SNS COLLEGE OF ENGINEERING

An Autonomous Institution

Coimbatore-107

19IT503-INTERNET OF THINGS

UNIT-1 IoT INTRODUCTION AND APPLICATIONS

Topic:4-- IoT Definitions - Observations - ITU-T Views-IOT Frameworks (HLSA)-Basic nodal capabilities

IoT Definitions-General Observations

- Originally the term “Internet of Things” was invented by the MIT Auto-ID Center in 2001 and referred to an architecture that comprises **four elements**, as follows

1. Passive radio frequency identification (RFIDs), such as Class-1 Generation-2 UHFRFIDs, introduced by the electronic product code (EPC) Global Consortium and operating in the 860–960 MHz range1

Conti...

2. Readers plugged to a local (computing) system, which read the EPC.
3. A local system offering IP connectivity that collects information pointed by the EPC, thanks to a protocol called object naming service (ONS)
4. EPCIS (EPC Information Services) servers that process incoming ONS requests and returns physical markup language (PML) files, for example, XML documents carrying meaningful information linked to RFIDs

ITU-T Views

- ITU Telecommunication Standardization Sector (ITU-T)
- International Telecommunication Union (ITU)
- One can view the following as

Internet

- providing a number of technological capabilities or as a concept to provide an array of data exchange and linkage services.

Conti…

The infrastructure perspective

- describes the Internet as a global system of interconnected computer networks (of many conceivable technologies) that use the TCP/IP Internet Protocol Suite to communicate

The networks comprise

- millions of private, public, business, academic, and governmental servers, computers, and nodes.

ITU-T Views

- **View A:** IoT is just a concept (conceptual aspects of definition): the IoT does not refer to a network infrastructure; the IoT is not a technical term but a concept (or a phenomenon).
- Provide an array of data exchange and linkage services.
- **View B:** IoT is an infrastructure: The IoT refers to an infrastructure (Network infrastructure).

TABLE 2.1 Examples of Definitions for Case A (IoT is Just a Concept)

Candidate Definition	Reference
A technological revolution that represents the future of computing and communications, and its development depends on dynamic technical innovation in a number of important fields, from wireless sensors to nanotechnology	Source: ITU Internet Reports 2005: The Internet of Things, Executive Summary
The networked interconnection of objects—from the sophisticated to the mundane—through identifiers such as sensors, RFID tags, and IP addresses	Margery Conner, Technical Editor of EDN Magazine, "Sensors empower the 'Internet of Things' ", May 2010
The Internet of things *links the objects of the real world with the virtual world*, thus enabling anytime, anyplace connectivity for anything and not only for anyone. It refers to a world where physical objects and beings, as well as virtual data and environments, all interact with each other in the same space and time	Cluster of European Research Projects on the Internet of Things, "Vision and Challenges for Realizing the Internet of Things", March 2010
The IoT refers to as *ubiquitous networking or pervasive computing environments*, is *a vision* where all manufactured things can be network enabled, that is connected to each other via wireless or wired communication networks	European Network and Information Security Agency (ENISA)
The IoT is *a world where physical objects are seamlessly integrated into the information network*, and where the physical objects can become active participants in business processes. Services are available to interact with these "smart objects" over the Internet, query and change their state and any information associated with them, taking into account security and privacy issues. RFID, sensor networks, and so on are just enabling technologies	SAS
IoT is a [*high-level service concept* based on] existing and evolving global ICT (Information and Communication Technology) infrastructures that provide information services by interconnecting things	

TABLE 2.2 Examples of Definitions for Case B (Infrastructural Aspects of Definition)

Candidate Definition	Reference
A *global network infrastructure*, linking physical and virtual objects through the exploitation of data capture and communication capabilities. This infrastructure includes existing and evolving Internet and network developments. It will offer specific object identification, sensor and connection capability as the basis for the development of independent federated services and applications. These will be characterized by a high degree of autonomous data capture, event transfer, network connectivity, and interoperability	Coordination and Support Action (CSA) for Global RFID-related Activities and Standardization (CASAGRAS)
A global information and communication infrastructure enabling automated chains of actions (not requiring explicit human intervention) facilitating information assembly and knowledge production and contributing to enrichment of human life by interconnecting physical and logical objects based on standard and interoperable communication protocols and through the exploitation of data capture and communication capabilities supported by existing and evolving information and communication technologies NOTE: Physical objects may include sensors, devices, machines, and so on. Logical objects may include contents and so on	Originally produced by the discussion among China-Japan-Korea. ITU Q3/13 has made some modifications
A global ICT infrastructure linking physical objects and virtual objects (as the informational counterparts of physical objects) through the exploitation of sensor and actuator data capture, processing and transmission capabilities. As such, the IoT is an overlay above the "generic" Internet, offering federated physical-object-related services (including, if relevant, identification, monitoring, and control of these objects) to all kinds of applications.	Proposed by France Telecom on the IoT definition mailing list.
IoT is (*a global ICT infrastructure*) which provides information services by interconnecting things NOTE: Infrastructure should not be interpreted only as a network	

ITU-T Views

- IoT should be identified for all aspects of infrastructure such as service and functional requirements, architectures.

