物聯網現況及未來發展

CURRENT LANDSCAPE AND FUTURE DEVELOPMENT OF THE IOT/M2M

Prof. Fuchun Joseph Lin 林甫俊
Department of Computer Science
National Chiao Tung University
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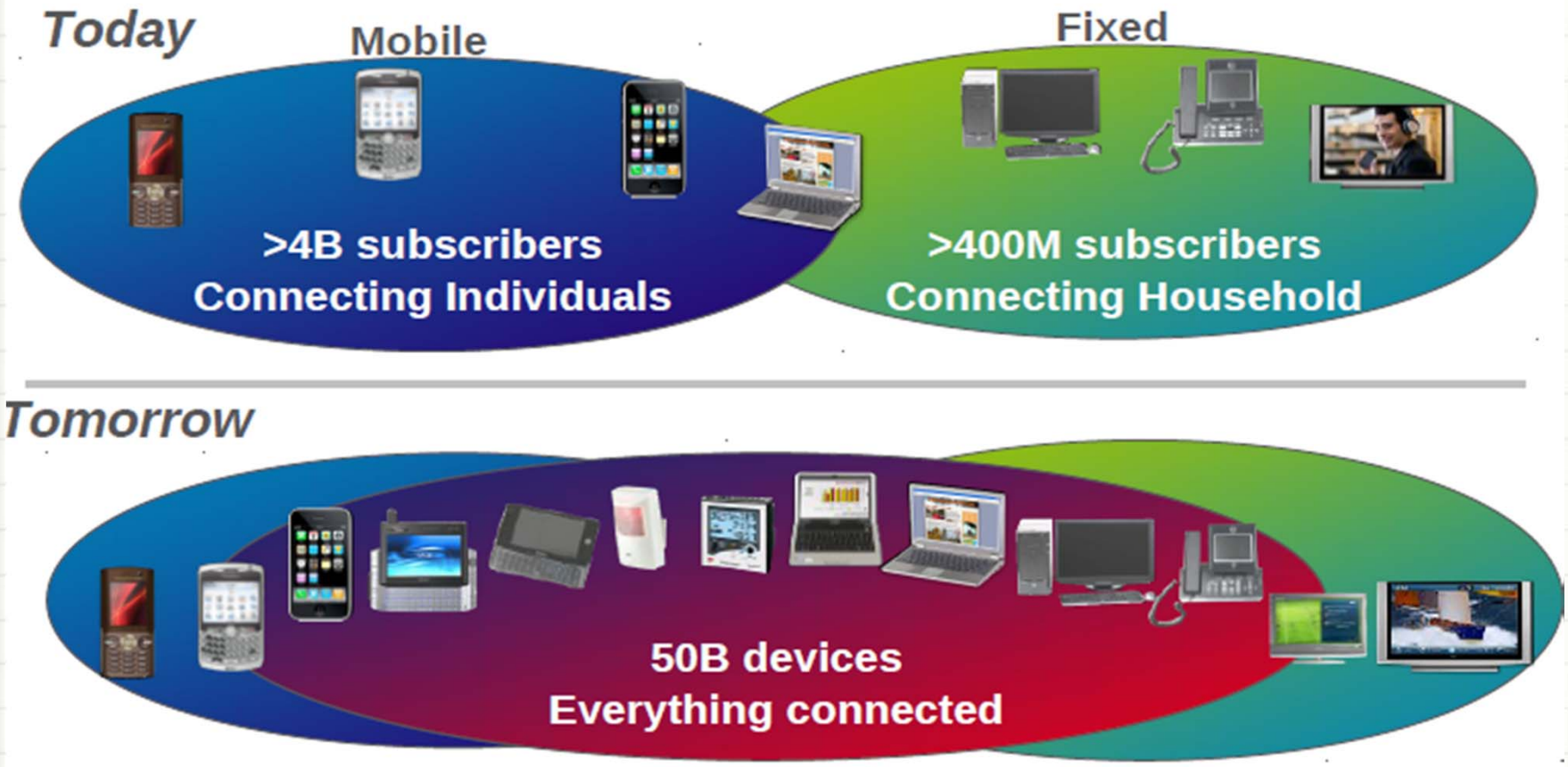
Outline

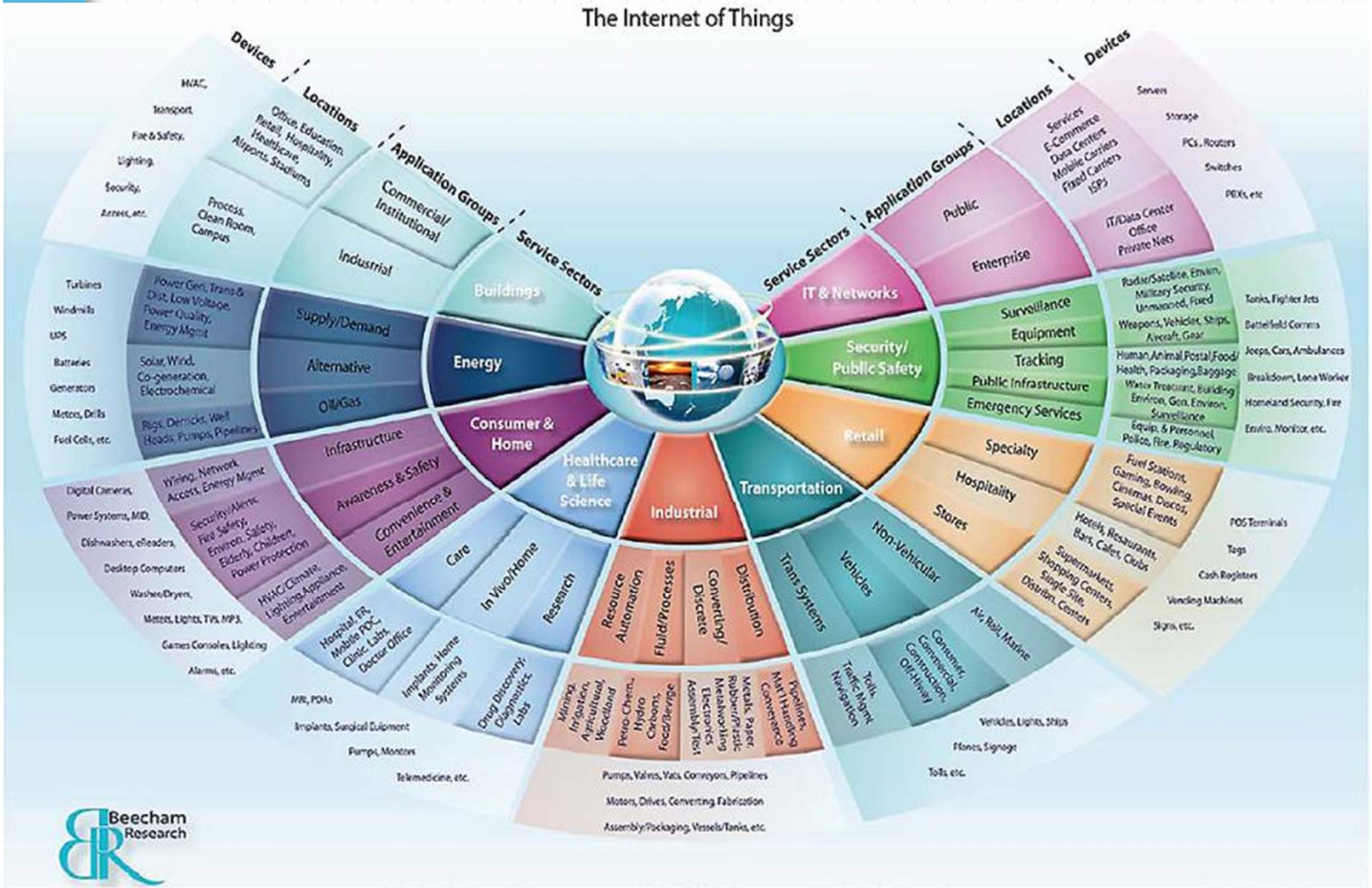
- Current Landscape of the IoT/M2M
- IoT/M2M System Architecture
  - Building Blocks Required
- Future Development of IoT/M2M
  - Toward a Common Service Platform
- NCTU Experience

