

CPS: Communications

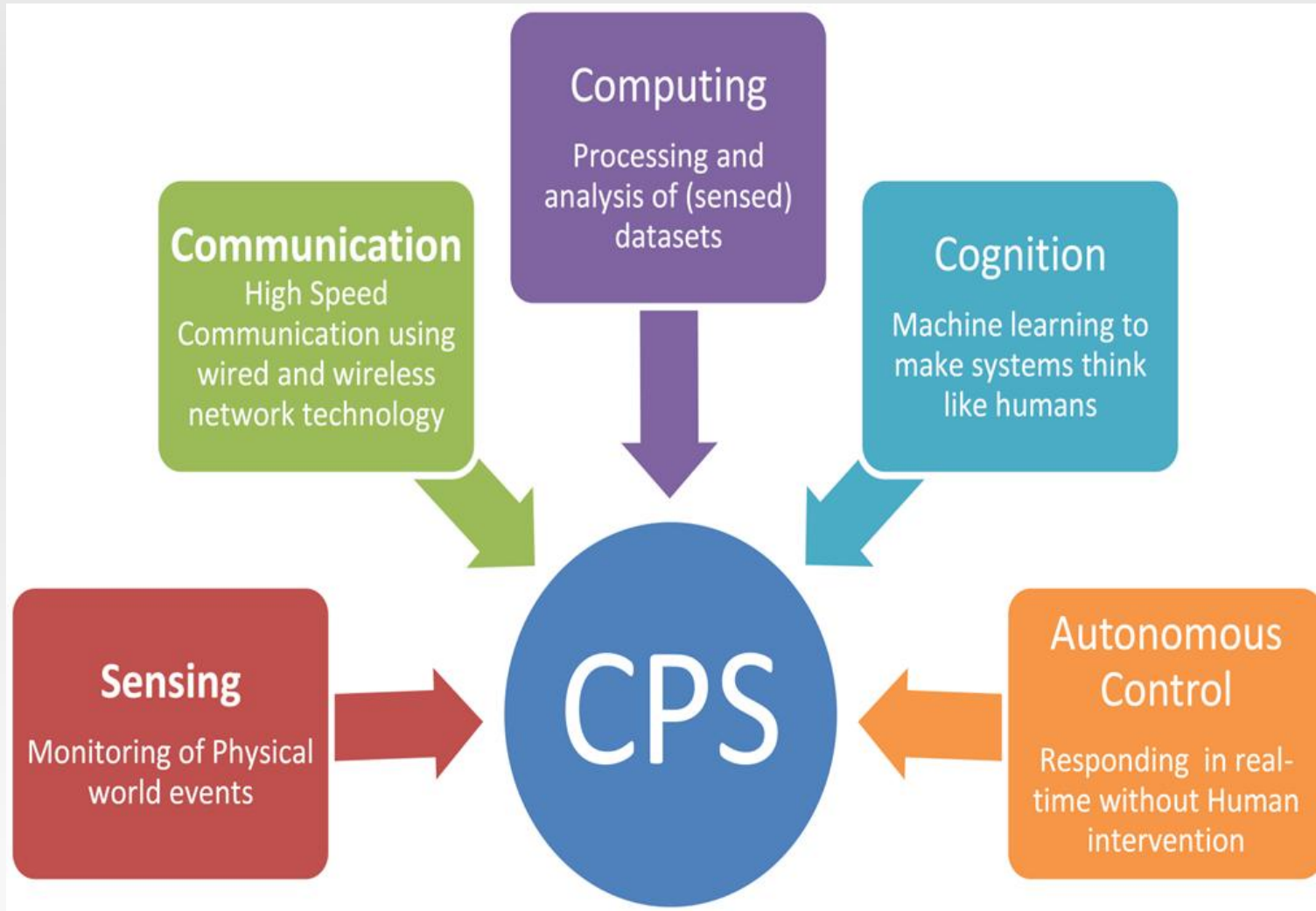
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IIT HYDERABAD

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CPS Building Blocks



Wireless Communication Technologies

- **Communication** is the act of exchanging ideas, information, and opinions.
- When we use technical equipment in communicating, it is called *communication technology*.
- When wireless medium is used in any communication technology then it is called **Wireless Communication Technology**.

Wireless Radio Access Technologies

- Cellular Networks: GSM, UMTS, LTE
- IEEE 802.11, 802.16 (WiMAX), 802.22
- Bluetooth
- ZigBee (802.15.4), UWB
- 6LoWPAN

Types of Communication

- Wireless Communication technology can be used for four distinct types of communication:
 - Human-to-human communication
 - Human-to-machine communication
 - Machine-to-human communication
 - Machine-to-machine communication

M2M sessions will outnumber H2H mobile sessions by a factor of more than 30 to one in 2020.