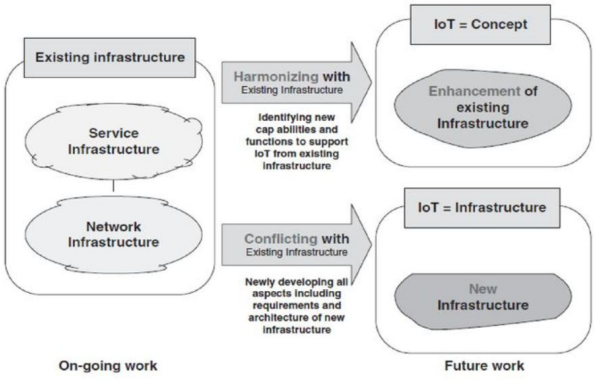


FIGURE 2.1 Direction for standardization according to IoT definition.

Working Definition

Definition:

- A broadly-deployed aggregate computing/communication application and/or application-consumption system, that is deployed over a local (L-IoT), metropolitan (M-IoT), regional (R-IoT), national (N-IoT), or global (G-IoT) geography, consisting of

(i) dispersed instrumented objects ("things") with embedded one or two-way communications and some (or, at times, no) computing capabilities,

(ii) where objects are reachable over a variety of wireless or wired local area and/or wide area networks,

(iii) whose inbound data and/or outbound commands are pipelined to or issued by a(n application) system with a (high) degree of (human or computer-based) intelligence.

Other related Working Definition

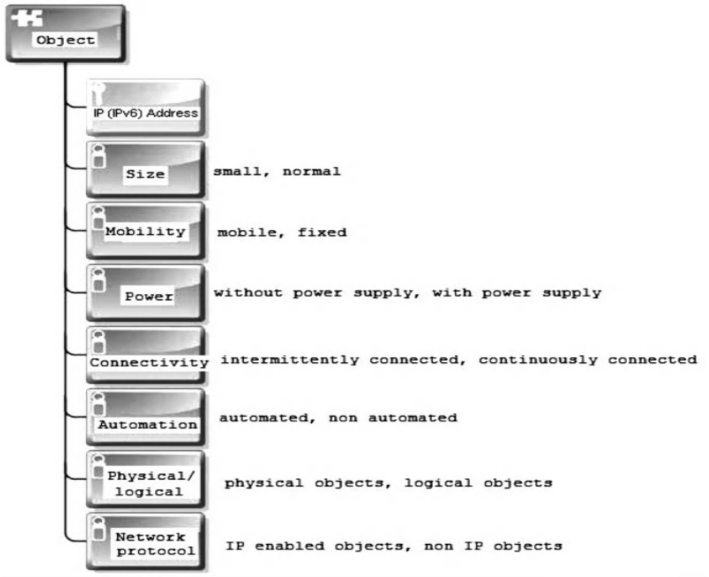
- Two other related “working definitions” are as follows:
- **Definition:** Sensors are active devices that measure some variable of the natural or man-made environment (e.g., a building, an assembly line, an industrial assemblage supporting a process).
- **Definition:** An actuator is a mechanized device of various sizes (from ultra-small to very large) that accomplishes a specified physical action, for example, controlling a mechanism or system, opening or closing a valve, starting some kind or rotary or linear motion, or initiating physical locomotion. An actuator is the mechanism by which an entity acts upon an environment.

IoT Definitions Working Definition

- An object is a model of an entity. An object is distinct from any other object and is characterized by its behavior.
- An object is informally said to perform functions and offer services (an object that performs a function available to other entities and/or objects is said to offer a service).

IoT Definitions Working Definition

- Object classification:



IoT Definitions Working Definition-Object characteristics

Objects have the following characteristics:

- have the ability to sense and/or actuate
- are generally small (but not always)
- have limited computing capabilities (but not always)
- are energy/power limited
- are connected to the physical world
- sometimes have intermittent connectivity
- are mobile (but not always)
- of interest to people
- managed by devices, not people (but not always)

IoT Definitions Working Definition

- M2M/H2M environment comprises three basic elements:
- (i) the data integration point (DIP)
- (ii) the communication network
- (iii) the data end point (DEP) (again, a machine M).

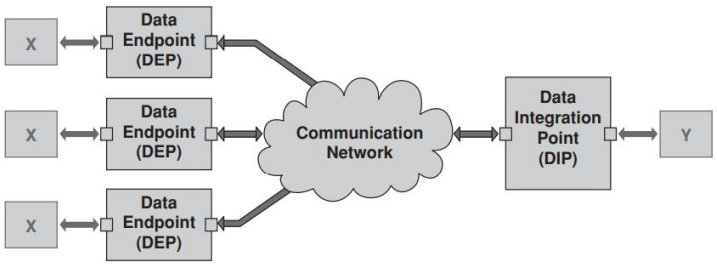


FIGURE Basic elements of an M2M application.