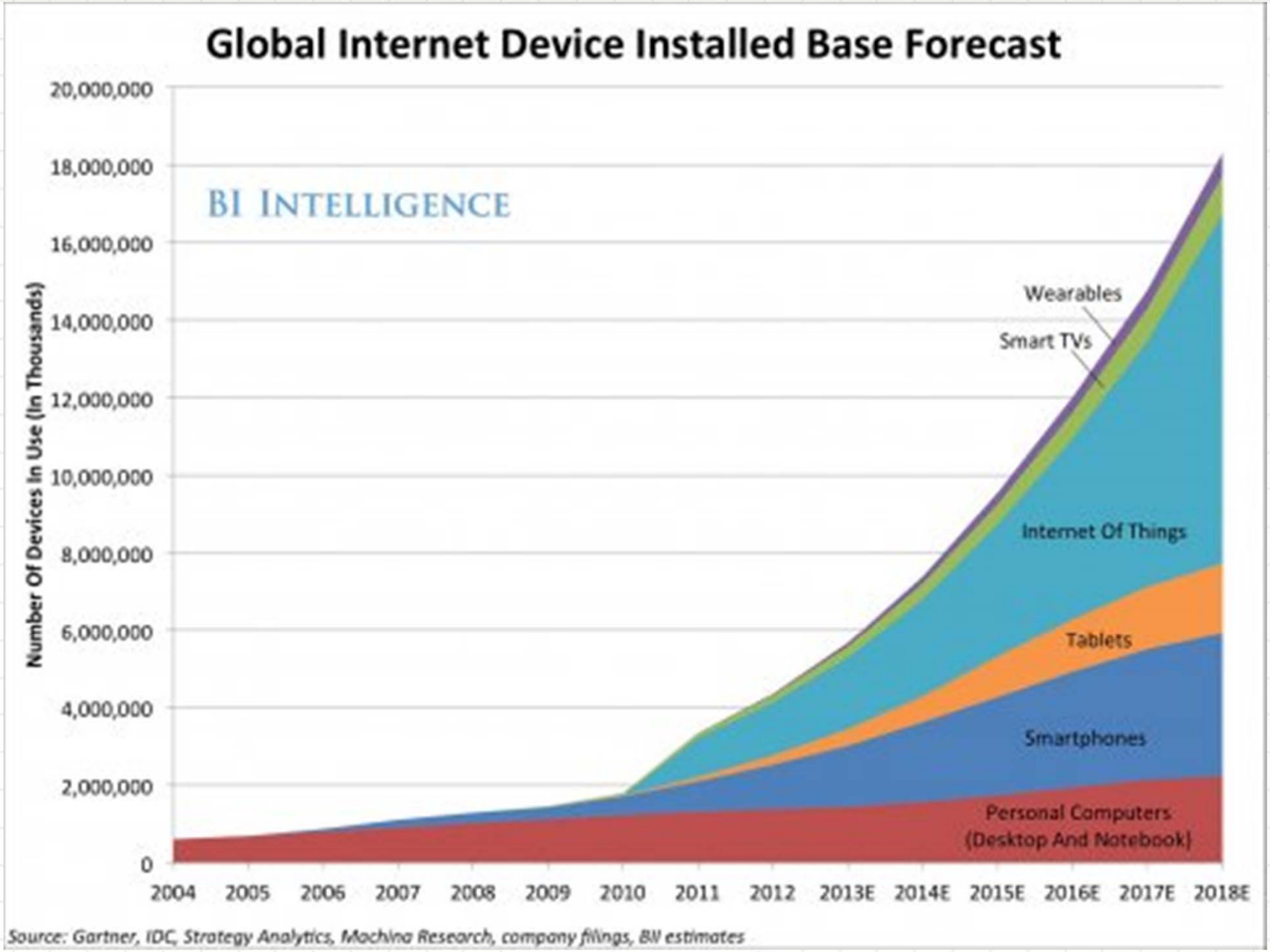
CURRENT LANDSCAPE OF THE IOT/M2M

IoT/M2M Trends

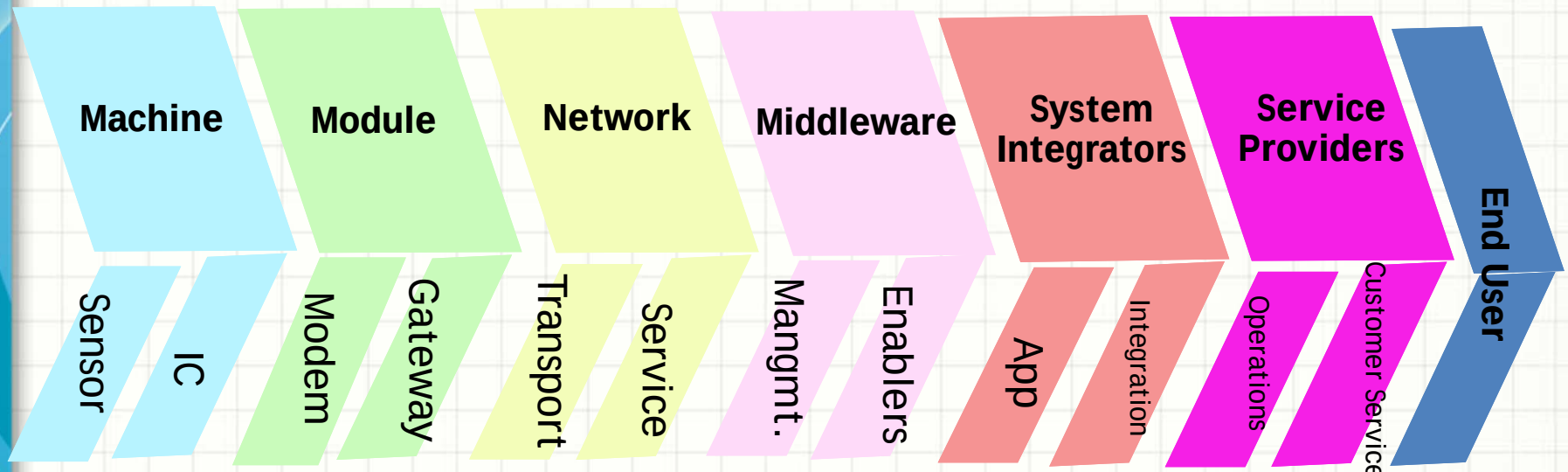


* Ericsson Research


The Internet of Things
Devices
Locations
Application Groups
Service Sectors
HVAC,
Transport
Fire & Safety,
Lighting,
Security,
Access, etc.
Office, Education, Retail, Hospitality, Healthcare, Airports, Stadiums
Process, Clean Room, Campus
Commercial/ Institutional
Industrial
Buildings
Energy
Consumer & Home
Healthcare & Life Science
Industrial
Transportation
Retail
IT & Networks
Security/ Public Safety
Public
Enterprise
Services
E-Commerce
Data Centers
Mobile Carriers
Fixed Carriers
ISPs
Servers
Storage
PCs, Routers
Switches
PBXs, etc
IT/Data Center
Office
Private Nets
Surveillance
Equipment
Tracking
Public Infrastructure
Emergency Services
Specialty
Hospitality
Stores
Turbines
Windmills
UPS
Batteries
Generators
Meters, Drills
Fuel Cells, etc.
Power Gen, Trans & Dist, Low Voltage, Power Quality, Energy Mgmt
Solar, Wind, Co-generation, Electrochemical
Rigs, Derricks, Well Heads, Pumps, Pipelines
Supply/Demand
Alternative
Oil/Gas
Infrastructure
Awareness & Safety
Convenience & Entertainment
Care
In Vivo/Home
Research
Resource Automation
Fluid/Processes
Converting/ Discrete
Distribution
Trans Systems
Vehicles
Non-Vehicular
Air, Rail, Marine
Consumer, Commercial, Construction, Off-Hiway
Tolls, Traffic Mgmt, Navigation
Digital Cameras,
Power Systems, MID,
Dishwashers, eReaders,
Desktop Computers
Washer/Dryers,
Meters, Lights, TVs, MP3,
Games Consoles, Lighting
Alarms, etc.
Wiring, Network Access, Energy Mgmt
Security/Alerts, Fire Safety, Environ. Safety, Elderly, Children, Power Protection
HVAC/Climate, Lighting/Appliance, Entertainment
Hospital ER, Mobile POC, Clinic Labs, Doctor Office
Implants, Home Monitoring Systems
Drug Discovery, Diagnostics, Labs
MRI, PDAs
Implants, Surgical Equipment
Pumps, Monitors
Telemedicine, etc.
Mining, Irrigation, Agricultural, Woodland
Petro-Chem., Hydro Carbons, Food/Bevrge
Metals, Paper, Rubber/Plastic, Metalworking
Electronics Assembly/Test
Pipelines, Mat'l Handling, Conveyance
Pumps, Valves, Vats, Conveyors, Pipelines
Motors, Drives, Converting, Fabrication
Assembly/Packaging, Vessels/Tanks, etc.
Vehicles, Lights, Ships
Planes, Signage
Tolls, etc.
Radar/Satellite, Encrypt, Military Security, Unmanned, Fixed
Weapons, Vehicles, Ships, Aircraft, Gear
Human, Animal, Postal, Food/ Health, Packaging, Baggage
Water Treatment, Building Environ, Gen. Environ. Surveillance
Equip. & Personnel Police, Fire, Regulatory
Tanks, Fighter Jets
Battlefield Comms
Jeeps, Cars, Ambulances
Breakdown, Lone Worker
Homeland Security, Fire
Enviro. Monitor, etc.
Fuel Stations, Gaming, Bowling, Cinemas, Discos, Special Events
Hotels, Restaurants, Bars, Cafes, Clubs
Supermarkets, Shopping Centers, Single Site, Distribn. Centers
POS Terminals
Tags
Cash Registers
Vending Machines
Signs, etc.
Beecham Research


Global Internet Device Installed Base Forecast
BI INTELLIGENCE
Number Of Devices In Use (In Thousands)
20,000,000
18,000,000
16,000,000
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
0
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013E
2014E
2015E
2016E
2017E
2018E
Wearables
Smart TVs
Internet Of Things
Tablets
Smartphones
Personal Computers
(Desktop And Notebook)
Source: Gartner, IDC, Strategy Analytics, Machina Research, company filings, BI estimates

IoT/M2M Ecosystem



Middleware Providers

Machine & Device Manufacturers

Service Providers

Network Equipment Providers

Application Developers

System Integrators

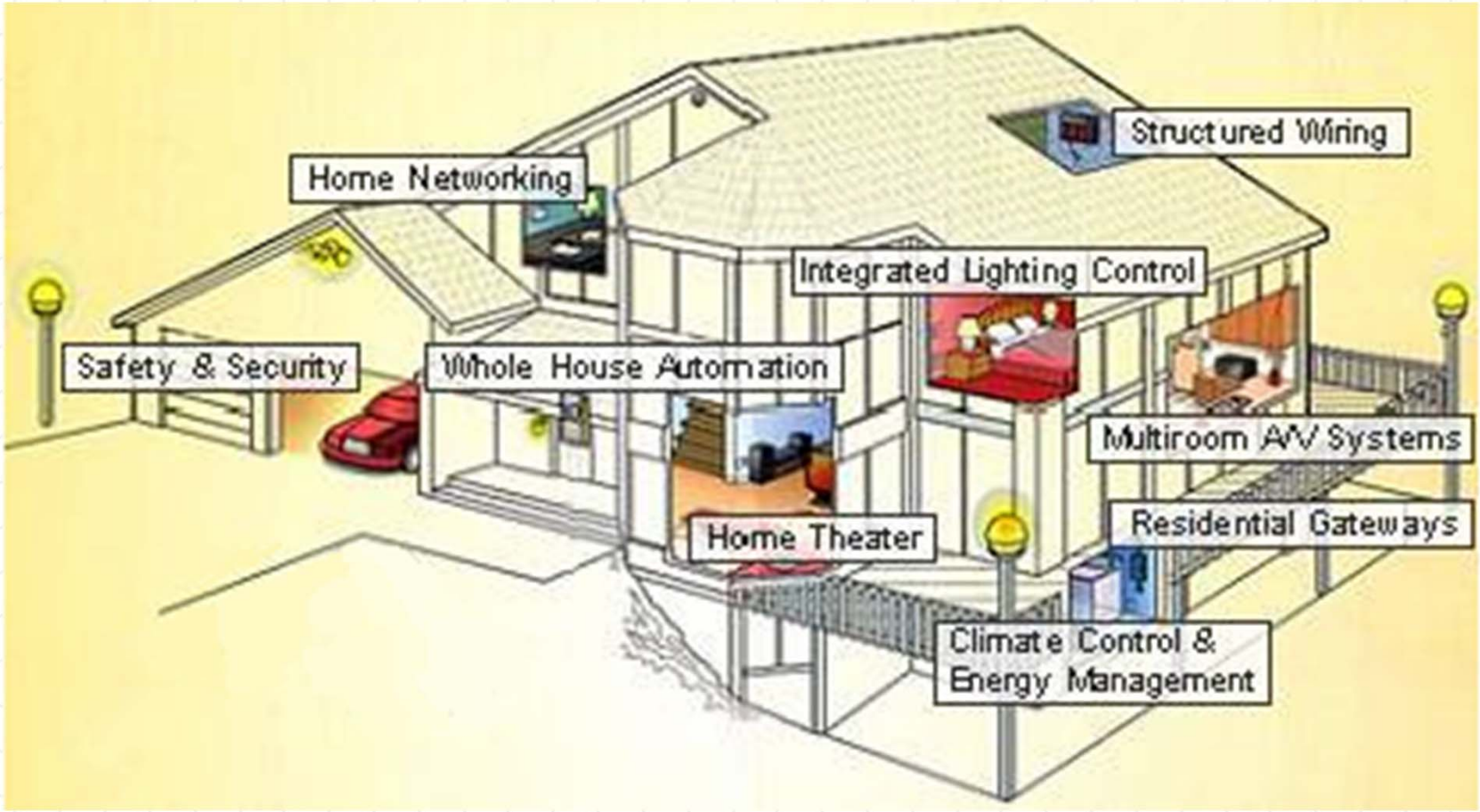
Smart Home

- Smart Home is built upon home area network (HAN). An HAN is a residential local area network (LAN) for communication between digital devices typically deployed in the home.

- A smart home connects all devices/appliances at home for sharing and also allows access from global Internet for monitoring and control to improve security, comfort and energy efficiency.

Reference: http://www.conference.cn/Conference.asp?ArticleID=5709

Smart Home (Cont.)



Source: Home Automation http://www.caba.org/

Emerging of Nest

- The Nest Learning Thermostat was introduced by Nest Labs in 2011.
- Nest was co-founded by former Apple engineers Tony Fadell and Matt Rogers in 2010.
- Was sold at 100,000 thermostats per month based on an estimated by Morgan Stanley in Jan. 2014. At $250 per unit, this means an annual revenue at $300 million.

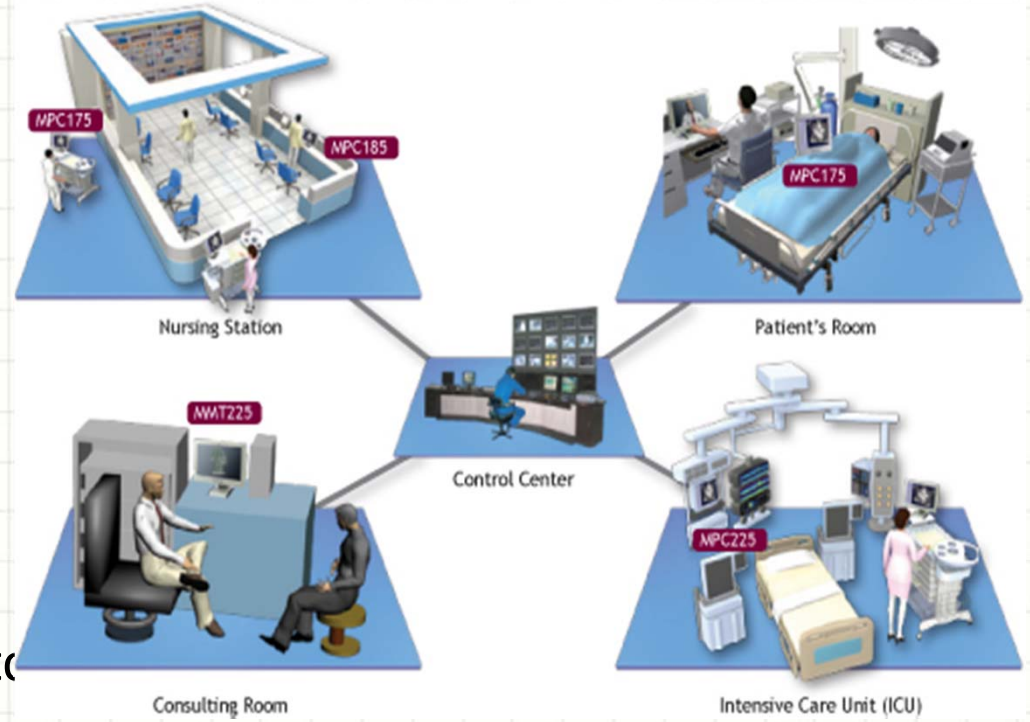
- In October 2013, Nest Labs announced its second product, the Nest Protect smoke and carbon monoxide detector.