Source: Forrester

Machine to Machine Communication

Introduction

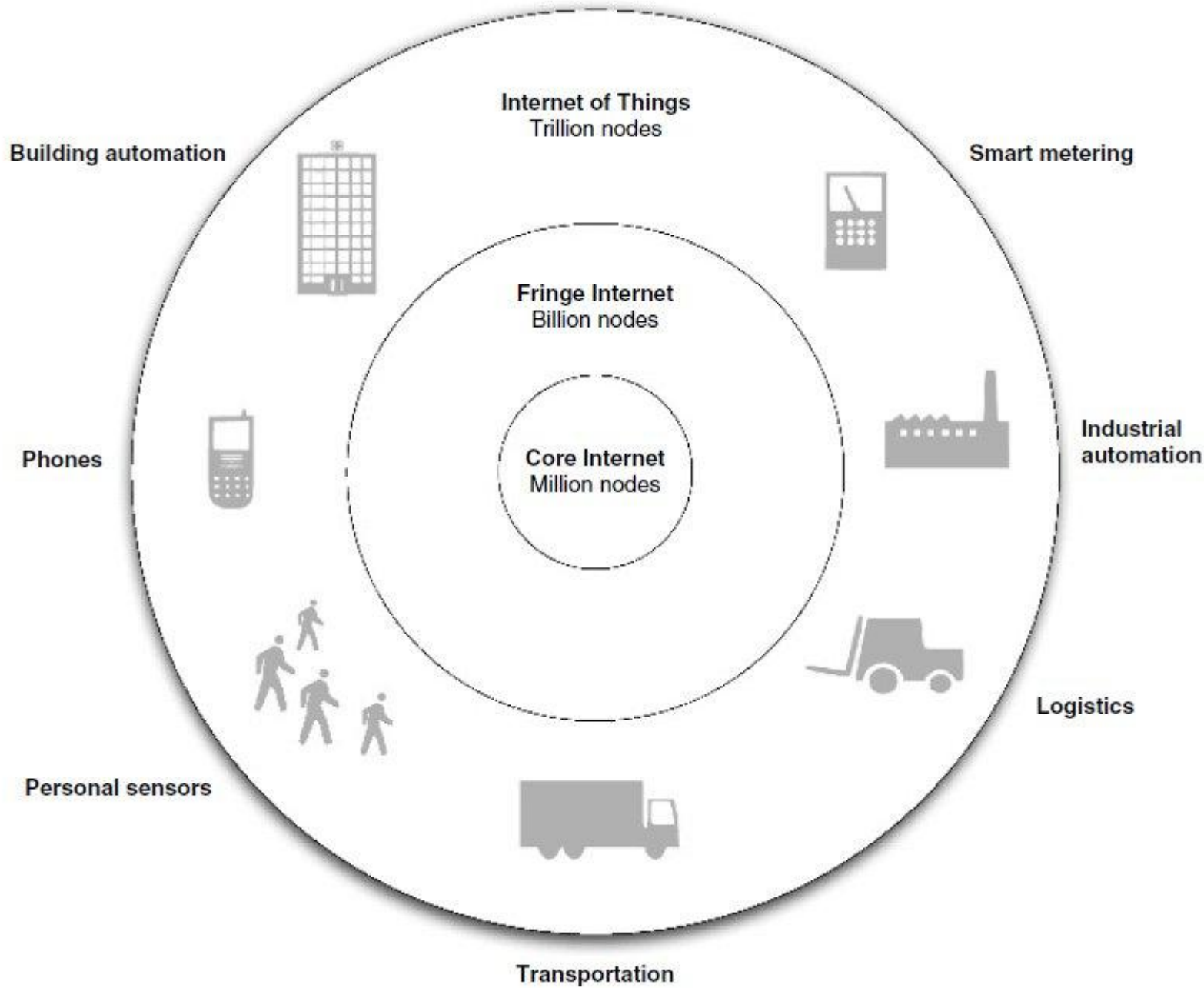
- M2M Definition from Numerex:

“M2M uses a device (sensor, meter, etc.) to capture an ‘event’ (temperature, inventory level, etc.), which is relayed through a network (wireless, wired or hybrid) to an application (software program), that translates the captured event into meaningful information (e.g., items need to be restocked).”

The Internet of 50 Billion Intelligent Devices (Internet of Things)!

- A large number of intelligent machines sharing information and making decisions without direct human intervention.
- Also named **Machine Type Communication (MTC)** in 3GPP
- Embedded Mobile (Internet)/Internet of Things

