Internet of Things

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Outline

• Internet of Things (IoT) basics
• IoT applications
• IoT platforms
• ThingSpeak IoT platform
Internet of Things prerequisites

• What you have already learnt?
  • Working with mobile in-built sensors
    – Lect 9
  • Working with external sensors and embedded systems
    – Lect 10
  • Working with communication protocols
    – Lect 11
• Working with Cloud services and respective API
  – Lect 8
Internet of Things (IoT)

• IoT allows people and things to be connected
  – Anytime, Anyplace, with Anything and Anyone, ideally using Any path/network and Any service

[European Research Cluster on IoT]

Image source: https://dyn.com/blog/what-needs-to-happen-before-iot-can-change-the-world/
History of IoT

- History: Internet-connected appliance - “The Only Coke Machine on the Internet” (Carnegie Mellon University, 1982)
- History: **Internet for Things** (Kevin Ashton, MIT Auto-ID Center, 1999)
  - RFID (Radio-frequency identification)
    - EPC (Electronic Product Code) Global Network
EPC Global Network

• Electronic Product Code (EPC)
Related Terms

• Cyber-Physical Systems (2006-)
  – Coined by National Science Foundation (U.S.)
  – Integrated embedded systems
  – Every physical thing embeds a networked ‘computer’

• Machine-to-Machine (M2M)
  – The root is much older than IoT (1970s)
  – Technologies to accelerate IoT
What is a *thing*?

- Can be a person with a heart monitor implant
- A farm animal with a biochip transponder
- An automobile that has built-in sensors
- Other natural or man-made objects
- With a **unique identifier** and the ability to communicate over the internet, without requiring human interaction.
Why it is so important?

- More connected devices than people
- Recent predictions go up to 500 billion devices by 2030
- Cisco believes the market size will be $19 trillion by 2025

Use Cases
Use Case: Smart Home

- Connected radiator/heater
- Connected air conditioner
- Connected camera
- Connected door
- Connected window
- Connected microwave
- Connected refrigerator
- Connected water boiler
Use Case: Smart Factory

- Connected production line
- Connected warehouse
- Connected shipment and logistics
- Federated resource database
  - Knowing which manufacturer has parts in stock
  - Knowing how long it takes to import the parts
  - Knowing shipping time
- Predictive production
  - Digital Twin
Use Case: Smart City

- **Connected government**
- **Connected utility**
  - e.g. water, electricity, petrol, natural gas etc.
  - Auto-billing
  - Dynamic control for saving
- **Connected traffic control system**
  - Smart traffic signal (auto-change based on traffic situation)
  - Communicable with smart vehicles
- **Connected facility**
  - E.g. telephone booth/box, information/map kiosk, public drinking fountain/bubbler etc.
  - Source and quality tracing
  - Auto-maintain, self-protective
- **Connected public transportation and stations**
  - Time control
  - Notification
  - Public security and safety control
  - Self- / Assisted driving
  - Assisted travelling (personalised notification)
Use Case: Smart Vehicles

- Connecting to manufacturer
  - Tracing conditions
  - Predicting states
  - Maintenance notification
- Connecting to Road-Side Units (RSUs)
  - Petrol/electricity stations
  - General services
  - Traffic system
- Connecting to proximal vehicles
  - Vehicle-to-Vehicle (V2V) network
- Self- / assisted driving
Use Case: Smart Healthcare

- Connected medicine
- Body sensor network
- Healthcare robot
- Healthcare-specific smart home
- Home-Hospital system
Use Case:
Smart Agriculture / Farming

- Connected Plants
- Connected Animals
- Connected Barn
- Connected Agricultural equipment
- Connected Packing and shipping
Environment Protection

• Great Barrier Reef in Australia
• Buoys equipped with sensors
  – collect biological, physical, and chemical data
  – to minimize and prevent reef damage

Source: Kip Compton, VP Internet of Things (IoT) Systems and Software Group The Internet of Things: What Does it Take to Make the Internet of Everything Real?
Where Mobiles can Fit?