Conti...

- Typically, a DEP (a machine M in a human H, as is the case in the MiH environment) is a microcomputer system, one end of which is connected to a process or to a higher level subsystem via special interfaces; the other end is connected to a communication network.
- A DIP can be an Internet server, a software application running on a firm-resident host, or an application implemented as a cloud service.

IOT- Framework: IoT Frameworks With help of High Level M2M System Architecture (HLSA)

- The HLSA comprises
  - the device and gateway domain,
  - the network domain, and
  - the applications domain.

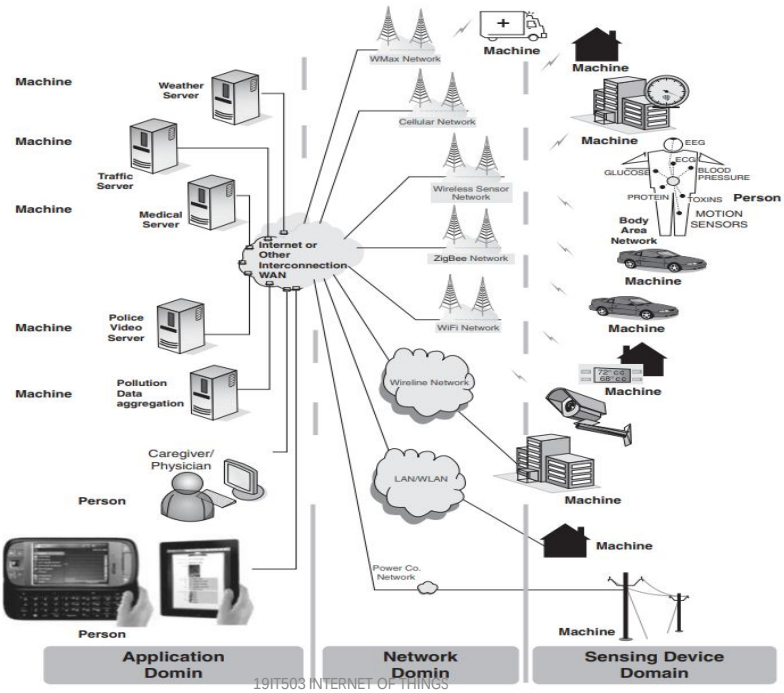


FIGURE . M2M domains.

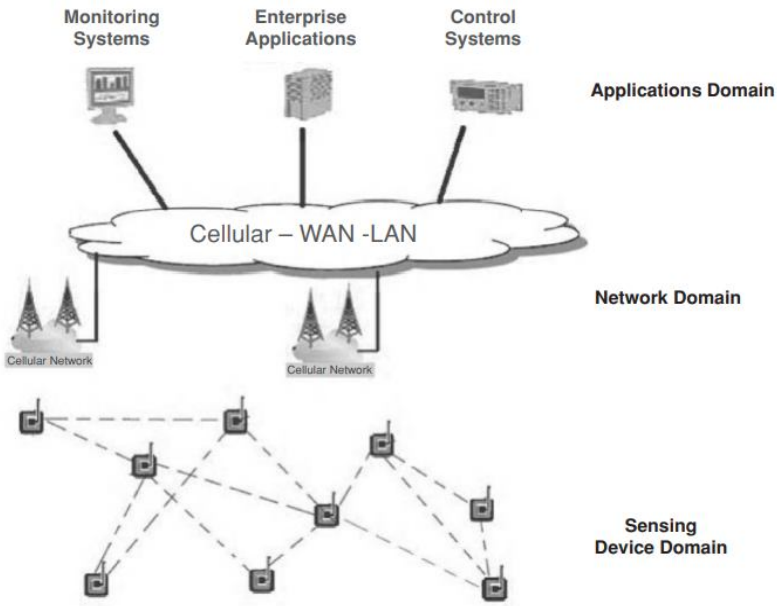


FIGURE Other example of M2M domains.

IOT- Framework: IoT Frameworks With help of High Level M2M System Architecture (HLSA)