Internet of Things Vision



Source: Zach Shelby and Carsten Bormann

M2M Applications

Security

- Surveillance applications, alarms, people tracking

Transportation

- Fleet management, emission control, toll payment

Health care

- e-Health

M2M Applications

Utilities

- Measurement, provisioning and billing of utilities, such as Oil and water

Manufacturing

- Production chain monitoring and automation

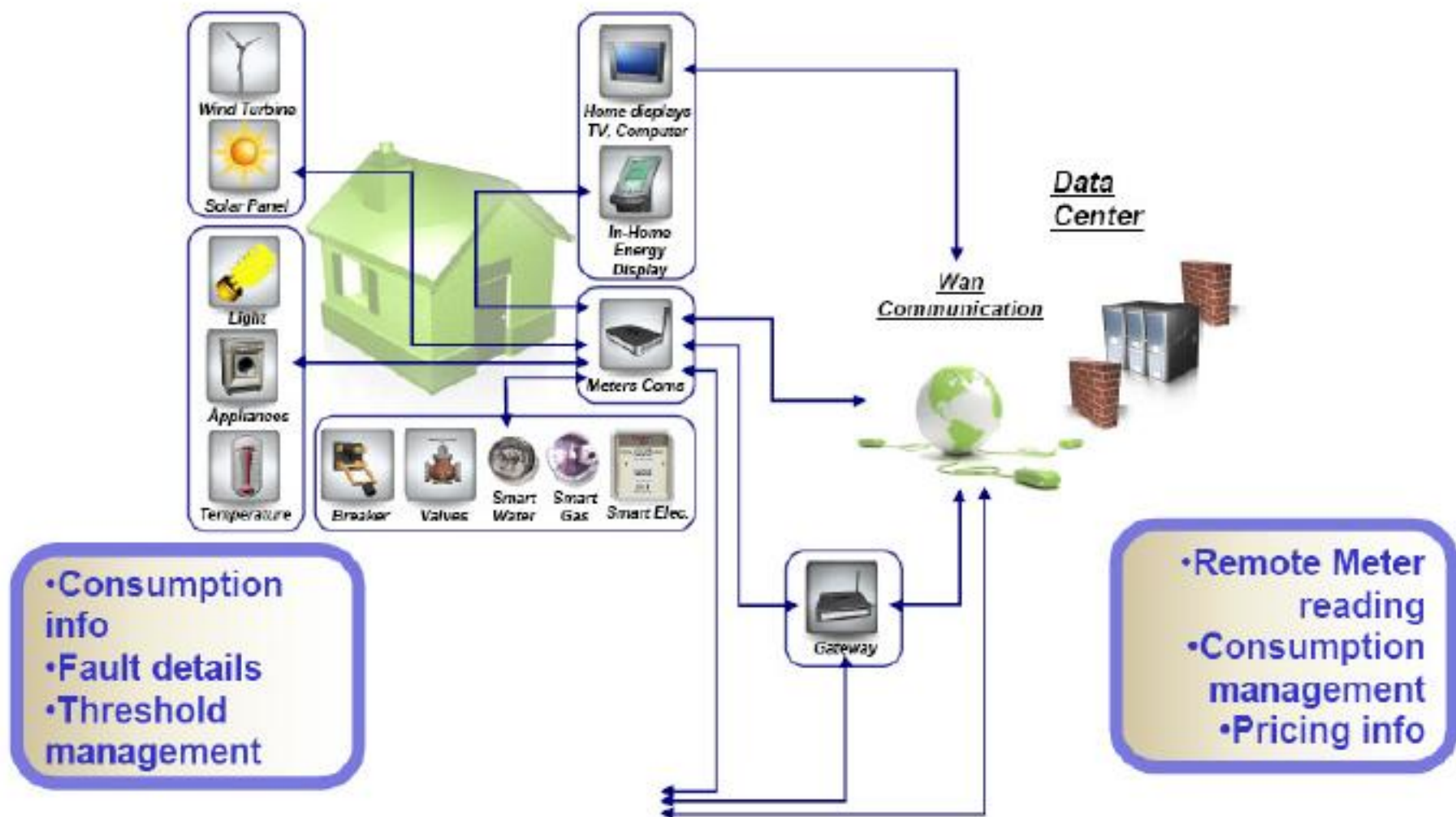
Facility Management

- Home / building / campus automation

Early M2M Prototype Systems

- GPS Navigation System
- Sensor Networks
- Smart Meters

M2M Application – Smart Metering



M2M Application – e-Health



M2M Community

The screenshot shows the M2M Community website interface. At the top, there is a navigation bar with the M2M.com logo and the tagline "Community for machine-to-machine, embedded wireless, and connected consumer devices development". Below the navigation bar, there are links for "Welcome, Guest", "Login", and "Register", along with a search bar.

The main content area is divided into several sections:

- M2M Developer Kits:** A section on the left side listing various operator kits for purchase, including at&t (US), O2 (35 European countries), kpn (32 European countries), movistar (35 European countries), ROGERS (Canada), Telstra (Australia), SingTel (Asia), and Beeline (Russia). Each listing includes an "Order Kit>>" link.
- Developer Central:** A central banner featuring a radio tower icon and the text "Developer Central" with the subtitle "Find the information you need to connect your device, get to market, and provide a great user experience." Below this banner is a navigation menu with tabs for "Overview", "Discussions", "Resources", "Dev Kits", "News", and "Communities".
- Recent Postings:** A table listing recent forum posts with columns for "Subject", "Views", "Replies", and "Author".
- Hot Topics:** A list of trending topics including "Antenna", "Certification", "Modules/Devices", "Network", and "SMS".
- Announcement:** A section for important news, featuring a workshop announcement for connected device developers in Palo Alto, CA on October 4, with a "Register now>>" link and logos for Ericsson and AT&T Foundry.
- Join the Conversation:** A section encouraging users to ask questions and start discussions, with a "Go" button.
- Tech Talk:** A section for technical discussions, currently showing a placeholder image.

Subject	Views	Replies	Author
Re: Dynamic Public IP address ? 1 day ago in Developer Central	768	3	by mariaL
Re: ZigBee+GPRS or GPRS Only 1 day ago in Developer Central	1,581	6	by mariaL
Re: GSM/GPRS OEM for mobile application 1 day ago in Developer Central	223	1	by mariaL
Re: Class is out! Don't get schooled on your module. 4 days ago in Developer Central	329	1	by Sandy
m2m Fraud and Security 4 days ago in Developer Central	195	0	by Alex
Communicating on SPI1 port of Telit 863Pro 4 days ago in Developer Central	409	0	by mbcontrol

AT&T M2M Developer Kit

https://att.m2m.com/devkit/ AT&T Connection Kit for M...

AT&T Connection Kit For Device Developers

BENCHMARK KIT

If your device is ready to connect, using an AT&T approved module, then get the power of AT&T's wireless broadband network and the command of AT&T Control Center with the Benchmark Kit.

jasper wireless

Includes 3 test SIMs for
\$199
Order Now

Full Access to AT&T Control Center

- Complete suite of developer tools
- Real-time visibility to device + network behavior
- Test-as-you-build for fast, quality development

Plus, developer guidelines and forum at M2M.com

Benchmark Device

- Establish successful benchmark connection
- See network connection details
- Test and troubleshoot connectivity

Exceptional Developer Support

- Developer guidelines and M2M.com forum
- Access to API sandbox
- Accelerated device certification

3 Test SIMs with AT&T Connectivity

- 30MB per SIM per month for 6 months
- 50 SMS messages per SIM per month
- Service across the United States ([map](#))

