inject false information
- Replay
  - Replay existing information

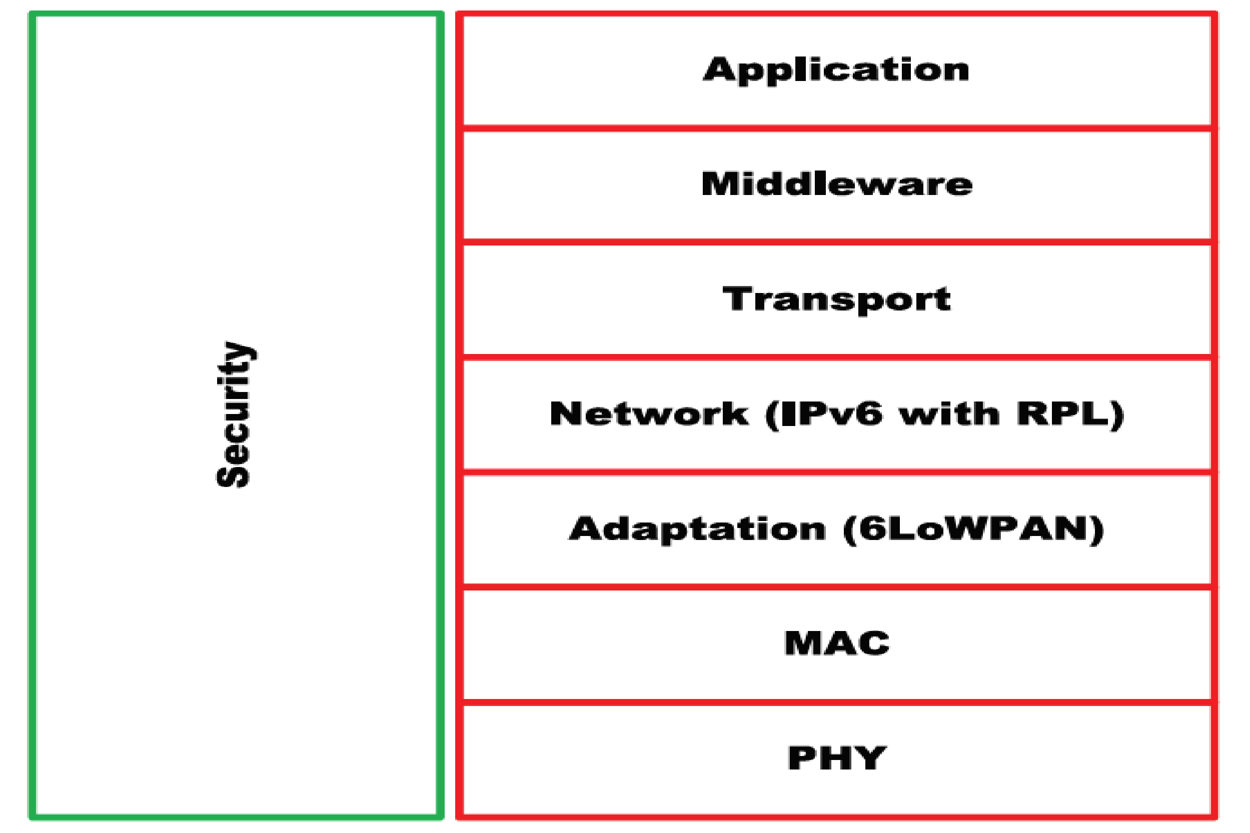
Attacks based on Host properties

- User Compromise
  - Compromise a user's health device or network
  - Mostly involves revealing passwords, cryptographic keys or user data
- Hardware Compromise
  - Physically tamper the device
  - Extract on – device program code, keys and data
  - Reprogram with false program
- Software Compromise
  - Forces malfunction by taking advantages of the vulnerabilities in either the operating system or other applications of the device

Attacks based on Network properties

- Standard Protocol Compromise
  - An attacker deviates from standard protocols
  - Acts maliciously to threaten service availability, message privacy, integrity, and authenticity
- Network Protocol Stack Attack

Network Protocol Stack Attack



Proposed Security Model

- Security services should have dynamic properties

- Should include 3 main services
  - Protection Service
  - Detection Service
  - Reaction Service

Proposed Security Model