Intro to Internet of Things

ITU ASP COE TRAINING ON
“Developing the ICT ecosystem to harness IoTs”

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History of IoT

• The first **telemetry** system was rolled out in Chicago way back in 1912. It is said to have used telephone lines to monitor data from power plants.

• Telemetry expanded to weather monitoring in the 1930s, when a device known as a **radiosonde** became widely used to monitor weather conditions from balloons.

• In 1957 the Soviet Union launched Sputnik, and with it the Space Race. This has been the entry of **aerospace telemetry** that created the basis of our global satellite communications today.
History of IoT

- Broad adoption of M2M technology began in the 1980s with wired connections for SCADA (supervisory control and data acquisition) on the factory floor and in home and business security systems.
- In the 1990s, M2M began moving toward wireless technologies. ADEMCO built their own private radio network to address intrusion and smoke detection because budding cellular connectivity was too expensive.
- In 1995, Siemens introduced the first cellular module built for M2M.
History of IoT

• A second large wave of adoption and development of cellular M2M solutions became necessary when the Federal Communications Commission mandated a shutdown of analog networks in favor of the more spectrum-efficient digital network technology.

• 75% of M2M and industrial IoT applications use less than one megabyte per month of data.
History of IoT

“Machine to Machine” (M2M) (~1970s+)

Internet of Things Beginnings


Trojan Room Coffee Pot (first webcam) (1991)

Internet Toaster (1990)
Why IoT now?

- Ubiquitous Connectivity
- Widespread Adoption of IP
- Computing Economics
- Miniaturization
- Advances in Data Analytics
- Rise of Cloud Computing
Rpi zero: $5
IoT Definition

- **Wikipedia**: The Internet of Things (IoT) refers to uniquely identifiable objects and their virtual representations in an Internet-like structure.
  

- **Cisco**: The Internet of Things (IoT) is the network of physical objects accessed through the Internet, as defined by technology analysts and visionaries. These objects contain embedded technology to interact with internal states or the external environment. In other words, when objects can sense and communicate, it changes how and where decisions are made, and who makes them.

ITU Definition

• Recommendation ITU-T Y.2060 provides an overview of the Internet of Things (IoT). It clarifies the concept and scope of the IoT, identifies the fundamental characteristics and high-level requirements of the IoT and describes the IoT reference model.
• Date: 2012-06-15
The IoT can be viewed as a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies (ICT).

Source: Recommendation ITU-T Y.2060
Things

Things are objects of the physical world (physical things) or of the information world (virtual world) which are capable of being identified and integrated into communication networks. Things have associated information, which can be static and dynamic.

Source: Recommendation ITU-T Y.2060
Things

• **Physical things** exist in the physical world and are capable of being sensed, actuated and connected. Examples of physical things include the surrounding environment, industrial robots, goods and electrical equipment.

• **Virtual things** exist in the information world and are capable of being stored, processed and accessed. Examples of virtual things include multimedia content and application software.

Source: Recommendation ITU-T Y.2060
ITU Definition

Source: Recommendation ITU-T Y.2060
Any-Time/Place/Thing

Source: Recommendation ITU-T Y.2060
ITU Definition

A device is a piece of equipment with the mandatory capabilities of communication and optional capabilities of sensing, actuation, data capture, data storage and data processing. The devices collect various kinds of information and provide it to the information and communication networks for further processing. Some devices also execute operations based on information received from the information and communication networks.

Source: Recommendation ITU-T Y.2060
Fundamental characteristics

- **Interconnectivity**: With regard to the IoT, anything can be interconnected with the global information and communication infrastructure.

- **Heterogeneity**: The devices in the IoT are heterogeneous as based on different hardware platforms and networks. They can interact with other devices or service platforms through different networks.

- **Dynamic changes**: The state of devices change dynamically, e.g., sleeping and waking up, connected and/or disconnected as well as the context of devices including location and speed. Moreover, the number of devices can change dynamically.

Source: Recommendation **ITU-T Y.2060**
Fundamental characteristics

• **Enormous scale**: The number of devices that need to be managed and that communicate with each other will be at least an order of magnitude larger than the devices connected to the current Internet. The ratio of communication triggered by devices as compared to communication triggered by humans will noticeably shift towards device-triggered communication.

Source: Recommendation ITU-T Y.2060
Predictions

IoT is being enabled by advances in miniaturization, wireless connectivity, and increased data storage capacity.

Today
- 300,000 developers devoted to IoT
- 4.5 million developers will be devoted to IoT

2013
- $1.3 trillion IoT Market
- 13% compound annual growth rate (CAGR)

2020
- $3.04 trillion

According to International Data Corporation (IDC)

PwC’s 6th Annual Digital IQ survey
Predictions

Connected Devices

In 2014 nearly 2 billion connected devices will be shipped

This number will grow to nearly 8 billion devices for the year 2020

*Not including mobile phones

- Home (Consumer) 3,745.71 (device millions)
- Transport (Mobility) 392.72 (device millions)
- Body (Health) 360.03 (device millions)
- Buildings (Infrastructure) 1,726.59 (device millions)
- Cities (Industry) 1,524.70 (device millions)

Internet of Fewer Things

History of the future

One to many to any: ICTs from happy few to the masses

- Mainframe (1 computer, many people)
- PC (1 person, 1 computer)
- Digital native computing (1 person, many screens)
- Internet of everything