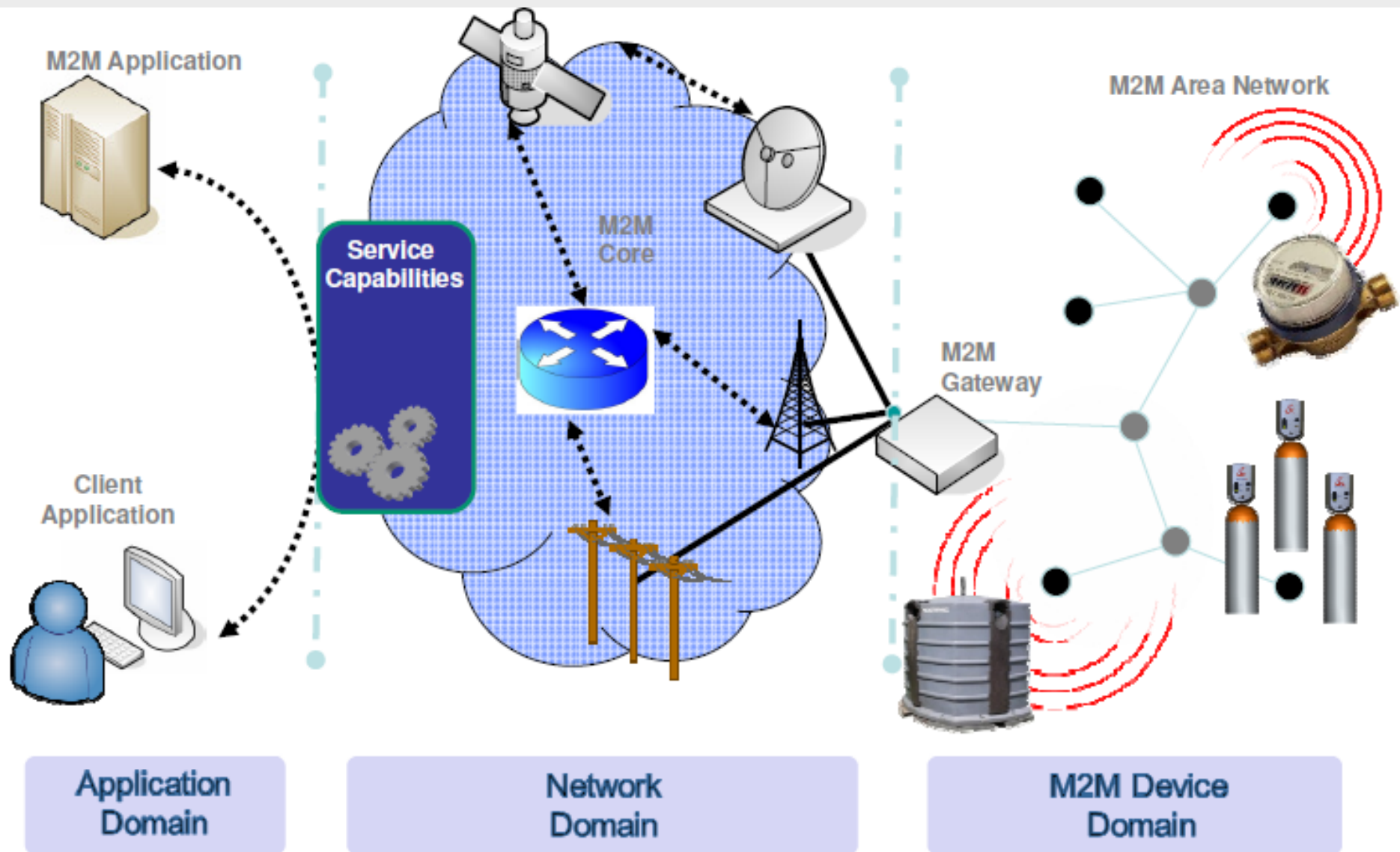
Typical M2M Characteristics

- Low-energy, Low-cost, Low-processing power
- Infrequent and small data transmissions
- Enormous number of MTC nodes
- Two-way communication
- Low-latency and Reliable transmission (QoS)
- No mobility or limited mobility

M2M Architecture

- M2M Architecture consists of three interlinked domains:
 - M2M Device Domain
 - Network Domain
 - Application Domain

M2M Architecture



Architecture ...

M2M Device Domain

- **M2M Device**

A device capable of replying to request for data contained within that device or capable of transmitting data contained within those devices autonomously

- **M2M Area Network**

Provide connectivity between M2M Devices and M2M Gateways

- **M2M Gateway**

Use M2M capabilities to ensure M2M Devices inter-working and interconnection to the communication network

Architecture ...