- Google acquired Nest Labs for US$3.2 billion (~200 employees) in February 2014 and left Nest Labs to use its own brand.

https://www.youtube.com/watch?v=L8TkhHgkBsg Source: Wikipedia

E-Healthcare

- Remote patient monitoring
  - Remotely obtain heart rate, blood glucose levels, and other parameter of body through WAN.
- Homecare living
  - Actively provide information of taking medication, health knowledge.
- Asset tracking
  - Track high-value asset such as intravenous pumps, wheel chairs etc



Reference: http://axiomtek.com/solutions/healthcare.asp

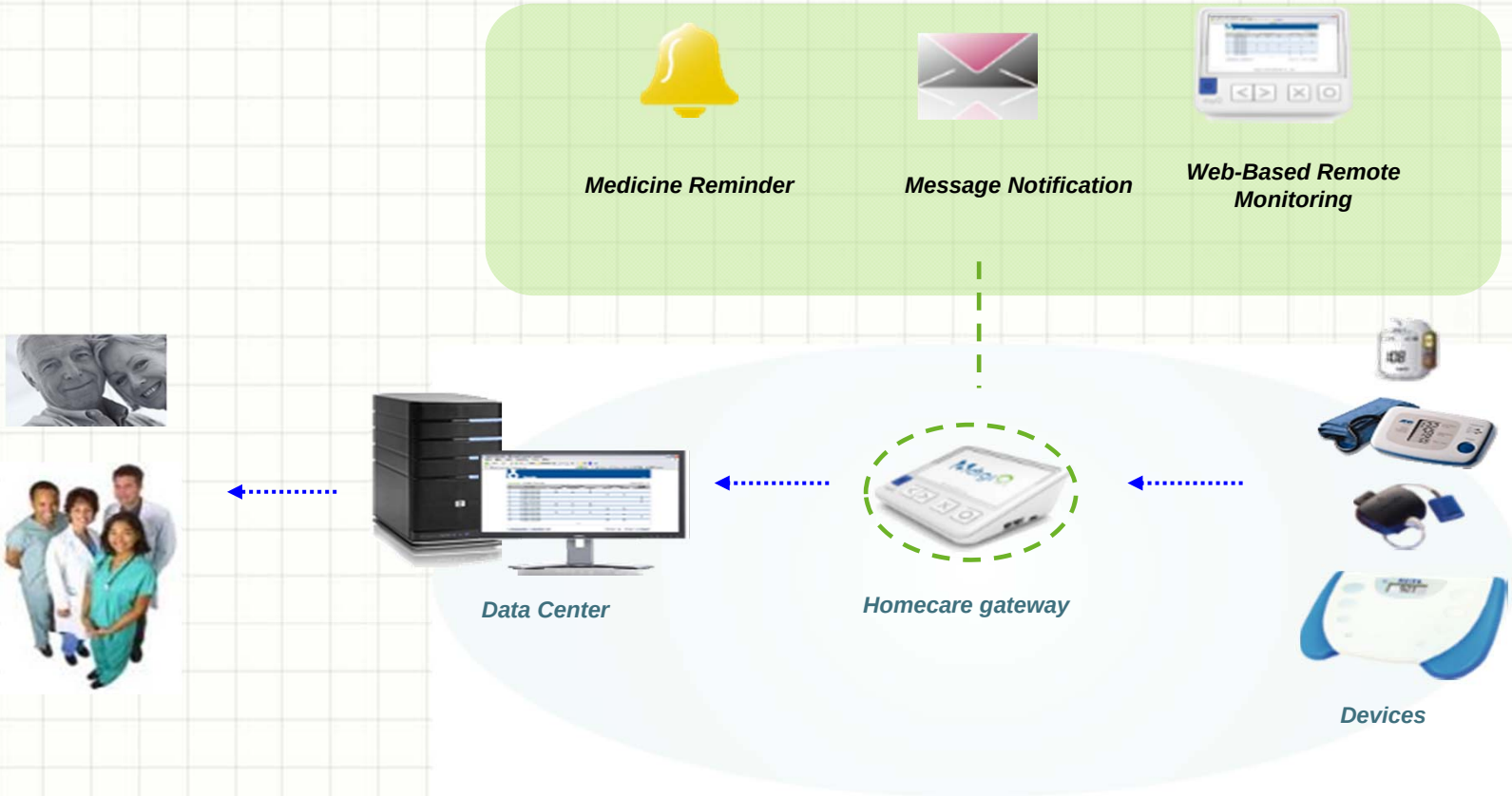
Wearable Medical Equipment

- Wearable watch
  - Life sensing and watching
  - Function: time, weather conditions, and medication remind mechanism

- Wearable physiological monitoring device
  - Real-time, continuous
  - Future applications: hyperactive children, Parkinson's disease, epilepsy (癲癇)

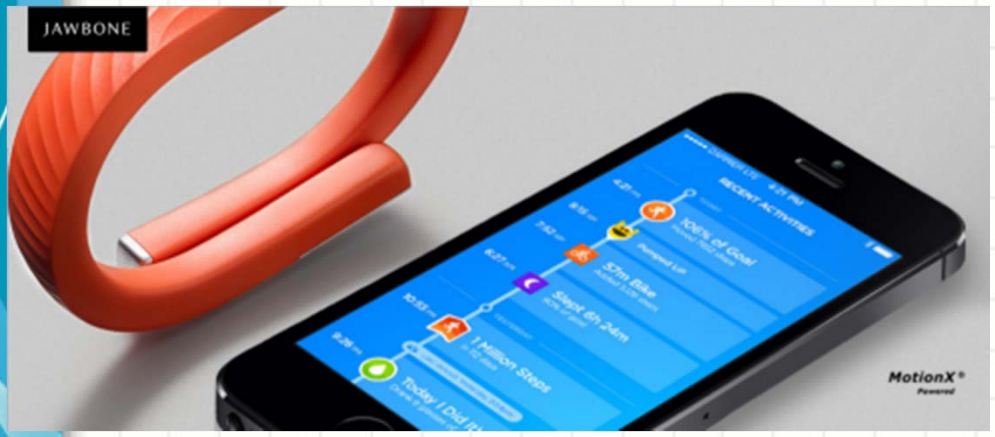
Source: Chang-Gung University

Clinical Interaction Module and System



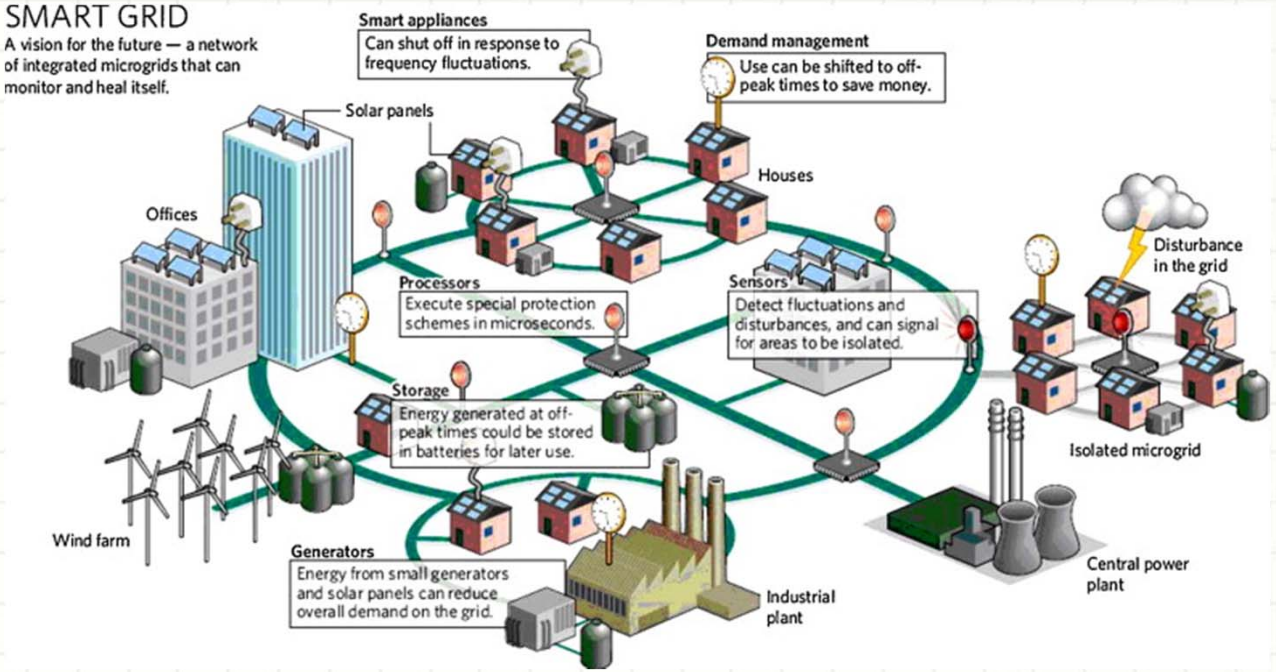
Source: Chang-Gung University

Emerging of Wearable Devices for Health Improvement



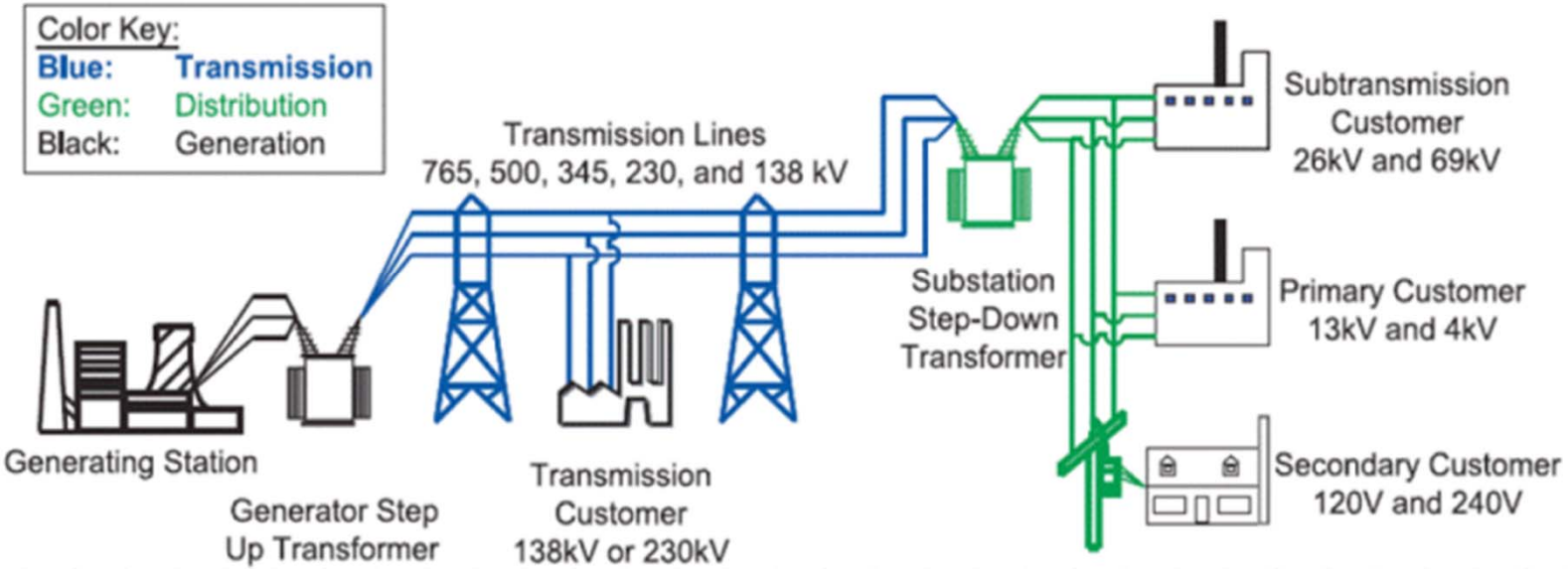
Smart Grid

- A smart grid is an electrical grid that uses information and communications technology to gather and act on information, such as information about the behaviors of suppliers and consumers.
- Fundamental re-engineering of the electricity services industry



Reference: http://www.geekwithlaptop.com/so-called-utility-%E2%80%9Csmart%E2%80%9D-meters-open-to-attack

