Introduction to IoTs

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Today Lecture

- What is IoTs?
- IoT Elements
  - Sensing
  - Connectivity
  - Analytics

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A Connected World

Million of devices will be connected.
How will they share the channel resources?

A Paradigm Shift

- Throughout the 20th century, Computers received **inputs** from humans (keyboard, mouse) and delivered **information** to humans who then took the necessary **action**.
- We are moving into an era where **computers** will collect their own information from the environment, make **their own decisions** and take **their own actions**.

Is There a Definition?

- **CISCO:** “The Internet of Things is the networked connection of physical objects. The Internet of Everything is the networked connection of those physical objects along with people, data, and process”.

- **HUAWEI:** “The Internet of Things intelligently connects humans, devices, and systems”

- **ERICSSON:** “Enabling anything to be connected and providing ’smartness’ to these connected things will bring value across a number of sectors in the Networked Society”.

- **TELEFONICA:** “The Internet gave us the opportunity to connect in way we could never have dreamed possible. The Internet of Things will take us beyond connection to become part of a living, moving, global nervous system.”

- And so on.....

What IoT Is.. And it is not?

- It is **not** a new technology.
- Nor is it a mashup of technologies.
- It **is** a shift in thinking, a new **paradigm**.
- A way of applying a rich set of (current and new) technological solutions.
- In a carefully planned way, according to architectural design patterns.
- **DATA IS KING**: Collect and analyse to refine and optimise.

Why Now?

THINGS

Source: Cisco IBSG projections, UN Economic & Social Affairs http://www.un.org/esa/population/publications/longrange2/WorldPop2300final.pdf

Why Now?

CONNECTIVITY

Why Now?

DATA

Search engine trend for “Big Data” term
(Source: Google Trends)

THINGS

We have the networking technology!

(a) DC2274: Low-power wireless manager *(1 deployed)*

(b) Long-range prototype board *(3 deployed)*

(c) DC9018: External antenna mote *(2 deployed)*

(d) DC9003: chip antenna mote *(16 deployed)*

dust networks™

METRONOME SYSTEMS

- >50,000 SmartMesh networks deployed
- >99.999% end-to-end reliability
- >10 years of battery lifetime
- Developed as part of the REALMS associate team

Courtesy of Thomas Watteyne

Smart Building - VersaSense

www.versasense.com

MicroPnP

https://www.youtube.com/watch?v=R0fLOblcwDM

CONNECTIVITY

Playing with Meshes

https://makeamesh.eu-gb.mybluemix.net

The Actual Deployment

"Dust Networks SmartMesh Power and Performance Estimator"

http://www.linear.com/docs/42452

The Big Picture

Mesh Networks

IoT devices are usually part of a **mesh network** that provides them connectivity

How is a **mesh network** constructed?

What is the structure of a MESH?

Each node in the network communicates to either neighboring nodes or to the sink (or gateway)

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The node 3-hops away will require more time to send the information to the gateway than the node that is 1-hop away from the gateway

What is the structure of a MESH?

What is the best routing? A long research behind (read the survey paper)

From MANET To IETF ROLL Standardization: A Paradigm Shift in WSN Routing Protocols

Thomas Watteyne, *Member, IEEE,* Antonella Molinaro, *Member, IEEE,* Maria Grazia Richichi, *Member, IEEE,* Mischa Dohler, *Senior Member, IEEE*

Routing is not MAC…

Playing with Meshes

https://makeamesh.eu-gb.mybluemix.net

DATA

IoTs Applications

Connected Car

Today's network connection enables enhanced infotainment, telematics and various in-car connected systems. Vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) wireless technology, collectively known as V2X, will improve road safety, reduce traffic congestion and enhance the overall passenger experience.

Health Care

IoT greatly improves the quality and effectiveness of services by allowing healthcare system professionals the ability to monitor a patient's condition remotely: gives better information for diagnosis and doesn't require in-hospital stays.