Network Domain

- **M2M Communication Networks**

Communications between the M2M Gateway(s) and M2M application

E.g. Access Networks (xDSL, LTE, WiMAX, and WLAN) and Internet

Applications Domain

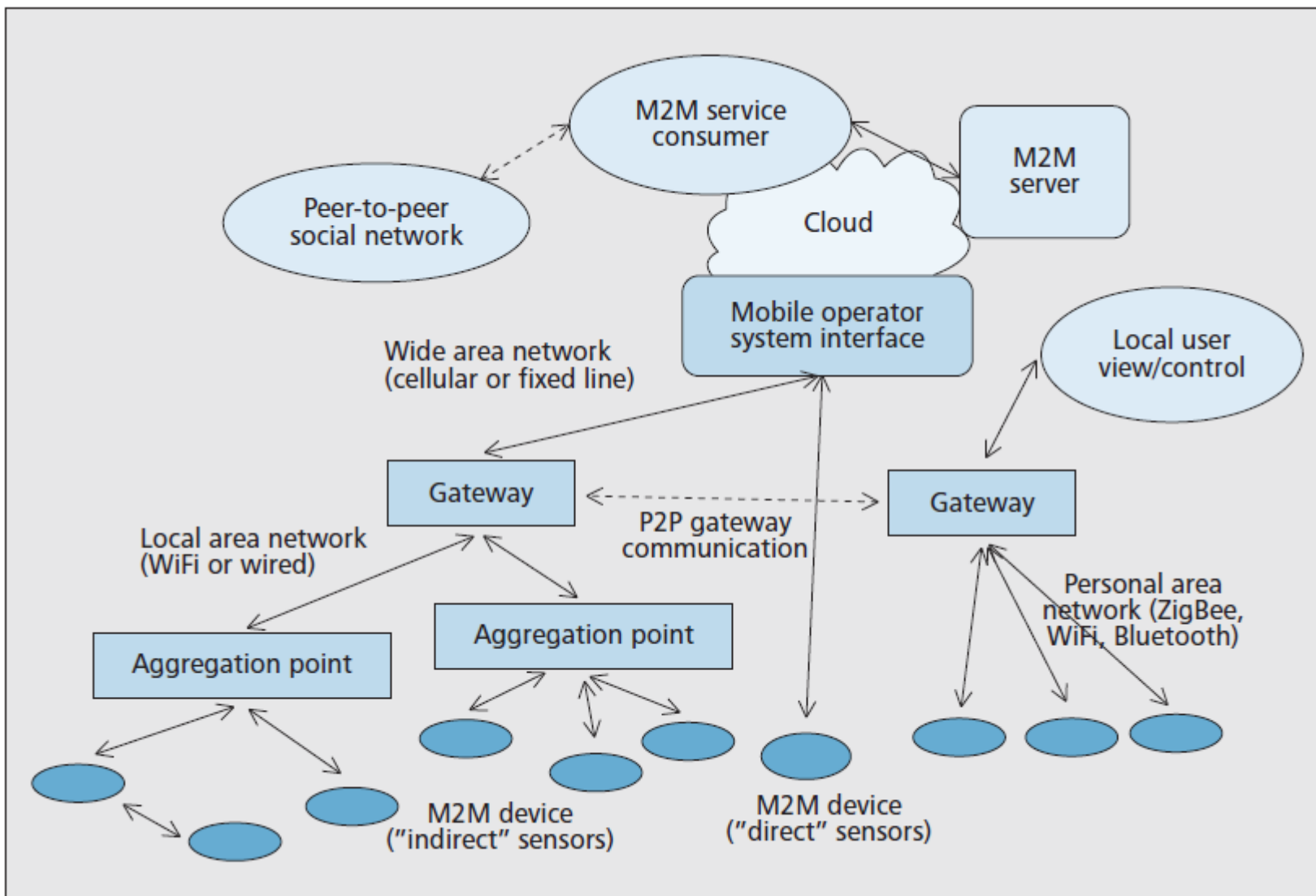
- **M2M Applications:**

Contains the middleware layer where data goes through various application services and is used by the specific business-processing engines

M2M System

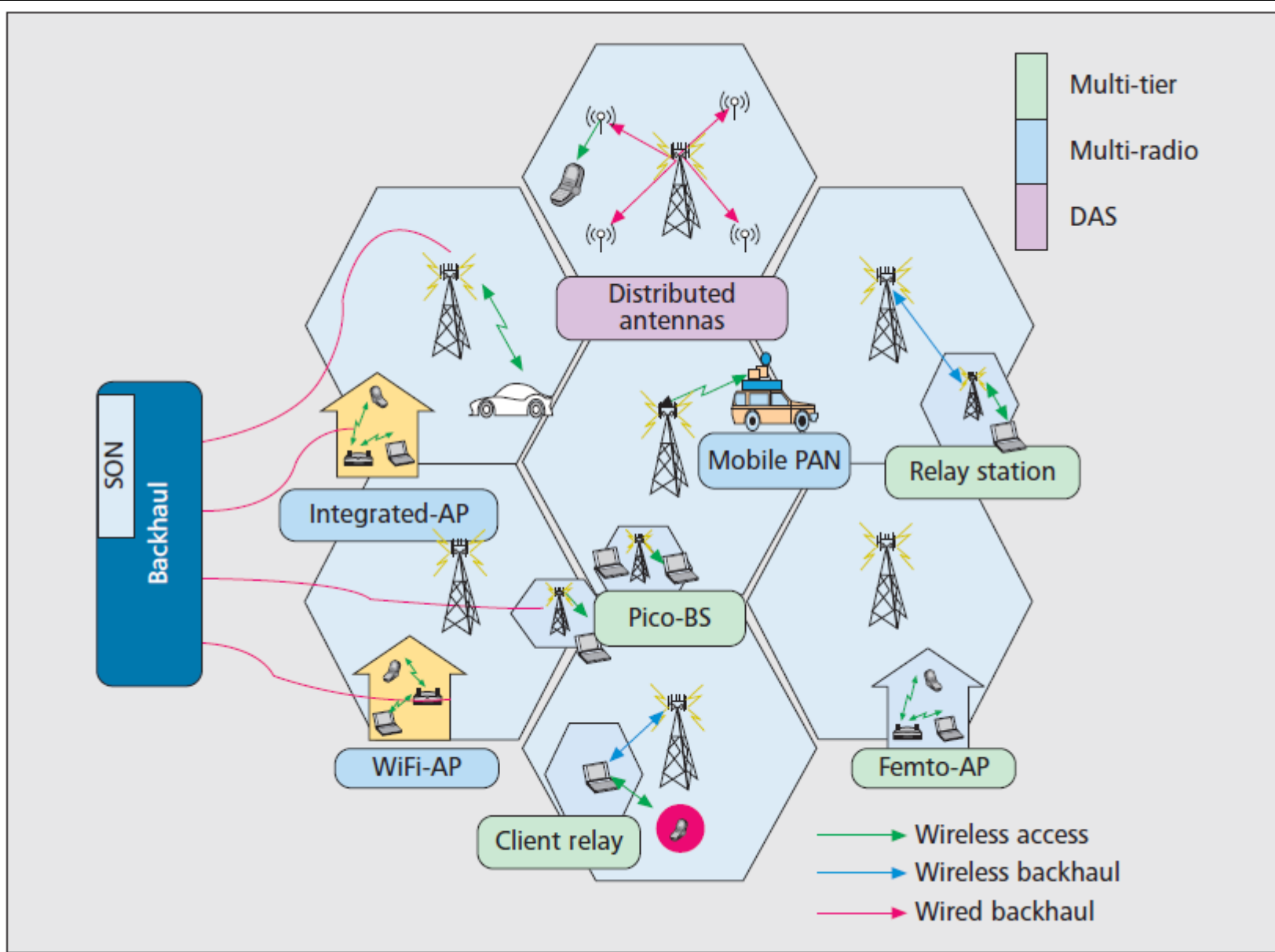
- Sensors: Energy efficient/Self-powered
- Communication Module: Wireline/Wireless (IPv6, VPN)
- Embedded SIMs
- Middleware platforms
 - To give s/w developers an application view of end-to-end M2M data
 - Functionality includes SIM activation, routing, buffering, formatting, managing M2M data
- MNOs (AT&T, O2, Vodafone)
- MVNOs (Wyless, Wireless Logic)
- MVNEs (Aspider Sols): SIM card agreement, IP address management, cost control, fraud management