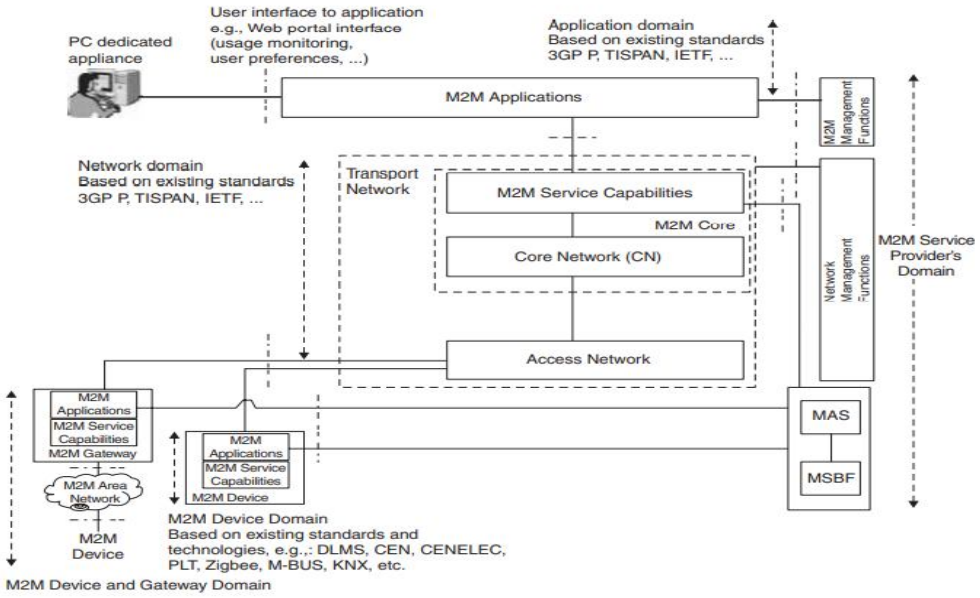


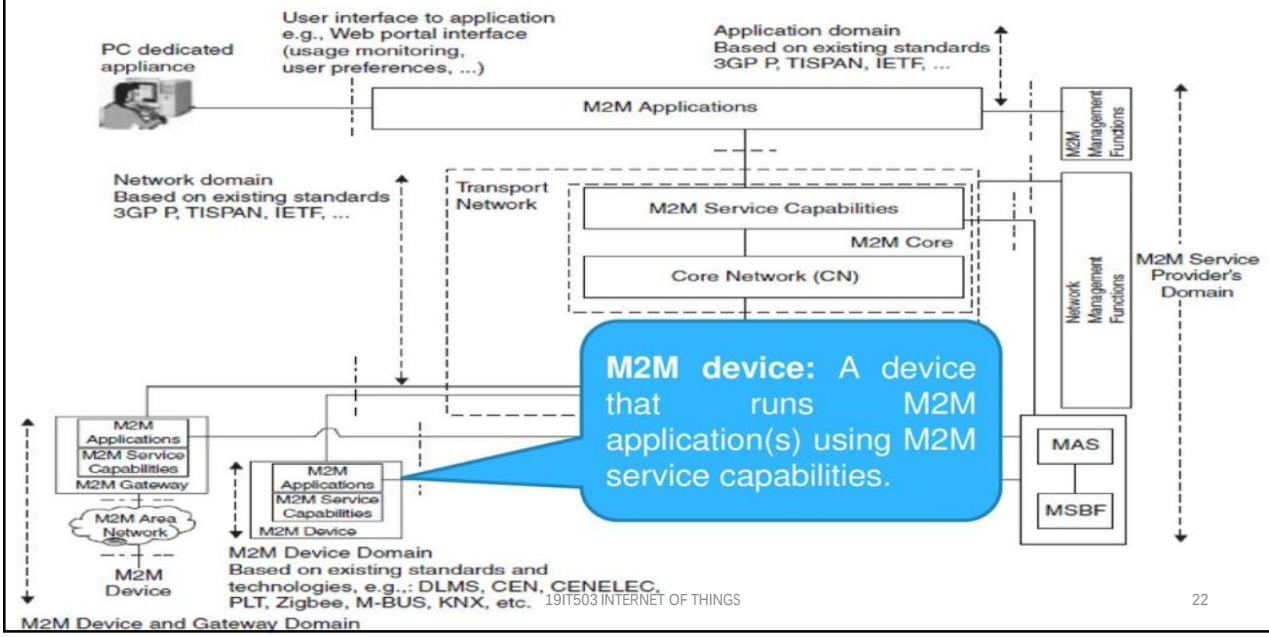
FIGURE M2M HLSA.

IOT- Framework

- The device and gateway domain is composed of the following elements:

1. M2M device
   a. Direct Connectivity
   b. Gateway as a Network Proxy
2. M2M area network
3. M2M gateway

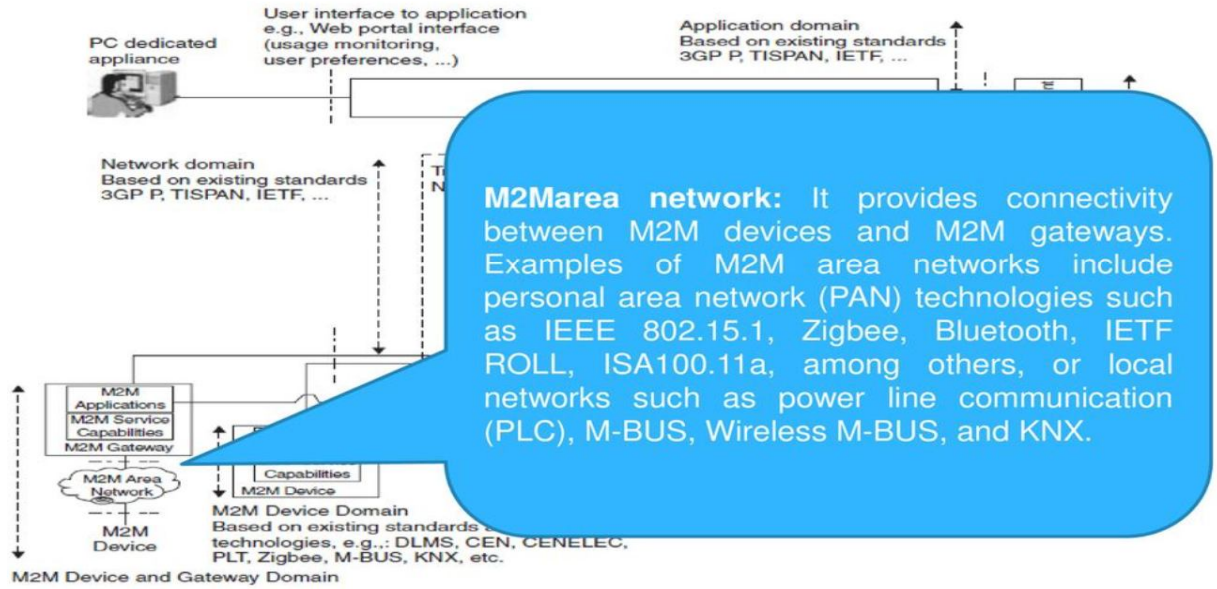
Device and Gateway Domain



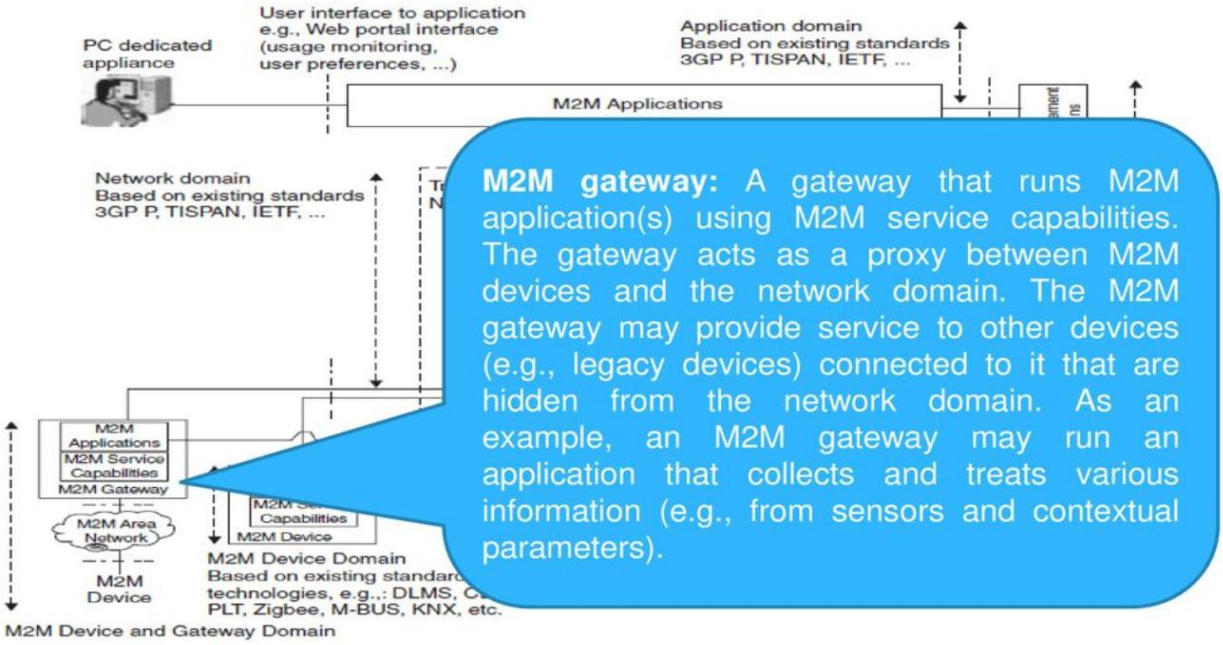
Device and Gateway Domain

- M2M devices connect to network domain in the following manners:
- **Case 1 "Direct Connectivity":**
- M2M devices connect to the network domain via the access network. The M2M device performs the procedures such as registration, authentication, authorization, management, and provisioning with the network domain. The M2M device may provide service to other devices (e.g., legacy devices) connected to it that are hidden from the network domain.
- **Case 2 "Gateway as a Network Proxy":**
- The M2M device connects to the network domain via an M2M gateway. M2M devices connect to the M2M gateway using the M2M area network. The M2M gateway acts as a proxy for the network domain toward the M2M devices that are connected to it.
  - Examples of procedures that are proxied include authentication, authorization, management, and provisioning. (M2M devices may be connected to the network domain via multiple M2M gateways.)