Legacy Electric Grid Architecture

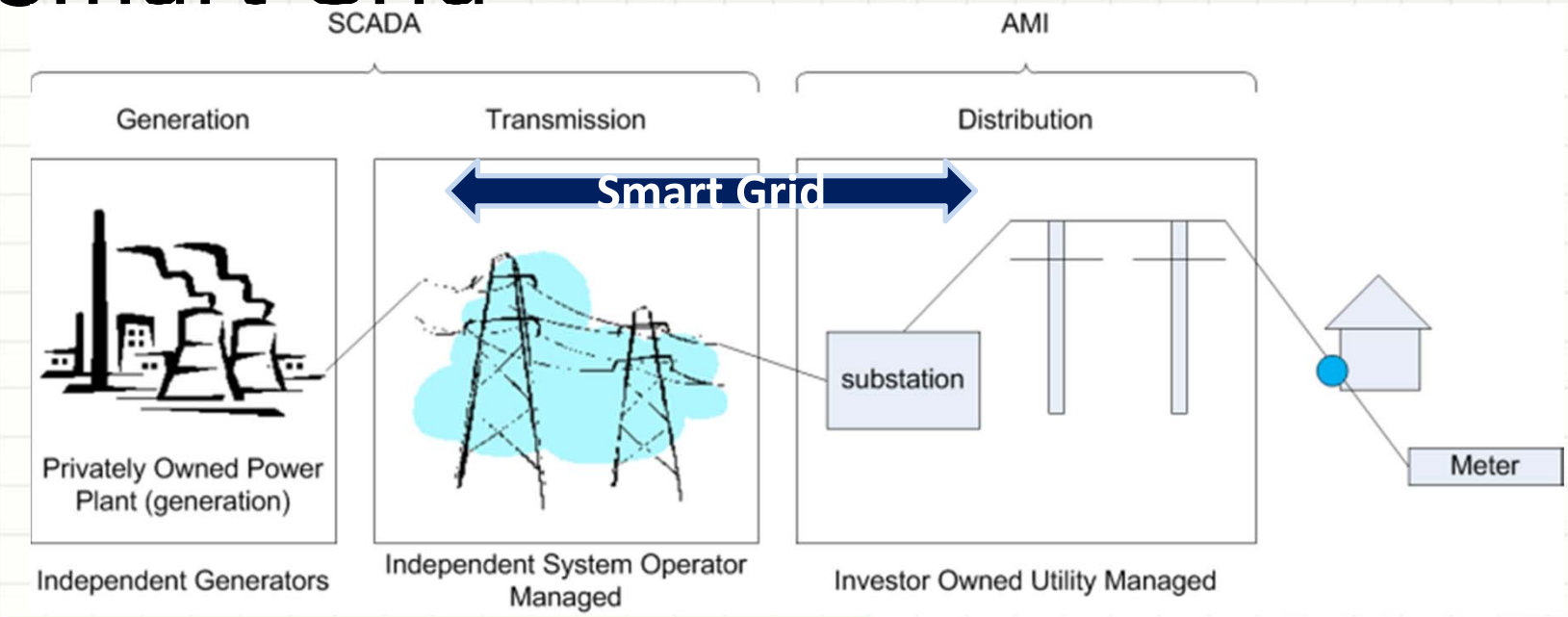


Source: NIST Smart Grid Program Review

- **Centralized, bulk generation, mainly coal and natural gas**
- **Responsible for 40% of human-caused CO2 production**
- **Controllable generation and predictable loads**
- **Sized for infrequent peak demand – operates at 50% capacity**
- **Limited automation and situational awareness**
- **Lots of customized proprietary systems**
- **Lack of customer-side data to manage and reduce energy use**

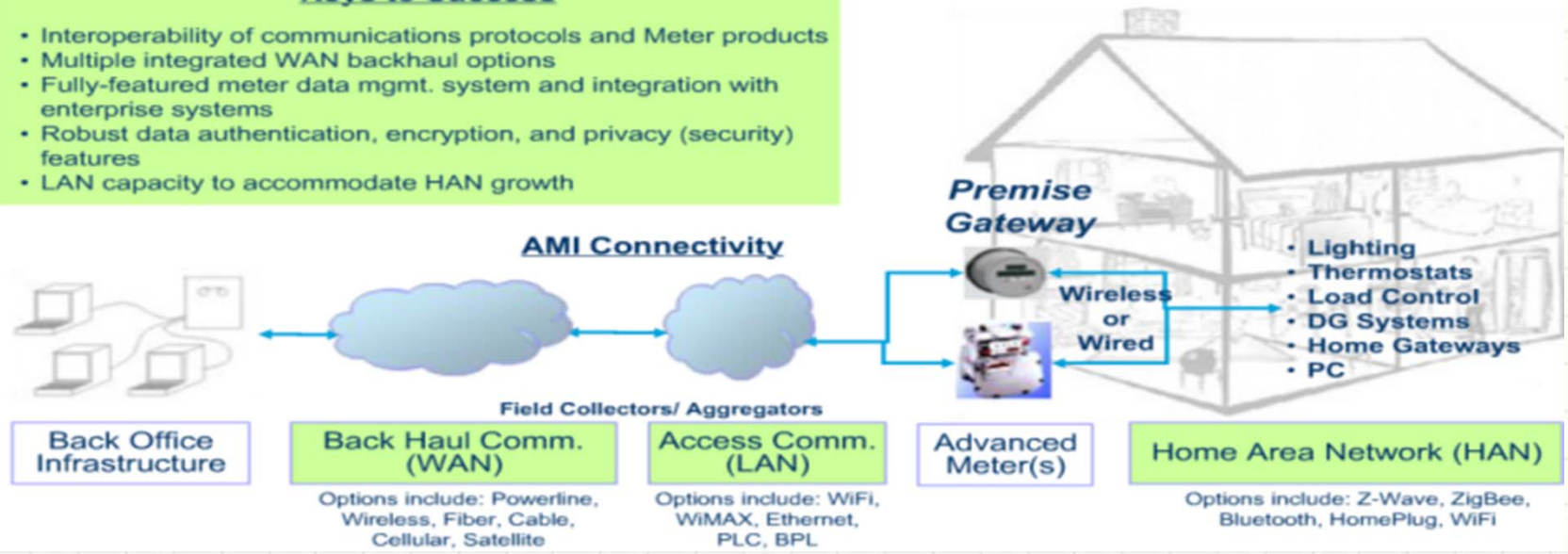
One-way flow of electricity

Smart Grid



Keys to Success

- Interoperability of communications protocols and Meter products
- Multiple integrated WAN backhaul options
- Fully-featured meter data mgmt. system and integration with enterprise systems
- Robust data authentication, encryption, and privacy (security) features
- LAN capacity to accommodate HAN growth



Source: KEMA DNV

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Connected Vehicle

- Fleet management
  - Obtain information of a group of vehicles such as vessels or cars, and send dispatch notification to them

Source: orci.research.umich.edu

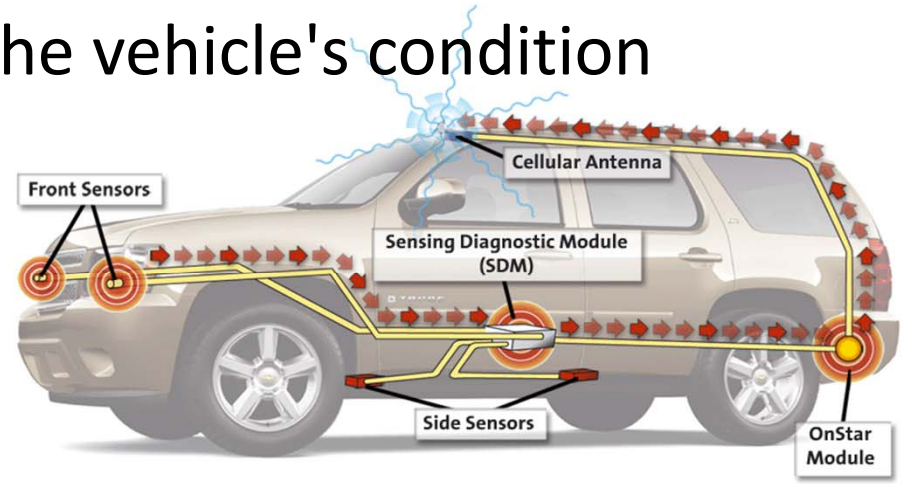
- Vehicle maintenance
  - Obtain operating parameters from vehicle to diagnosing mechanical issues.
  - Bilaterally communicate with car dealers: get software update and reminders.
  - Compute insurance premium by the risks of vehicles
  - Entertainment, theft prevention, emergency call, toll, and so on.

OnStar

- Since beginning operations in 1995, General Motors' OnStar system has grown to become the USA's leading provider of in-vehicle safety, security and communications services using wireless and Global Positioning System (GPS) satellite technology.
- OnStar is available on more than fifty 2009 and newer GM models. There are already 6 million OnStar subscribers in the U.S. and Canada in July 2012.

Technical

- the service relies on CDMA mobile phone voice and data communication, as well as location information using GPS technology
- In the event of a collision, detected by airbag deployment or other sensors, it can automatically send information about the vehicle's condition and GPS location to OnStar call centers



Features

- Emergency Services
- Security Services
- Navigation
- Connections
- Diagnostics


cingular
9:41 AM
SMS
Text
Calendar
Photos
Camera
Calculator
Stocks
Maps
Weather
Notes
Clock
Settings
Phone
Mail
iPod
21 Alt Nation
Rock
Blazing Lazer
Ford
SYNC
Microsoft

FORD SYNC

Ford SYNC

- Developed with Microsoft, is an advanced software platform that provides consumers the convenience and flexibility to bring digital media players and Bluetooth-enabled mobile phones into their vehicles and operate the devices via voice commands or with steering wheel's redundant radio controls.
- In Nov. 2012, Ford announced SYNC had been installed in 5 million cars.

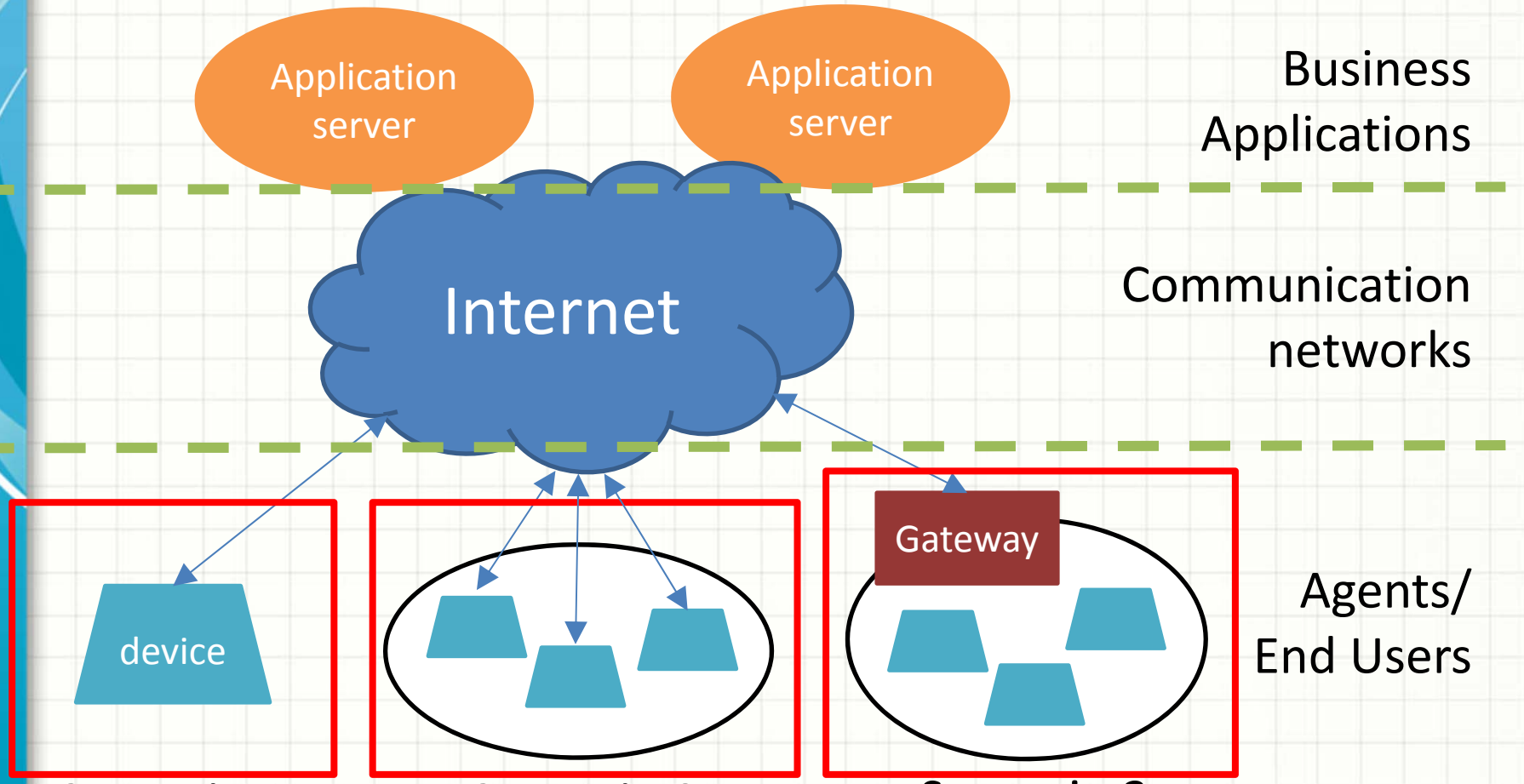
Technology

- Ford uses Microsoft software to read information from user's smartphone while he/she is driving.
- Sync uses user's phone's wireless to connect with outside.
- With Sync, the user are in the middle of an in-car web of communication between he/she, his/her cell phone and his/her Ford Sync head-unit via Bluetooth

IOT/M2M SYSTEM ARCHITECTURE

BUILDING BLOCKS REQUIRED

IoT/M2M System Structure



M2M Devices

- Battery powered
  - E.g., water meters are located outdoors and cannot be easily connected to a power supply.
- Embedded
  - Many devices are deployed in systems with specific operating condition and with limited computation power.
  - E.g., the OBD in car
- Here to stay
  - Many devices are static or with very low mobility.

Catalog of IoT/M2M Sensors

- Accelerometer : Measure the three-axis acceleration
- Magnetic : Measure the magnetic potential vector
- Orientation : Measure the direction
- Gyroscope : Measure the orientation, based on angular momentum
- Temperature :Measure the temperature
- Light: Measure the luminosity
- Pressure : Measure the pressure
- Proximity : Measure whether any object is closing
- GPS : Positioning the current latitude and longitude
- NFC : Allow smartphones to transfer data to each other within 10 cm
- Etc.