High Level M2M Architecture



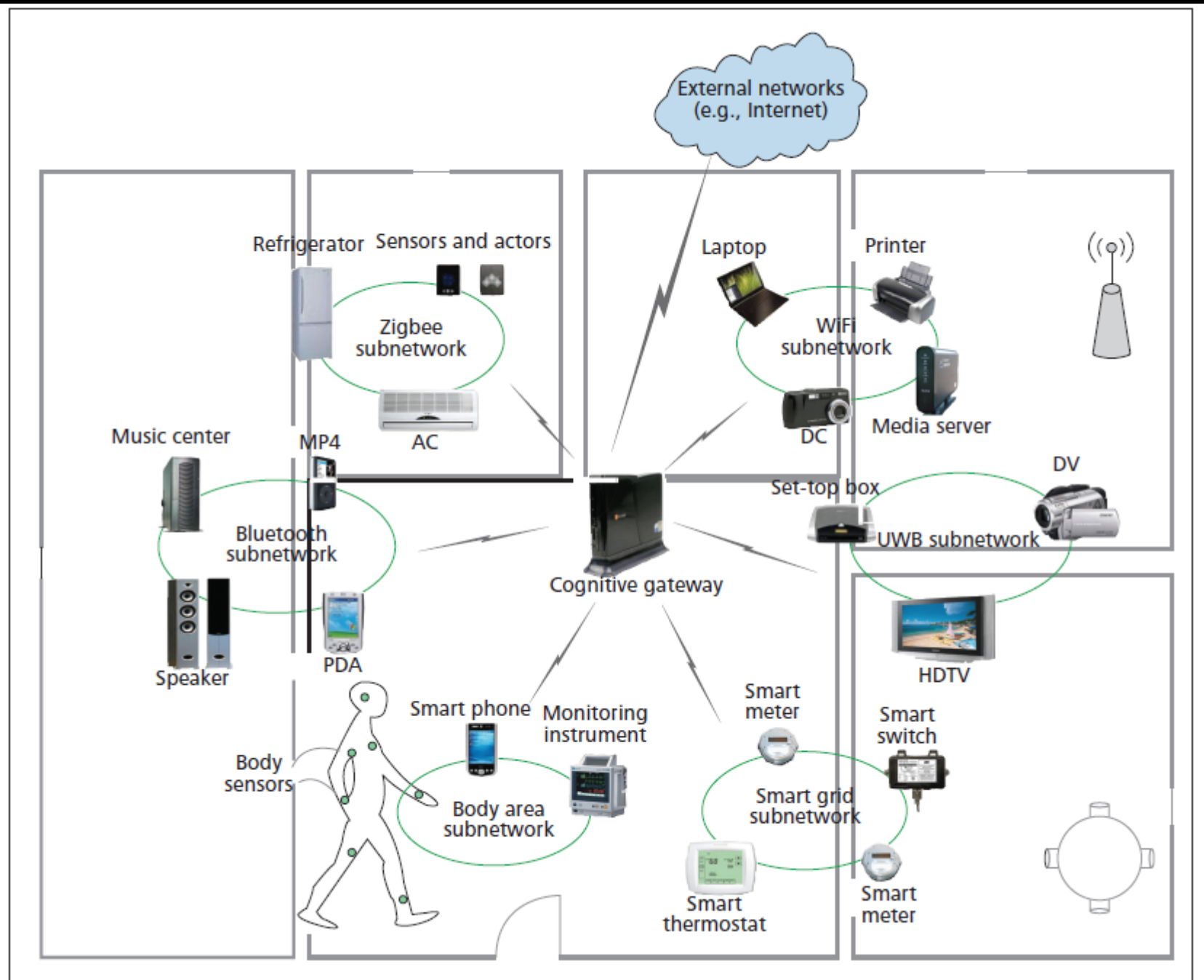
Source: Reference [GWu2011]

Hierarchical M2M Architecture



Source: Reference [IEEE2010]

Home M2M Architecture



Radio Technologies for M2M

Standard	Area	Rate	Energy-constrained	Typical applications	Data Type
Zigbee	Personal area	Low	Yes	Automatic control	Sensors, monitoring, smart grid
Bluetooth	Personal area	Low	Yes	Music sharing	Voice, low-rate data, music
UWB	Personal area	High	No	Video, file sharing	Video, high-rate data, files
802.15.6	Body area	Low	Yes	Healthcare	Biomedical data
WiFi	Local area	High	No	Home thermostats, water metering	VoIP, data, video
Femtocell	Local area	High	No	Cellular phones	VoIP, data, video

Source: Reference [YZhang2011]

Issues in M2M

- Naming, Address and routing:

Alternative addressing solution based on IP addresses should be studied

- Power Saving @ M2M devices:

- ❖ Policies must be developed to save battery power of M2M devices for uninterrupted communication.
- ❖ Optimizing sensing, processing, and transmission activities to save battery power

- Power Saving @ Base Stations

- Scalability of Network Architecture for Trillions of nodes

- Diverse M2M Applications Requirements

- Reliability:

Reliability in sensing, transmission, and processing must be considered.