• Mobiles themselves have lot of inbuilt sensors
• IoT sensors/things do not have sufficient amount of energy and processing power
  – To connect directly to the internet through Wi-Fi or mobile networks
• Mobile device can work as a sink/relay
  – To collect the sensor data and upload them to the backend servers
  – Especially, when the sensors are deployed sparsely
  – Provide data directly to the end users (Mobile Host - Lecture 8)
Layers of Cloud-centric IoT

- Remote Cloud-based processing
- Connectivity nodes & Embedded processing
- Sensing and smart devices
Sensing and Smart Devices

- **IoT Devices**
  - Sensors and actuators
  - Motion, Temp, Light, Open/Close, Video, Reading, Power on/off/dimm etc.

- **Communication protocols**
  - Wireless and wired
  - Protocols such as ZigBee, Z-Wave, Wi-Fi/Wi-Fi Direct, Bluetooth etc.
  - Network congestion is a challenge

- **Arduino & Raspberry Pi**
  - For rapid prototyping

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Gateway/Connectivity Nodes

• Primarily deals with the sensor data acquisition and provisioning
• Embedded processing saves the communication latencies
• Predictive analytics
  – Collect data only occasionally
• Mobiles can also participate as Gateways
  – This brings in the scope of mobile web services and mobile cloud services for IoT
Mobile Cloud (Lecture 8)

- Harness cloud computing resources from mobile devices

- Binding models
  - Task delegation
    - Follows traditional SOA (Service Oriented Architecture) model to invoke cloud services
  - Mobile code offloading
    - Offload to a cloud based surrogate based on system and code profilers input

- Ideal Mobile Cloud based system should take advantage of some of the key intrinsic characteristics of cloud efficiently
  - Elasticity & AutoScaling
  - Utility computing models
  - Parallelization (e.g., using MapReduce)
Enormous amounts of unstructured data
- In Zetabytes ($10^{21}$ bytes) by 2020 [TelecomEngine]
- Has to be properly stored, analysed and interpreted and presented

Big data acquisition and analytics e.g. with MapReduce and Spark

In addition to big data, IoT mostly deals with big streaming data
- Message queues such as Apache Kafka to buffer and feed the data into stream processing systems such as Apache Storm
- Apache Spark streaming
IoT platform

• Middleware and the infrastructure that enables end-users to interact with smart objects
• Huge number of platforms are already available
• Based on different architectures [Mineraud et al, CC 2016]
  – Mostly cloud-based
  – Centralized
  – Decentralized etc.
IoT platform - features

- Data storage
- Data processing/Analytics
- Visualization of data
- Device management and Discovery
- Support different communication protocols
- Support heterogeneity
IoT platforms - examples

• Open Source Platforms
  – Node-RED https://nodered.org/
  – FP7 OpenIoT http://www.openiot.eu/
  – IoT-framework
  – ThingSpeak https://thingspeak.com/
  – etc.

• Commercial Platforms
  – Google Cloud IoT https://cloud.google.com/solutions/iot/
  – AWS IoT https://aws.amazon.com/iot/
  – Cumulocity https://www.softwareag.cloud/site/product/cumulocity-iot.html
    • Platform used in our IoTSS laboratory
  – etc.
ThingSpeak

- IoT analytics platform service that allows you to aggregate, visualize and analyze live data streams in the cloud

https://thingspeak.com/pages/learn_more?Education
ThingSpeak - Features

- Prototyping and building IoT systems without setting up servers or developing web software
- Can easily configure devices to send data to ThingSpeak using popular IoT protocols
  - Updates of channel feed via the REST and MQTT APIs
- Visualization of sensor data in real-time
- Live data stream aggregation and analytics
- Aggregate data on-demand from third-party sources
- Use the power of MATLAB to make sense of the IoT data
- IoT analytics automatically based on schedules or events
  - TimeControl function that enables event-triggered alerts
IoT and Smart Solutions Laboratory
Course Projects - Team projects

• Open ended projects
• With features learnt in the course
  – Each project should have at least 3 features
  – Databases, maps, background services etc.
  – Full list available on course page
• 3 person projects
  – <3 should have strong reason
    • You will already loose some points at teamwork
• Need to submit working prototype, source code and a project report
• Further details on course page
Next lecture

• Students present their project ideas
  – Full team should be present
  – Define roles of individuals in the project
• 5 min for each team
• Backed by slides
• Write an abstract
References