Catalog of IoT/M2M Devices

- Type of IoT/M2M Devices
  - Smartphone
  - IP camera
  - Robot
  - Smart Bulb
  - E-Lock
  - Thermostat
  - Smart Watch
  - Activity Tracker
  - Healthcare
  - Etc.


Jawbone UP24

Dropcam


iPhone


Parrot Ar. Drone


Sony Smart Watch


WowWee Rovio

Kwikset Kevo E-Lock


Philips Hue Smart Bulb


iRobot Roomba 830

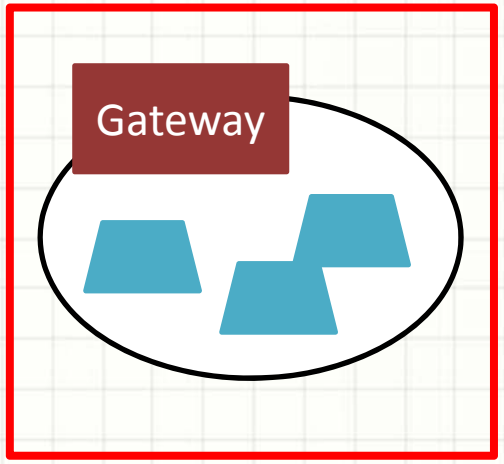
Bluetooth Blood Pressure Monitor

NEST

Honeywell Lyric Thermostat

M2M Area Networks

- "M2M area network" is introduced by ETSI
- Provide PHY and MAC layer connectivity between M2M devices connected to the same M2M area network
- Allow M2M devices to gain access to a public network via a gateway



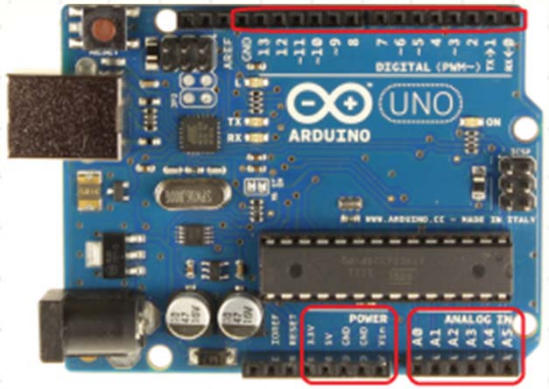
M2M area network

⇳

devices + gateway

Category of Sensor Platforms

Raspberry Pi



Arduino UNO

NXP JN516x-EK001

Intel Galileo

Catalog of M2M Area Network Protocols (1)

- CoAP/6LoWPAN/RPL
- RFID
- Bluetooth
- WiFi
- Zigbee (based on IEEE 802.15.4)
- Zigbee Smart Energy 2.0
- M-Bus – Utility metering
- ANSI C12 – Electricity metering
- KNX – HVAC, lighting and building automation

Catalog of M2M Area Network Protocols (2)

- LonWorks – Control and automation
- ModBus – Industry automation and metering
- Power Line Communications
- BACnet – Building automation and control
- Insteon – Smart Home
- DLMS/COSEM - Multi utility metering
- Z-Wave – Home automation
- Dali – Lighting control
- X10 - Home automation
- DLNA/UPnP – home multimedia sharing
- Etc.

Characteristics of M2M Applications

- A large amount of devices
  - Scalability issues
  - Non-classical usage patterns in mobile networks
    - E.g., not always active - only be triggered for specific reason and only do things in some fixed time.
- A large variety of devices
  - Heterogeneous systems
  - Diverse requirements, e.g., data exchange rate
  - Build common-enabling capabilities
- Transparency: no need of the interference of humans
- Intrusiveness: privacy issues
- Criticality: life-savers, life-critical

Service Platforms for IoT/M2M Applications

- **Commercial Offers**
  - Xively
  - Nimbits
  - Axeda
  - Device Insight
  - Thingworx
  - Ninja Blocks platform
  - ioBridge (Web Gateway)
  - Thingvibe
  - Digi
  - Bosch
  - SAP
  - Etc.
- **Standard-Compliant Prototype**
  - OpenMTC (Licensed Source)
  - OM2M (Open Source)
- **Open Source**
  - OSIOT Interoperability Project
  - Eclipse M2M Industry Group
    - Koneki
    - Paho
    - Lua
    - MQTT
    - OM2M (Open Source)
  - Contiki – IP-based open source operating system for the IoT
  - Etc.

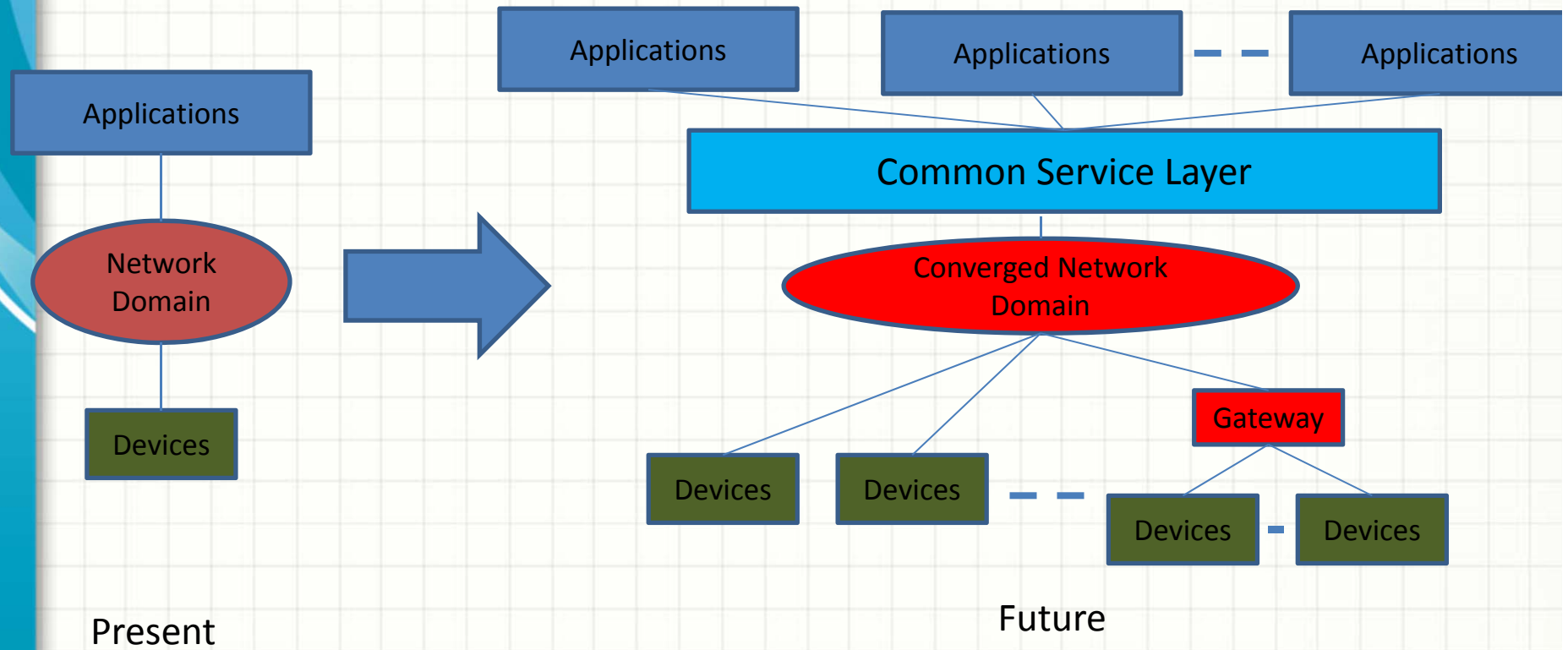
Challenges

- Fragmentation of solutions
  - It is important to have service platforms that can be reused for multiple applications.
- Network misalignment
  - large numbers of devices generating very small amounts of data transport and potentially a very significant overload of the control and connectivity planes.
- Security issues
  - E.g., eHealth, Smart Grid, etc.
- Privacy issues