Device and Gateway Domain



M2Marea network: It provides connectivity between M2M devices and M2M gateways. Examples of M2M area networks include personal area network (PAN) technologies such as IEEE 802.15.1, Zigbee, Bluetooth, IETF ROLL, ISA100.11a, among others, or local networks such as power line communication (PLC), M-BUS, Wireless M-BUS, and KNX.


User interface to application
e.g., Web portal interface
(usage monitoring,
user preferences, ...)
PC dedicated
appliance
Application domain
Based on existing standards
3GP P, TISPAN, IETF, ...
M2M Applications
Network domain
Based on existing standards
3GP P, TISPAN, IETF, ...
M2M
Applications
M2M Service
Capabilities
M2M Gateway
M2M Area
Network
M2M
Device
Capabilities
M2M Device
M2M Device Domain
Based on existing standard
technologies, e.g.,: DLMS, C
PLT, Zigbee, M-BUS, KNX, etc.
M2M Device and Gateway Domain
M2M gateway: A gateway that runs M2M application(s) using M2M service capabilities. The gateway acts as a proxy between M2M devices and the network domain. The M2M gateway may provide service to other devices (e.g., legacy devices) connected to it that are hidden from the network domain. As an example, an M2M gateway may run an application that collects and treats various information (e.g., from sensors and contextual parameters).

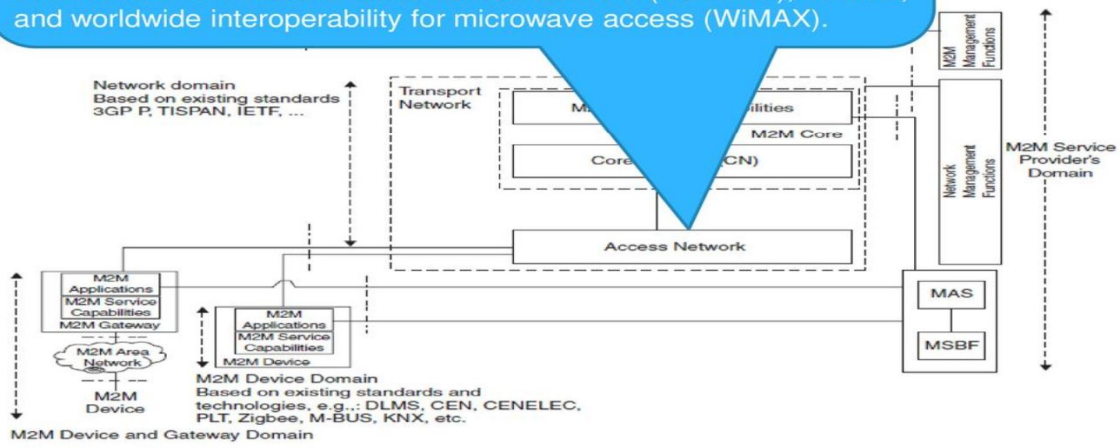
IOT Frameworks- Network Domain

Network domain

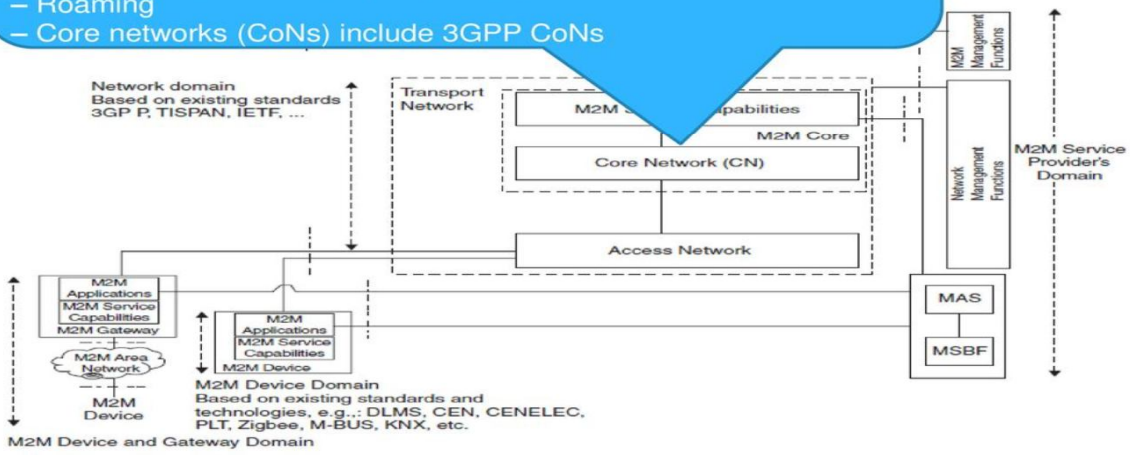
- Composed of the following elements:

1. **Access network**
2. **Core network**
3. **M2M service capabilities**

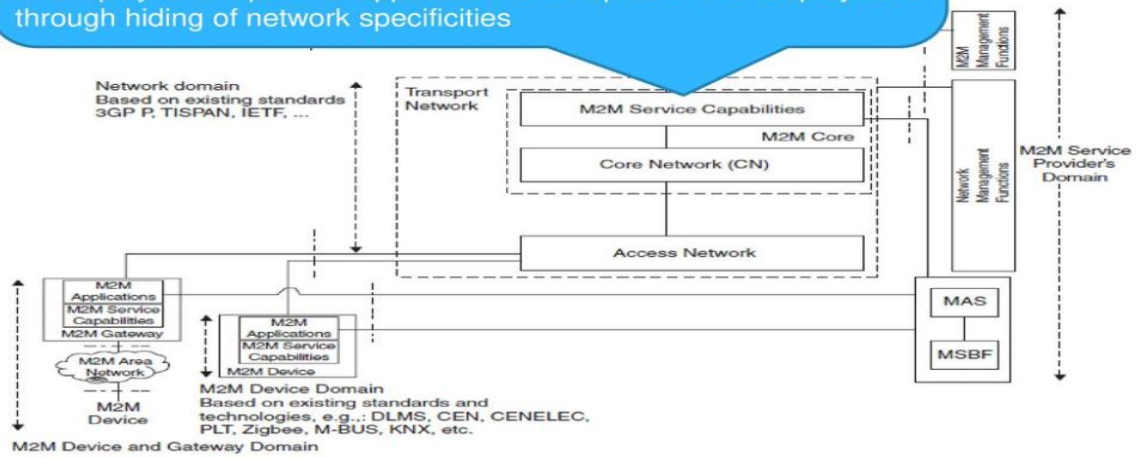
Access network: A network that allows the M2M device and gateway domain to communicate with the core network. Access networks include (but are not limited to) digital subscriber line (xDSL), hybrid fiber coax (HFC), satellite, GSM/EDGE radio access network (GERAN), UMTS terrestrial radio access network (UTRAN), evolved UMTS terrestrial radio access network (eUTRAN), W-LAN, and worldwide interoperability for microwave access (WiMAX).



Core network: A network that provides the following capabilities (different core networks offer different features sets):
– IP connectivity at a minimum, and possibly other connectivity means
– Service and network control functions
– Interconnection (with other networks)
– Roaming
– Core networks (CoNs) include 3GPP CoNs



M2M service capabilities:
– Provide M2M functions that are to be shared by different applications
– Expose functions through a set of open interfaces
– Use CoN functionalities
– Simplify and optimize application development and deployment through hiding of network specificities

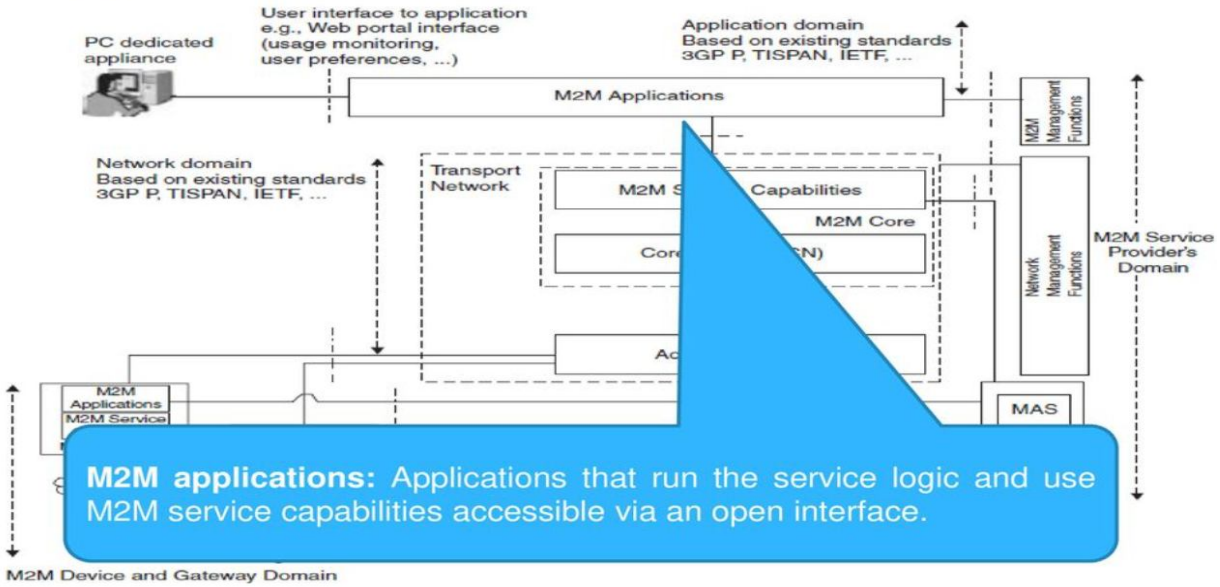


IOT Framework-Network domain

Network domain

- The "M2M service capabilities" along with the "core network" is known collectively as the "M2M core."