Volumes, B


Internet born

Mobile broadband, smartphones, tablets

Social Media

Connected car

Internet of things

Mass wearables

Cognitive computing

Artificial intelligence
Gartner Hype Cycle

- Peak of Inflated Expectations
- Plateau of Productivity
- Slope of Enlightenment
- Trough of Disillusionment
- Technology Trigger
Interest: Google Trends

Interest over time

11 Dec 2012
18 Aug 2013
26 Apr 2015
Interest: #iot on Twitter

Estimated Tweets per Hour (based on 1% Sample)

Timezone: America/Chicago
Sensor Nodes

- Main components of a WSN node
  - Controller
  - Communication device(s)
  - Sensors/actuators
  - Memory
  - Power supply
Sensor Nodes

- Memory
- Controller
- Sensor(s)/actuator(s)
- Power supply
- Communication device
Network Connectivity

Key aspects when considering network connectivity:

• **Range** - are you deploying to a single office floor or an entire city?

• **Data Rate** - how much bandwidth do you require? How often does your data change?

• **Power** - is your sensor running on mains or battery?

• **Frequency** - have you considered channel blocking and signal interference?

• **Security** - will your sensors be supporting mission critical applications?
# Connectivity Landscape

<table>
<thead>
<tr>
<th>Wireless-</th>
<th>Personal Area Networks (WPAN)</th>
<th>Local Area Networks (WLAN)</th>
<th>Wide Area Networks (WWAN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANT+, Bluetooth, 4.0 LE RFID, NFC 802.11.4, ZigBee</td>
<td>Wi-Fi</td>
<td>LoRa, Weightless, Dash 7 WiMax, 2G, 3G 4G/LTE, Satellite</td>
<td></td>
</tr>
</tbody>
</table>

- **Range**
  - short to long
  - long

- **Bandwidth**
  - narrow to broad
  - broad

- **Battery Life**
  - short to long
Sensors

## Functionality vs. Sensor Type

### Highest Cost
- Long-term install/deployment
- Industrial scale deployment
- Extreme accuracy/precision
- Typically large enterprises
- Ease of solution interoperability

### $150-$1000+
- Chemical/Gas
- Electrical/Capacitive
- Pressure/Load/Weight
- Proximity/Position

### $50-$150
- Residential/commercial
- Advanced development kits
- Consumer-based support
- Cloud partnership capability
- Fast deployment
- Medium infrastructure required
- Low-Medium accuracy/Precision

### $0-$50
- Single function
- DIY/Prototyping often needed
- Limited without other hardware
- Requires basic equipment
- Geared towards amateurs
- Singular functionality
- No infrastructure required

### Lowest Cost
- Water Treatment/Flow
- Weather/Temperature
- Motion/Velocity
- Acoustic/Sound/Vibration
- Light/Imaging
- Proximity/Position
- Flex/Force/Strain
Applications

Ambient Umbrella

Glowing intelligence lets you know that there’s rain in today’s forecast.
MyVessyl Cup

It can hold 13 ounces of liquid. The battery takes 60 minutes to fully charge and will last for 5-7 days. Also has wire-free charging.

https://www.myvessyl.com/

Egg Minder
THE SMART EGG TRAY
Applications
Today: Intranets of Things

Tomorrow: Internet of Things

Connected devices

Interconnected devices

New user experiences
These things are starting to talk to each other and develop their own intelligence. Imagine a scenario where your meeting was pushed back 45 minutes.

This is communicated to your alarm clock, which allows you 5 extra minutes of sleep.

...your car knows it will need gas to make it to the train station. Fill-ups usually take 5 minutes.

...there was an accident on your driving route causing a 15 minute detour.

...your train is running 20 minutes behind schedule.

And signals your car to start in 5 minutes to melt the ice accumulated in overnight snow storms.

And signals your coffee maker to turn on 5 minutes late as well.
# IoT Landscape

## Internet of Things Landscape 2016

### Applications (Verticals)

- **Personal**
  - Wearables
    - Apple Watch
    - Samsung Gear
  - Fitness
    - Fitbit
  - Health
    - LIFESCAN
- **Home**
  - Automation
    - Nest
  - Security
    - Canary
  - Kitchen
    - Dropcam
  - Sensing
    - Lutron
- **Consumer Robotics**
  - Jibo
- **Bicycles / Motorbikes**
  - SmartRider

### Platforms & Enablement (Horizontals)

- **Software**
  - Axeda
  - Predix
- **Full Stack**
  - Telic
- **Developer**
  - rensy.io
- **Security**
  - Bastille
- **Analytics**
  - Splunk
- **Sensor Networks**
  - Lascar Electronics
  - SST MoteSoft

### Interfaces

- **Virtual Reality**
  - oculus
  - Vive
  - PlayStation VR
- **Augmented Reality**
  - Microsoft Hololens
  - Sony
- **Other**
  - Amazon Alexa
  - NVIDIA THALMIC

### Building Blocks

- **Hardware**
  - Processors / Chips
  - ARM
  - Samsung
- **Software**
  - Mobile OS
  - Android
  - BlackBerry
- **Connectivity**
  - Bluetooth
  - Wi-Fi
  - LwIP

### Partners

- **Manufacturing**
  - Foxconn
  - Flex
- **Retail**
  - Walmart
  - Nike
- **Incubators**
  - 500 Startups
  - TechStars
- **Consultants / Services**
  - Dell
  - Accenture

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