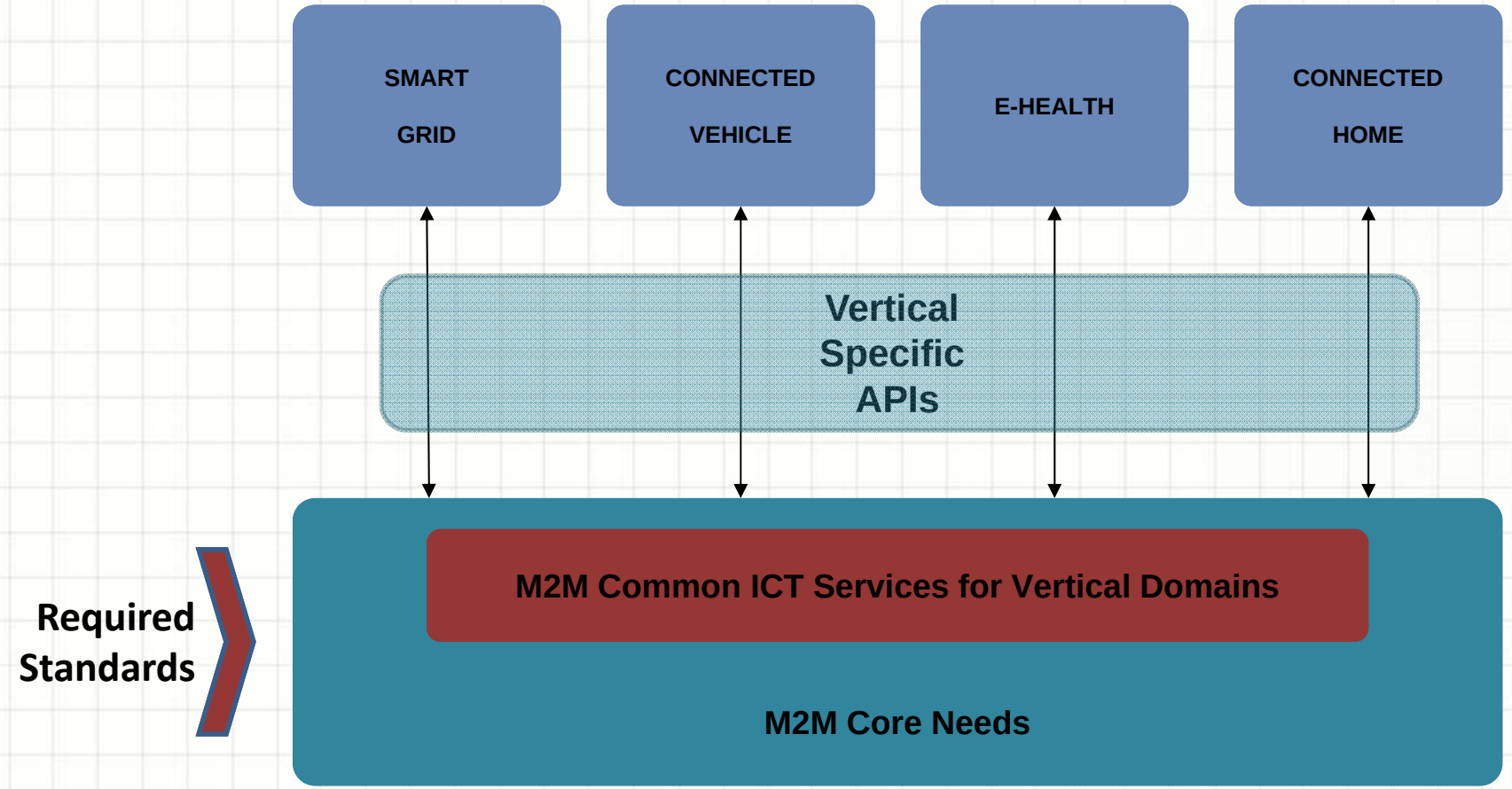
FUTURE DEVELOPMENT OF IOT/M2M

TOWARD A COMMON SERVICE PLATFORM

Why IoT/M2M Common Service Platform



Common Horizontal Service Layer



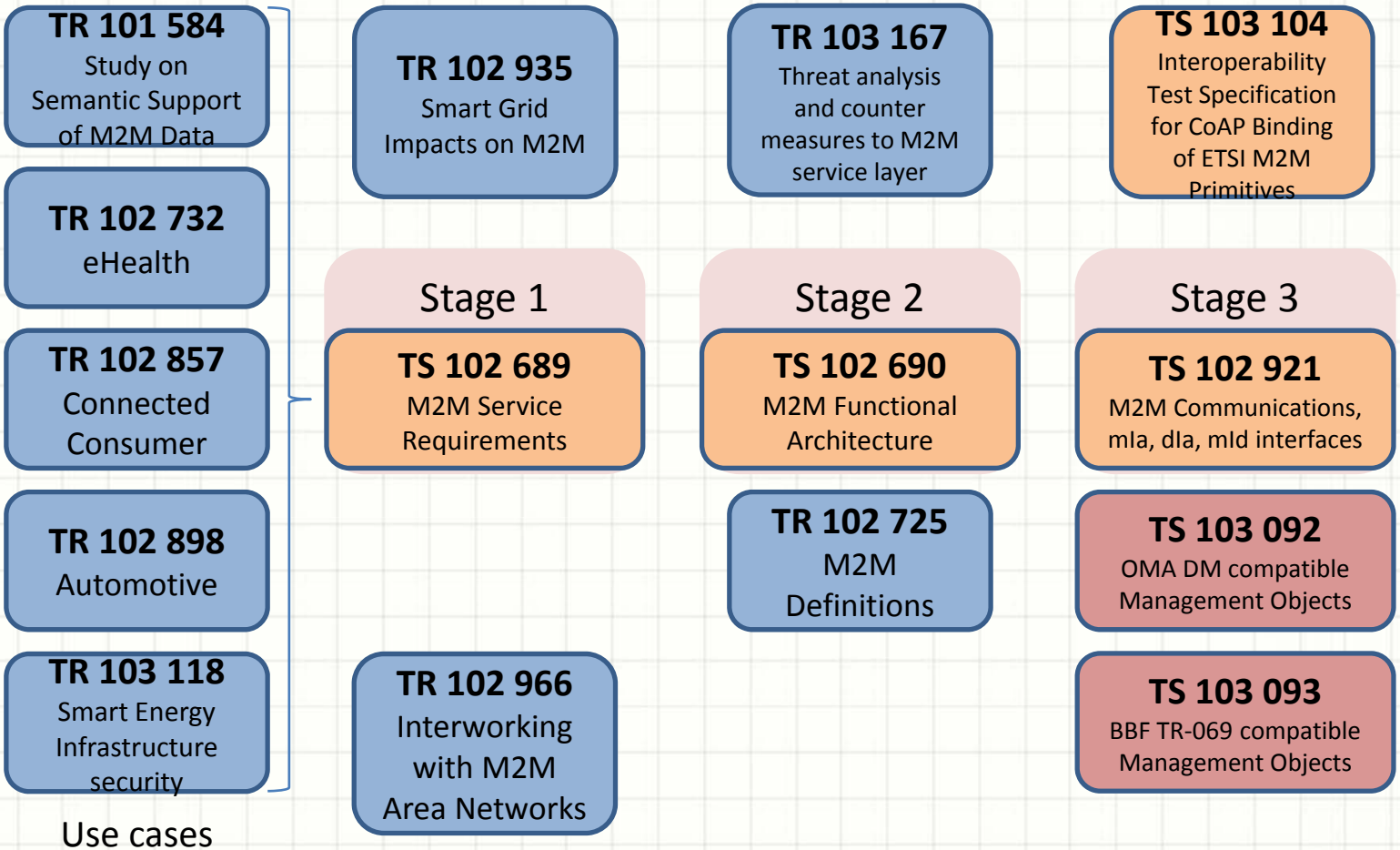
ETSI TC M2M

- ETSI (European Telecommunications Standards Institute) TC (Technical Committee) M2M established in Jan. 2009
  - To develop and maintain an end-to-end overall telecommunication high level architecture for M2M
  - To identify gaps with existing standards and provide specifications to fill these gaps

Output of ETSI TC M2M

- M2M Release 1 Specifications completed at the end of 2011.
  - May 2010 – M2M use cases TRs for connected consumer, city automation, automotive, eHealth and smart metering.
  - August 2010 – Stage 1 TS (M2M Requirements)
  - 3rd Quarter 2011 – Stage 2 TS (M2M Architecture)
  - 4th Quarter 2011 – Stage 3 TS (M2M Interfaces, APIs)

ETSI M2M Specification Work



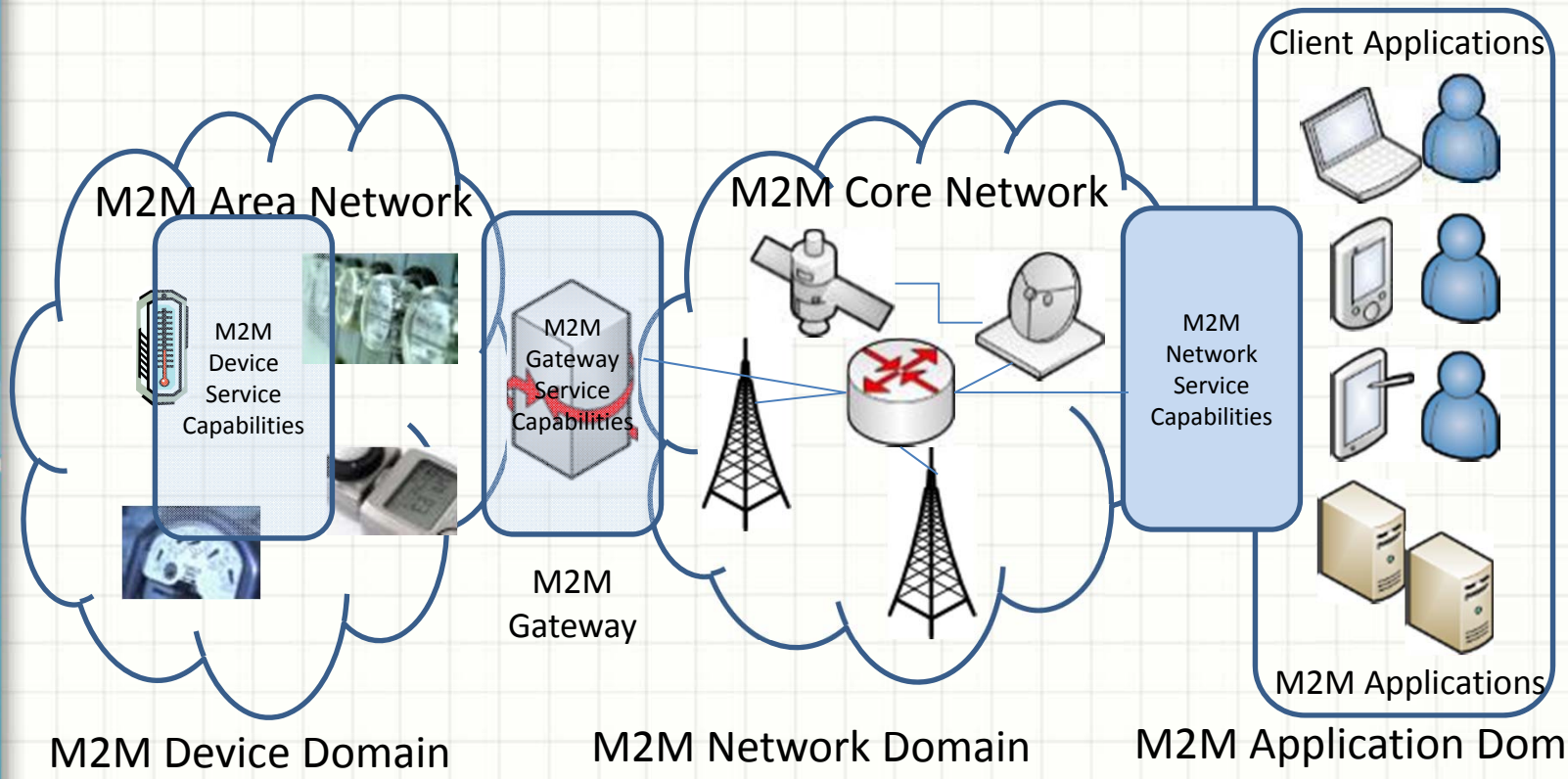
ETSI M2M TC Release 2

Finished in the beginning of 2013 with a short list of features:

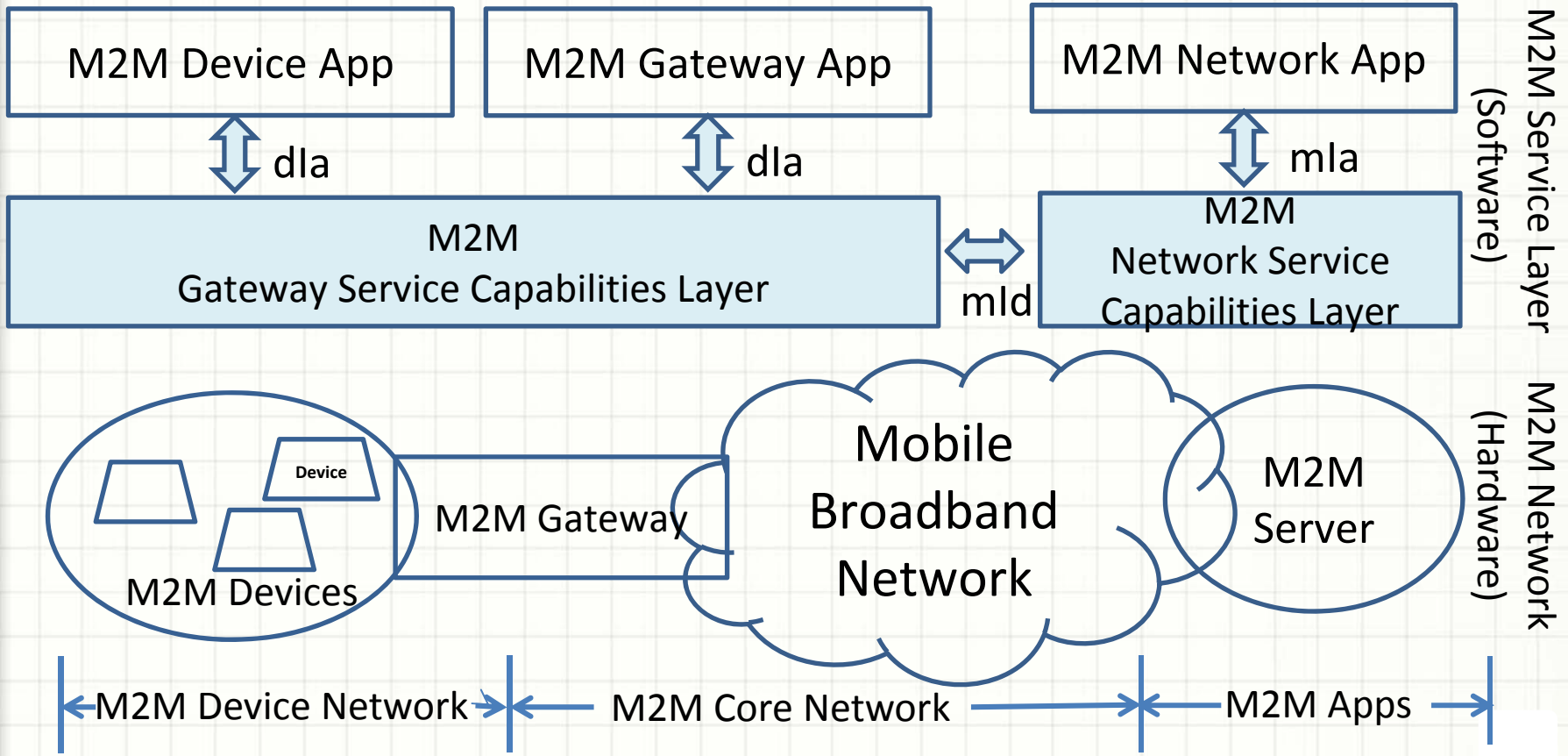
- Charging: Defining architectural framework for charging, including correlation with charging information from the underlying network
- Inter-domain communications between service platforms, i.e. inter-NSCL communication, on mIm reference point (a variant of mId).
- M2M Light: Allowing very constrained device can connect directly to the network platform.
- Semantic interworking guidelines: common semantic rules to allow applications belonging to different industrial segment, to understand the shared data