Industry Automation

Along with increased automation, it provides smart, connected and robot-based industrial production capable of learning and exchanging information resulting in highly efficient manufacturing systems and products that require far fewer resources.

Smart Energy

IoT brings tools to monitor and measure energy usage, to reduce energy consumption and waste, and to maximize the benefits of alternative generation technologies: solar, wind, wave, geothermal and others.

Keysight technologies:
https://www.keysight.com/main/editorial.jspx?cc=DJ&lc=eng&ckey=2670326&nid=-11143&id=2670326

IoTs Applications

Smart Wearables

From personal health- and fitness-oriented devices (that offer biometric measurements) to smart collars that can make life easier for everyone from livestock farmers to home pet owners.

Smart Home

In the connected home – along with our computers, entertainment systems and smart TVs – numerous short-range connections that include temperature control, lighting, locks and alarms will be used.

Smart City

Efficiencies with IoT will flow from commercial building heating and security, waste collection, street lighting, power savings and enhanced traffic flow through adaptive speed limits and stop lights.

Smart Agriculture

IoT provides real cost and efficiency benefits to the agriculture industry. Potential applications include water saving through smart irrigation linked to soil analysis, monitoring crop conditions to maximize yield, tracking the health and location of livestock and providing real-time local weather information.

Keysight technologies:
https://www.keysight.com/main/editorial.jspx?cc=DJ&lc=eng&ckey=2670326&nid=-11143&id=2670326

Environmental - SnowHow

www.snowhow.io

Name	Operational Since	Elevation (m)	# Devices (Managers/NeoMotes/Repeaters)	# Sensors
Alpha	2013	2269	37 (1/ 10/ 27)	70
Bear Trap	2013	1518	38 (1/ 10/ 27)	70
Caples Lake	2013	2437	37 (1/ 11/ 25)	79
Dolly Rice	2014	1980	11 (1/ 10/ 0)	70
Duncan Peak	2013	2907	42 (1/ 11/ 30)	78
Echo Peak	2013	2478	54 (1/ 10/ 43)	71
Mount Lincoln	2013	2477	36 (1/ 11/ 24)	78
Onion Creek	2013	1891	11 (1/ 10/ 0)	72
Owens Camp	2014	1586	24 (1/ 11/ 12)	77
Robbs Saddle	2013	1812	33 (1/ 10/ 22)	70
Schneiders	2013	2673	38 (1/ 10/ 27)	70
Talbot Camp	2014	1738	11 (1/ 10/ 0)	70
Van Vleck	2013	2069	38 (1/ 10/ 27)	70
Total			414 (11/134/264)	945

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IoTs Applications - Save the Peaches

PEACH

predicting frost events in peach orchards

Metronome Systems NeoMote

The Metronome Systems Network Manager

http://www.savethepeaches.com

IoTs Economy

Ala Al-Fuqaha , et al. “Internet of Things: A Survey on Enabling Technologies, Protocols, and Applications”’, IEEE COMMUNICATION SURVEYS & TUTORIALS, VOL. 17, NO. 4, FOURTH QUARTER 2015.

Today Lecture

not new technology
just a way to think

- What is IoTs?
- IoT Elements
  - Sensing
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  - Analytics

The Objects and the Cloud

The IoT Elements

- Sensing
- Communication
- Computation/Data Analytics

The IoT Elements

A Classical OSI Model

Conceptual IoT Models

The IoT Stack - Framework

The IoT Stack - With Examples

SENSING

Characteristics

- **Range** –maximum and minimum value range over which a sensor works well. Sensors may work well outside this range, but require additional calibration. e.g. the output may no longer be linear.

- **Accuracy** – how well the sensor measures the environment in an absolute sense, i.e. how good the data is when compared with a recognized standard. e.g. a temperature sensor accurate to 0.001^{o} C is expected to agree within 0.001^{o} C with a known temperature standard. This is what you want to compare results with other observations.