- Security:

- ❖ System must be protected from internal and external attacks.
- ❖ Requirements: Confidentiality, Integrity, Authentication, Access Control, Privacy, Availability

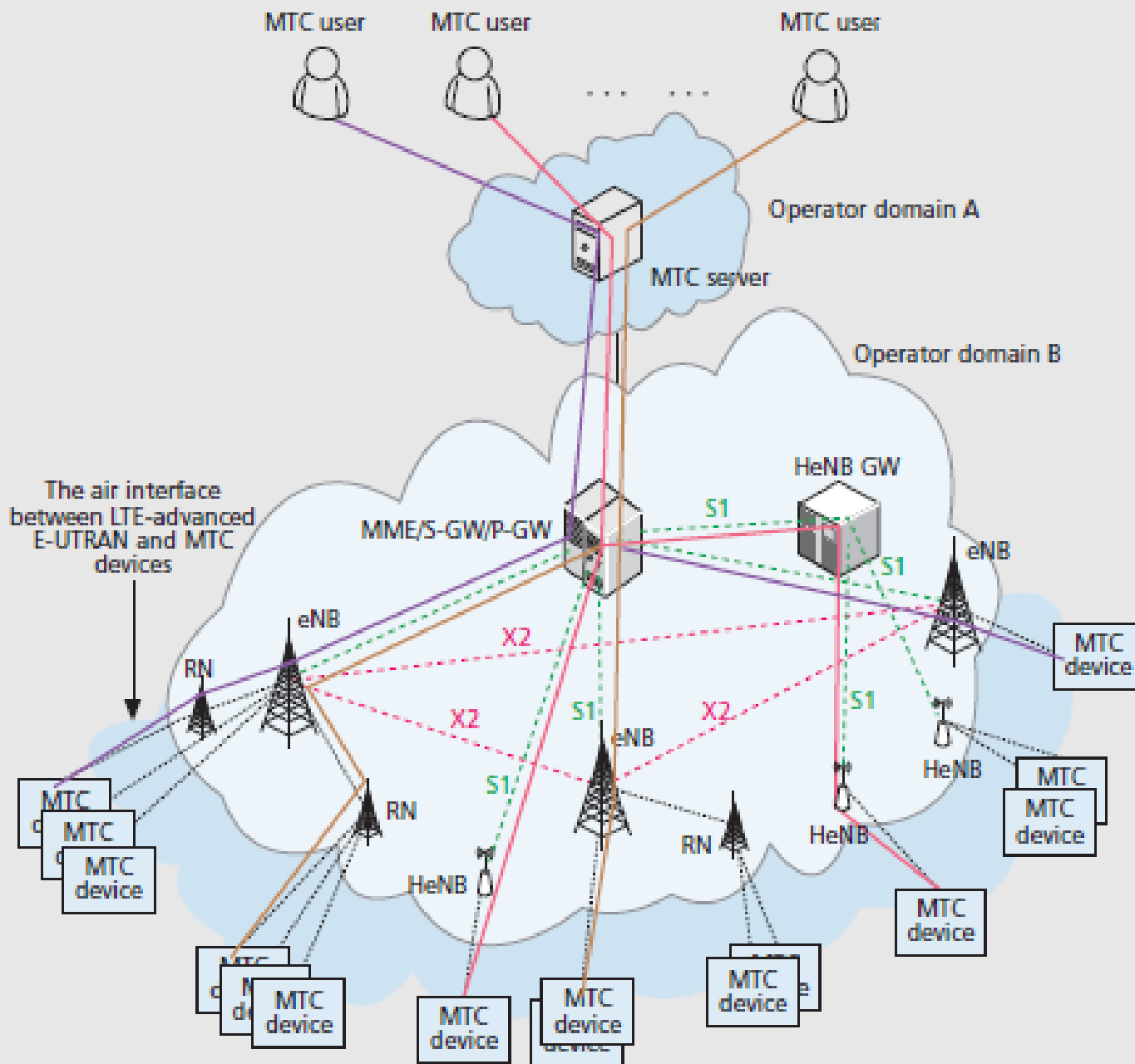
- Service levels and QoS

New QoS profiles needs to be defined

RAT Optimizations for M2M

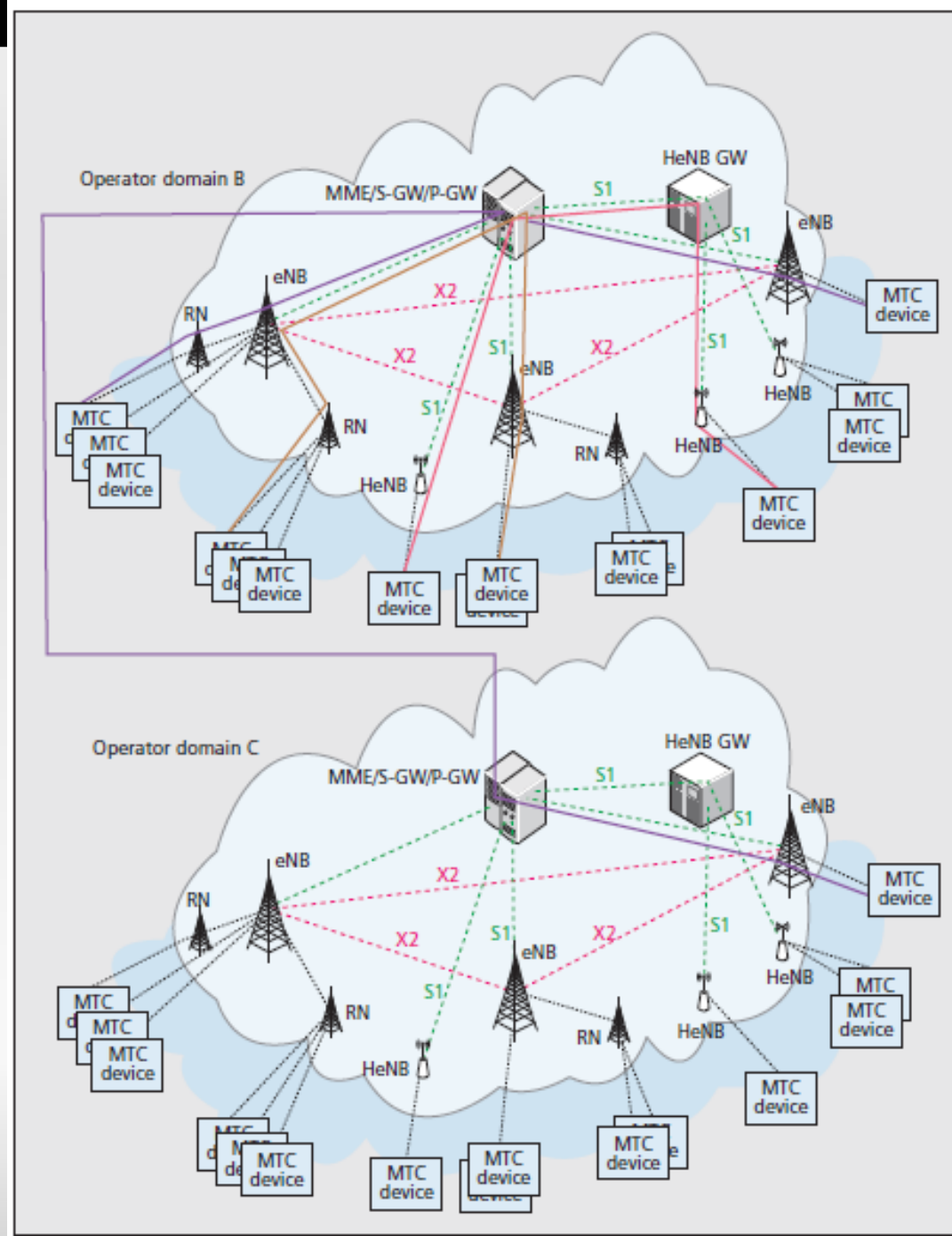
Features	Applications	Standards impacts							
		Sleep and idle mode	Mobility management	Link adaptation	BW request & Allocation	HARQ and ARQ	Frame structure	Network entry	Cooperation
Mass device transmission	Security Metering Tracking		√	√	√	√	√	√	√
High reliability	Health Security Health	√	√	√	√	√	√		√
Access priority	Remote maint & control	√	√		√	√	√	√	
Very low power	Tracking Remote maint & control	√	√	√	√	√	√	√	√
Small data burst	Metering Remote maint & control	√				√			
Low/no mobility	Metering	√	√	√	√			√	√
Monitoring and security	Vehicular Payment	√					√	√	

3GPP M2M Architecture -- 1



Source: [SLien2011]

3GPP M2M Architecture -- 2



Source: [SLien2011]

LTE for M2M?

Are sophisticated link adaption techs required?

- MIMO, Beam forming, Adaptive Modulation, HARQ, CoMP Tx for Higher Data Rate

Are there enough resources on control channel?

- 10 MTCs per sub-frame in PDCCH
- New Frame structure for M2M?

Random access channel contentions!

- Enormous no of MTC Devices
- BO scheme/ Separate resources

Energy, Complexity, QoS, Mobility, Reliability

- These become more critical & different issues compared to UEs of H2H

SDO	M2M development
3GPP	Release 10: identify requirements and optimize radio and network for features such as low power, congestion and overload control, identifiers, addressing, subscription control and security. Release 11 and beyond: network improvements for device to device communication, M2M gateway, enhancements for M2M group and co-located M2M devices, network selection and steering, service requirements and optimizations.
ETSI	M2M network architecture: define functional and behavioral requirements of each network element to provide an end-to-end view.