Source: ETSI SmartM2M

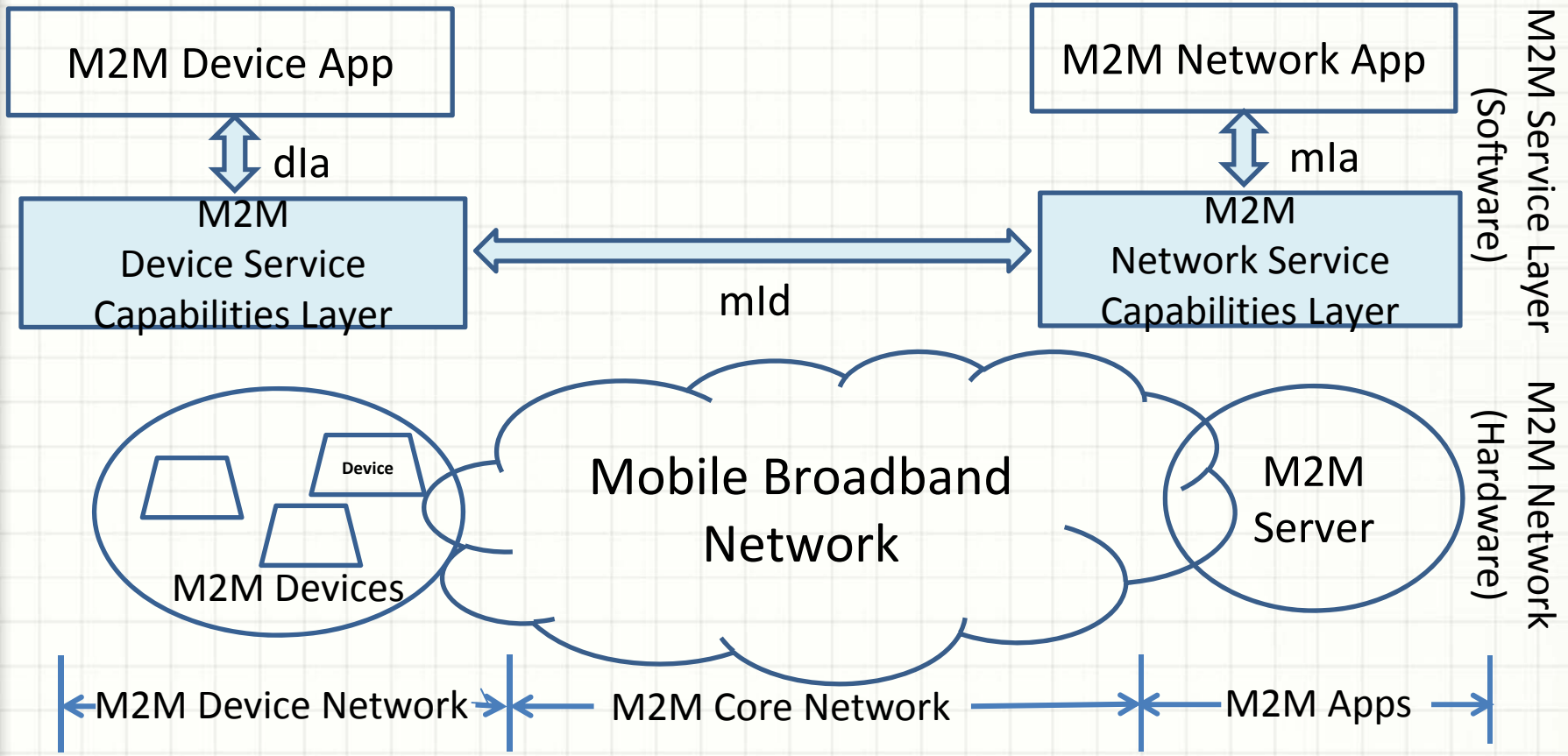
ETSI M2M Network High Level Architecture



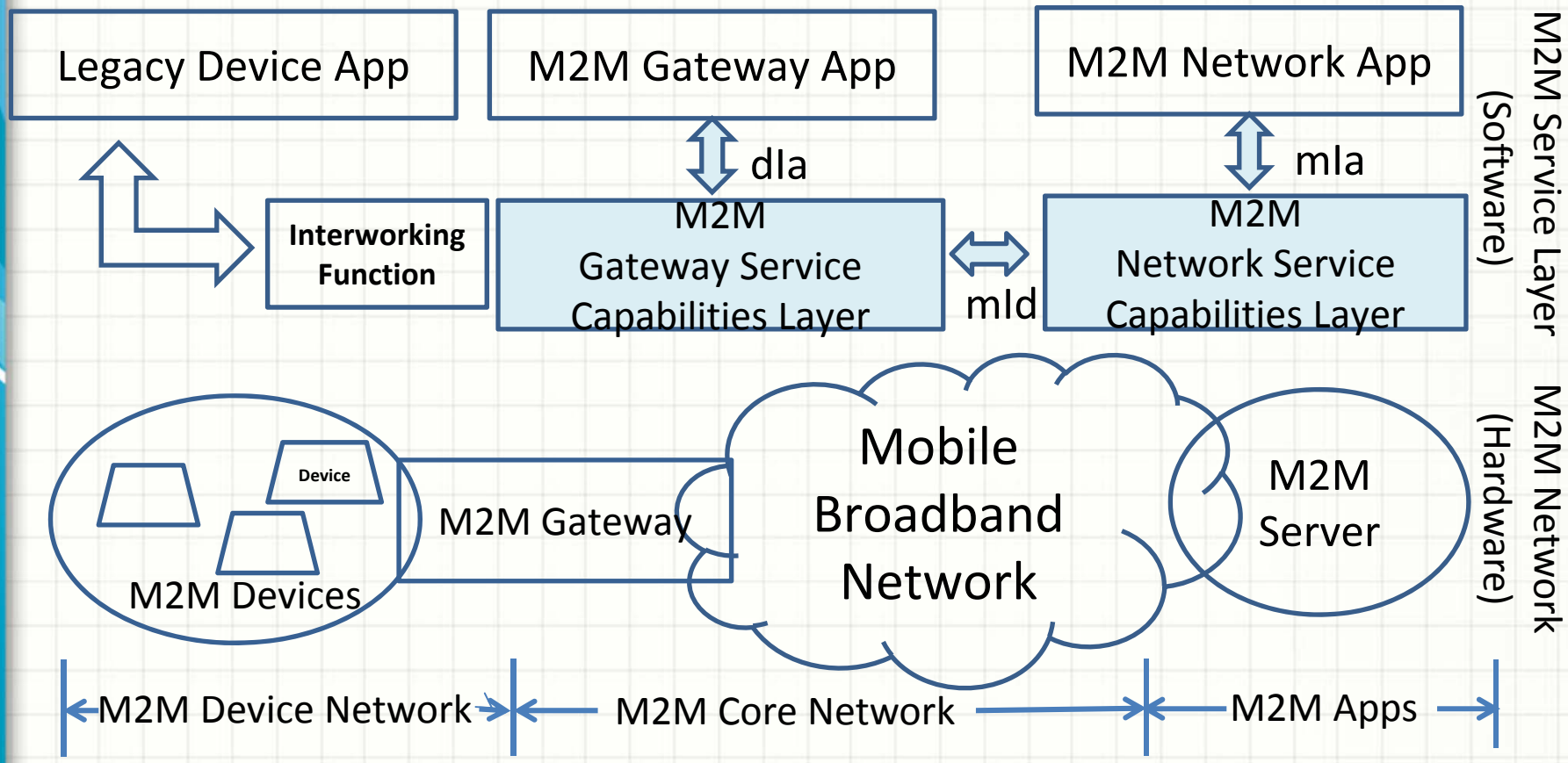
ETSI M2M Functional Architecture (1)



ETSI M2M Functional Architecture (2)



ETSI M2M Functional Architecture (3)



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M2M Core Network

- Wide Area Network: includes both access and core networks. Access networks can be wireless, mobile, fixed or other types.
- M2M Network Service Capabilities Layer (NSCL): functional modules that implement common M2M functions sharable by many M2M applications through open interfaces.
- Network Applications: M2M applications reside in the core network.

M2M Area Network

- M2M Area Network: Many varieties of protocols for different vertical applications
- Device

  Three types of devices –

  1. Proprietary devices: devices that only support proprietary interfaces.
  2. Devices with M2M service capabilities (Device SCL)
  3. Devices without M2M service capabilities
- Gateway

  Equipped with M2M service capabilities (Gateway SCL).

M2M Applications

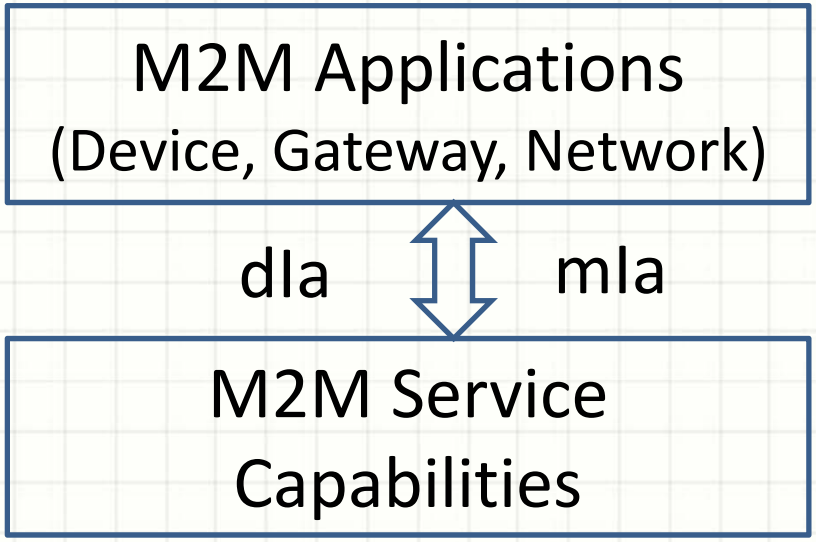
- M2M applications can reside on
  - application servers in the core network,
  - M2M gateways or
  - M2M devices.

What are Service Capabilities?

- The M2M SCs are the cornerstone of the M2M standardization effort! They are network functions implemented in software .
- Major objectives of M2M standardization:
  - Identify the functionalities that are to be exposed to the applications
  - Standardize vertical interfaces that allow applications to make use of M2M SCs
  - Standardize horizontal interfaces at the service level between M2M SCs
  - Identify how SCs can make use of core network capabilities

M2M Service Capabilities Framework

- M2M service capabilities can reside on the device (via dIa), the gateway (via dIa) or the network (via mIa).

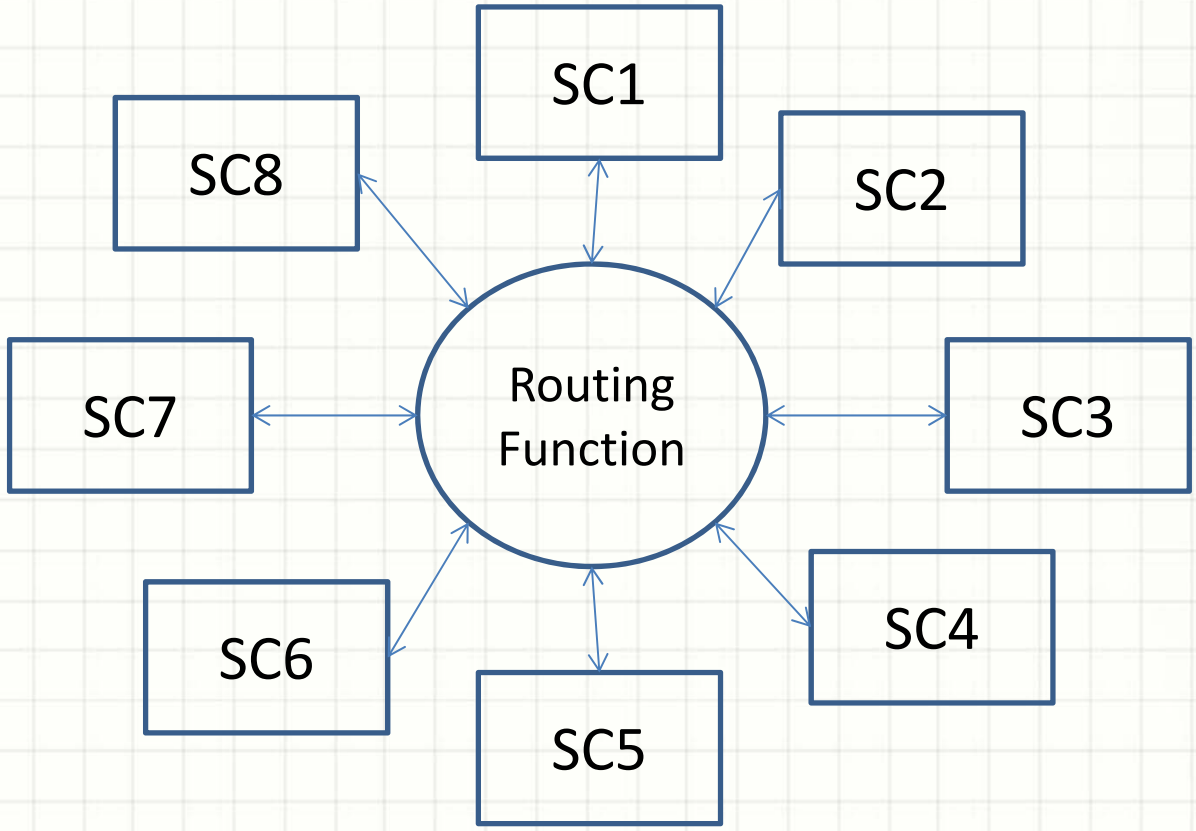


Overview of M2M Service Capabilities

x= D (Device) or G (Gateway) or N (Network)

1. Application Enablement (xAE);
2. Generic Communication (xGC);
3. *Reachability, Addressing and Repository (xRAR);*
4. Communication Selection (xCS);
5. *Remote Entity Management (xREM);*
6. *Security (xSEC);*
7. History and Data Retention (xHDR);
8. Transaction Management (xTM);
9. Compensation Broker (xCB);
10. Telco Operator Exposure (xTOE);
11. Interworking Proxy (xIP).