Applications domain



IoT Frameworks

- There are also management functions within an overall M2M service provider domain, as follows:
- 1. **Network management functions:** Consists of all the functions required to manage the access and core networks; these functions include provisioning, supervision, fault management.
- 2. **M2M management functions:** Consists of all the functions required to manage M2M service capabilities in the network domain. The management of the M2M devices and gateways uses a specific M2M service capability.
  - – The set of M2M management functions include a function for M2M service bootstrap. This function is called M2M service bootstrap function (MSBF) and is realized within an appropriate server. The role of MSBF is to facilitate the bootstrapping of permanent M2M service layer security credentials in the M2M device (or M2M gateway) and the M2M service capabilities in the network domain.
  - – Permanent security credentials that are bootstrapped using MSBF are stored in a safe location, which is called M2M authentication server (MAS). Such a server can be an AAA server. MSBF can be included within MAS, or may communicate the bootstrapped security credentials to MAS, through an appropriate interface (e.g., the DIAMETER protocol defined in IETF RFC 3588) for the case where MAS is an AAA server.

Basic Nodal Capabilities

- Remote device generally needs to have a basic protocol stack
- Basic protocol stack supports as minimum local connectivity and networking connectivity
- In addition, some higher layer application support protocols are generally needed, with varying degrees of computational/functional sophistication.

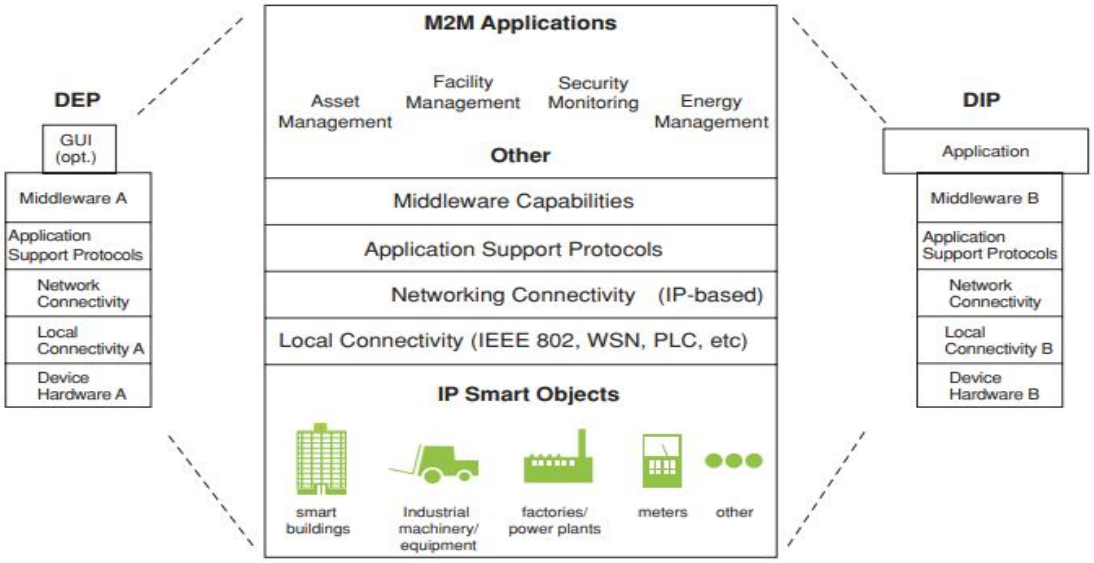


FIGURE Protocol stack, general view.

Conti…

- IoT devices may have capability differences, such as but not limited to the following: (Refer the above figure)
  - maximum transmission unit (MTU) differences,
  - simplified versus full-blown web protocol stack (COAP/UDP versus HTTP/TCP),
  - single stack versus dual stack,
  - sleep schedule,
  - security protocols,
  - processing and communication bandwidth.

Conti…

- Distributed control/M2M typically entails continuously changing variables to control the behavior of an application. Typical requirements include the following capabilities:
- Retransmission
  - Network recovers from packet loss or informs application
  - Recovery is immediate: on the order of RTTs, not seconds
- Network independent of MAC/PHY
- Scale
  - Thousands of nodes
  - Multiple link speed

Conti…

- Thousands of nodes
- Multiple link speeds
- Multicast
  - Throughout network
  - Reliable (positive Ack)
- Duplicate suppression
- Emergency messages
  - Routed and/or queued around other traffic
  - Other traffic slushed as delivered
- Routine traffic delivered in sequence
- Separate timers by peer/message

Conti…

- Polling of nodes
  - Sequential
  - Independent of responses
- Paradigm supports peer-to-peer
- Not everything is client/server
- Capabilities
- Discover nodes
- Discover node capabilities
- Deliver multisegment records (files)
- Exchange of multisegment records
- Network and application versioning
- Simple publish/subscribe parsers
- Security
  - Strong encryption
  - Mutual authentication
  - Protection against record/playback attacks
  - Suite B ciphers

Thank you