GSMA	GSM operation for M2M: define a set of GSM based embedded modules that address operational issues, such as module design, radio interface, remote management, UICC provisioning and authentication, and basic elements costs. Also define use-cases in vertical markets: health, utilities, automotive, and consumer devices.
IEEE	802.16p (WiMAX): optimize air interface for low power, mass device transmission, small bursts, and device authentication. Future topics: M2M gateway, co-operative M2M networks, advanced M2M features 802.11 (WiFi): update air interface to enable use of sub-GHz spectrum 802.15.4 (ZigBee): air interface optimization for smart grid networks
WiMAX Forum	Network system architecture specification: define usages, deployment models with low OPEX, functional requirements based on IEEE 802.16 protocols, and performance guidelines for end-to-end M2M system.
WFA	Smart grid task group: promote the adoption of Wi-Fi within the smart grid through marketing initiatives, government and industry engagement, and technical/certification programs Healthcare task group: maintain Wi-Fi as the preferred wireless access technology and increase adoption in the Home and Hospital Healthcare market segment.
OMA	Device manageability: define requirements for the gateway managed object
TIA	M2M SW architecture TR50: develop and maintain access agnostic interface standards for monitoring and bi-directional communication of events and information between smart devices and other devices, applications or networks.
CCSA NITS	CCSA TC10: focus on pervasive networks, including general requirements, applications, networking, sensing and related short range RF connectivity. NITS WGSN: focus on sensor network interface and data format, ID and security, vertical applications including airport and smart buildings.

Source: Reference [GWu2011]

Conclusions

- M2M Solutions → Internet of Things (CPS)
- Urgently needs standardization of various RATs for enabling mass scale deployments
- M2M deployments are another source of revenue for Network Operators, OEMs, IT industry
- Energy, QoS, Security, Cost are main factors

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