Architecture of M2M Service Capabilities



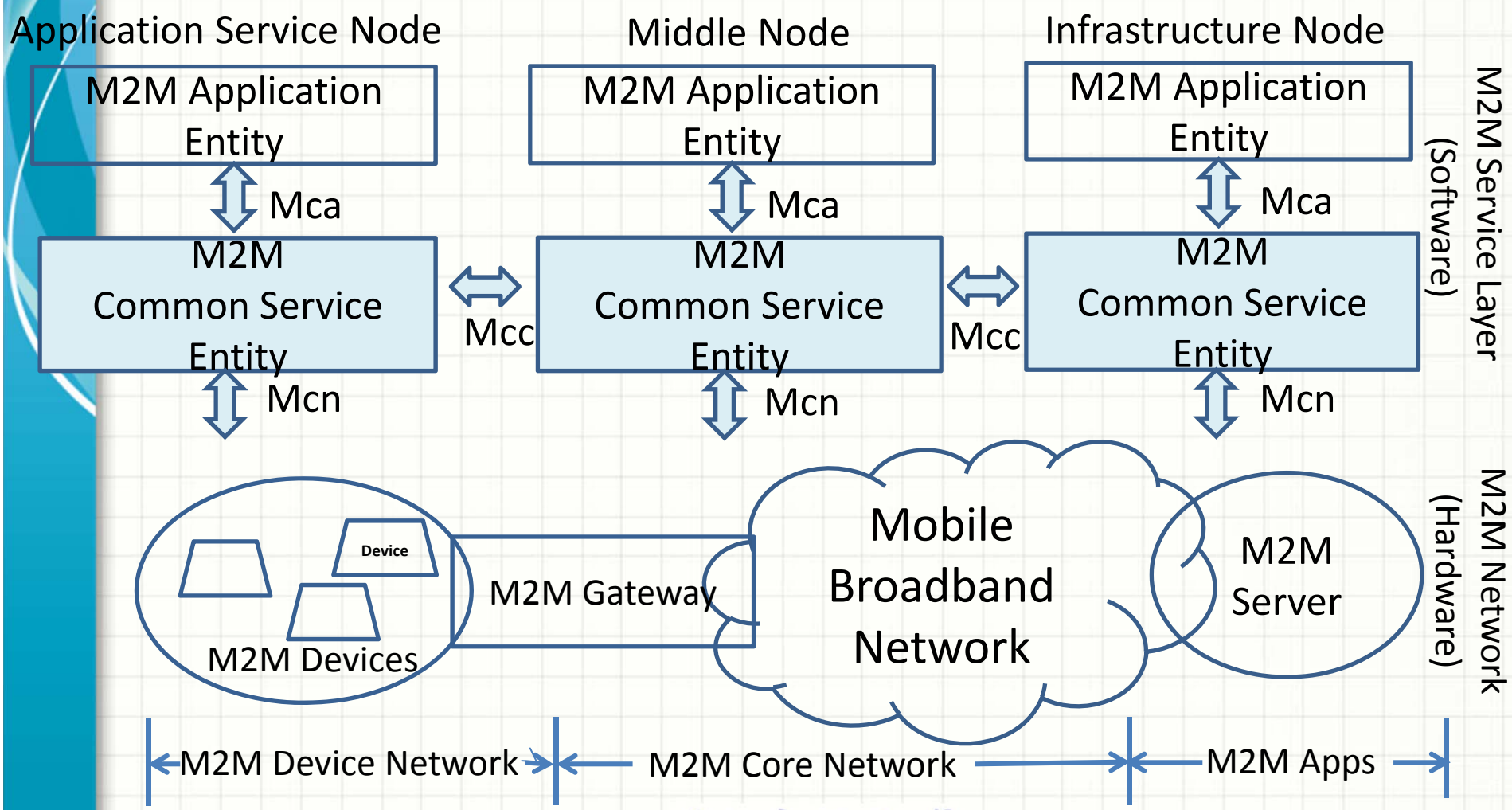
OneM2M Effort

- Launched In July 2012
- Global Initiative focused on consolidation and standardization of a common M2M Service Layer which can be embedded in hardware or software
- Objectives are to enhance interoperability, simplify development of applications, boost economies of scale, and reduce standards overlap
- Some of ETSI M2M technical specifications are transferred to oneM2M and ETSI is refocusing on EU issues.

Partner Type 1 (Founding SDOs) in oneM2M

- Japan – ARIB, TTC
- USA – ATIS, TIA
- China - CCSA
- Europe - ETSI
- Korea – TTA

OneM2M Functional Architecture



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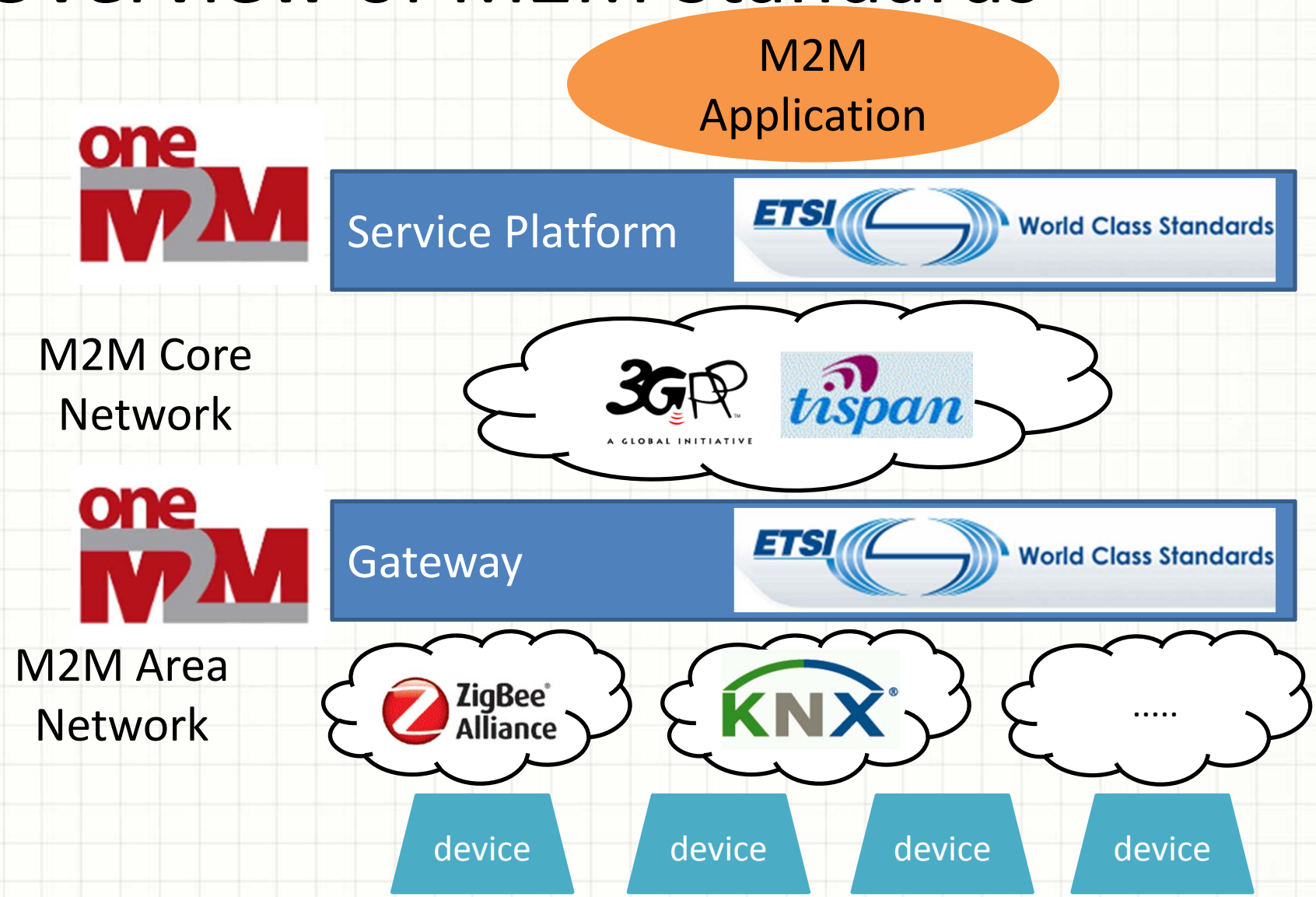
Reference Points

- Define three interfaces
  - Mca – between an AE and a CSE (mIa & dIa)
  - Mcc – between two CSEs (mId)
  - Mcn – between a CSE and the underlying network services (new!)

Overview of M2M Standards



NCTU Experience

OpenMTC as an Experimental Platform

- OpenMTC is an “ETSI standard compliant platform for M2M” developed by FOKUS. It implements the interfaces required for the communication among ETSI’s architecture domains.
- It also includes a basic subset of ETSI defined service capabilities for the correct functioning of an M2M system.
- In this experiment, we trained 14 NCTU students, as potential researchers or developers of creative applications, with OpenMTC.
- As an experiment, they are assigned to develop four smart campus IoT/M2M applications using OpenMTC.

M2M Applications under Experimental Trial

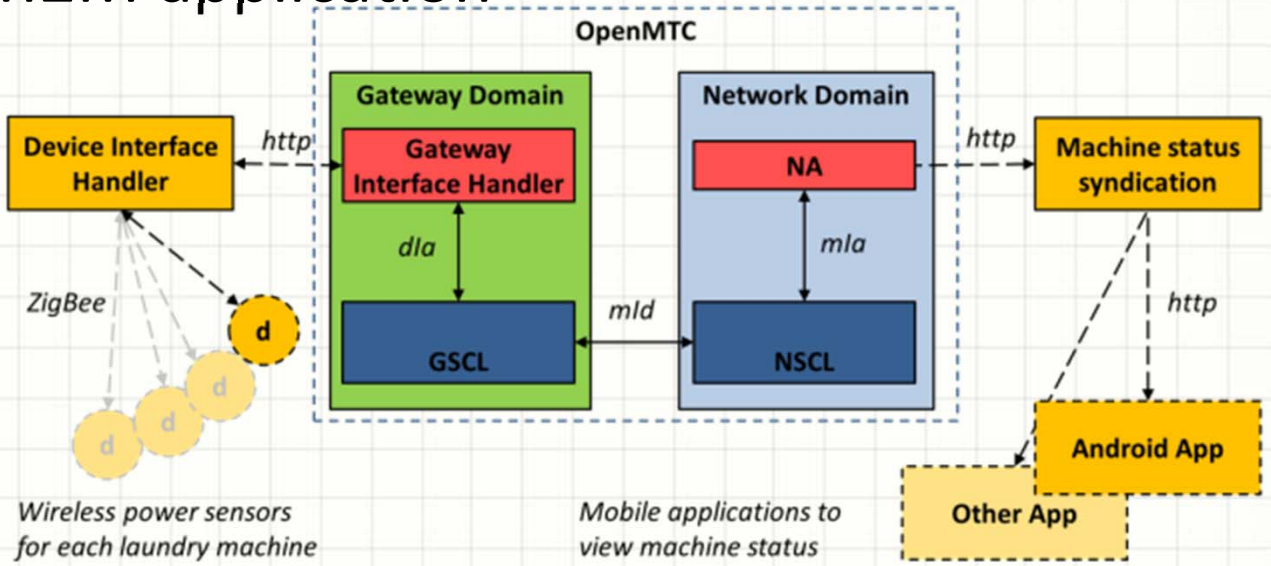
- These four applications include:
  - Bus tracking that allows an end user to track the location of the bus.
  - Building energy saving that allows automatic shutoff of appliances when no one is around.
  - Smart lighting that allows an end user to better manage lighting condition at home.
  - Facility view that monitors the availability of a facility (e.g. washers and dryers in a laundry room) and performs smart scheduling for the end users.

Evaluation of Development Experience (1)

- Result 1: Rapidness of application development
  - By relying on a common service platform such as ETSI M2M-based OpenMTC, student developers are relieved from the tedious task of developing complex underlying network infrastructure such as GSCL and NSCL.
  - They can focus on the application level effort involving mostly about the service features of the application itself.

Evaluation of Development Experience (2)

- Result 2: Four unique modules required for each IoT/M2M application



- Different ways of collecting data from M2M device /sensor network via Device Interface Handler module.
- Different ways of presenting data to the client application via Machine Status Syndication module.
- Different Gateway Interface Handlers in order to insert specific data collected into the GSCL resource tree.
- Different Network Applications (NAs) customized according to types of client applications.

Concluding Remarks

- A standardized IoT/M2M service platform is critical in creating a global ubiquitous IoT/M2M network that will
  - Interoperate with fast developing mobile networks and
  - Integrate all existing sensor/device networks and protocols in various vertical market
  - enable rapid creation of innovative IoT/M2M services.
- In the foreseeable future, the development of these IoT/M2M services will bring us into the era of smart living where the quality of human life can be greatly improved with increasing level of convenience, safety and efficiency.

Where to Find ETSI M2M and oneM2M Specifications

- Latest draft TR/TS and other useful information are available from

http://docbox.etsi.org/SmartM2M/Open/OneM2M - ETSI Pool 20130704.zip
http://docbox.etsi.org/SmartM2M/Open/OneM2M - ETSI Pool 20140228.zip
http://docbox.etsi.org/smartM2M/Open/Latest_Drafts/
http://docbox.etsi.org/smartM2M/Open/Information/

- oneM2M Candidate Release at http://www.onem2m.org/candidate_release/