- **Resolution** – the ability of a sensor to see small differences in readings. e.g. a temperature sensor may have a resolution of 0.000,01^{o}C, but only be accurate to 0.001^{o} C. Can detect relatively small changes in temperature, smaller than the accuracy of the sensor. Resolution in often controlled by the quantisation in digitising the signal so is not a function of the sensor itself, but of the sampling process.

Characteristics (2)

- **Repeatability** – This is the ability of a sensor to repeat a measurement when put back in the same environment. It is often directly related to accuracy, but a sensor can be inaccurate, yet be repeatable in making observations.

- **Drift/Stability** – This is the low frequency change in a sensor with time, i.e., with a given input you always get the same output. It is often associated with electronic aging of components or reference standards in the sensor.

- **Response time** – a simple estimate of the frequency response of a sensor assuming a change in the measurement

Characteristics (3)

- **Output** – What output is given for a change in the parameter being measured. For example, a voltage range e.g. 0 to 5 volts for an input range of 0 to 30°C.

- **Power Consumption** – What is needed to power the sensor, quite often specified as the current draw.

- **Setting Time** – After being switched on, how long before a valid measurement is ready.

- **Sampling time required** – How often do we need to repeat measurements to get an accurate picture of the phenomenon being measured.

What Can We Sense?

Biosensing

Fluid and gas

Light

Proximity

Current / power

Humidity

Position / motion

Temperature

Flow

Level

Pressure

Power Management

- Power draw increases with...
  - Vcc
  - Clock speed
  - Temperature
- However, it is predominantly affected by what elements of the microcontroller are switched on.
- Most have a number of low power modes.

Power Consumption – Clock Speed

CONNECTIVITY

IoT Standards Environment

Trade-offs in Wireless

Operating Range - Simplified

ZigBee vs WiFi vs Bluetooth

LoRaWAN Market positioning

Connectivity Overview

■ : > Billion units/year now
■ : Emerging

WPAN: Wireless Personal Area Network
WHAN: Wireless Home Area Network
WFAN: Wireless Field (or Factory) Area Network
WLAN: Wireless Local Area Network

WNAN: Wireless Neighborhood Area Network
WWAN: Wireless Wide Area Network
LPWAN: Low Power Wide Area Network

How do you Select Connectivity?

- Which coverage do I need?
- Which consumption can I afford?
- Which data-rate do I need?

Data Analytics

very quick overview

Type of Learning

- Machine learning algorithms:
  - Supervised learning: answer provided by an expert
  - Unsupervised learning: no answer provided by an expert
- Others: Reinforcement learning, recommender systems.

Type of Learning

Supervised Learning

Machine learning task of inferring a function describing the relationship between independent and dependent variables in a dataset. It relies on labelled examples

Unsupervised Learning

Machine learning task of inferring a function describing the structure of a dataset. It relies on unlabelled data.

Reinforcement Learning

It is concerned with how software agents ought to take actions in an environment so as to maximize some cumulative reward.

Linear and Logistic Regression

Multi-Class Classification

Binary classification:

Multi-class classification:

IoT Impact

"**Sensors** and ubiquitous **connectivity**, combined with **data and analytics**, open up new opportunities to innovate products and services and to increase the efficiency of operations. This digitization of the physical world—or Internet of Things (IoT)—creates new value for our clients and for their customers."

Check it out in the "Further readings" session on Moodle

What’s Next

- Review content material
- Look at the reading materials
- Dig deeper by looking at the “further resources” section

Resources

- Ashton “**That 'Internet of Things' Thing**”, RFID Journal, June 22nd, 2009.
- ITU and Cisco, "**Harnessing the Internet of Things for Global Development**", A contribution to the UN broadband commission for sustainable development
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- McKinsey&Company, "**The Internet of Things: Mapping the value beyond the hype**", McKinsey Global Institute, 2015
- European Alliance for Innovation (EAI), "**Internet of Things: Exploring the potential**", Innovation Academy Magazine, Issue n. 03, 2015
- J. Biron and J. Follett, "**Foundational Elements of an IoT Solution**", O'Reilly Media, 2016
- Digital Greenwich, "**Greenwich Smart City Strategy**", 2015