Internet of Things as an Enabler for Effective Healthcare
What is the “Internet of Things (IoT)?”

- The vision

  - Specialized elements of hardware and software, connected by wires, radio waves, and infrared, will be so ubiquitous that no one will notice their presence.

- A definition

  - 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.

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The IoT Connected World

Image source: https://hutgrip.com/2013/06/24/market-opportunity-for-the-next-big-thing/
IoT – An Added Dimension for ICT

Any TIME communication

- On the go
- Night / daytime

Any PLACE communication

- Outdoor
- Indoor (away from a computer)
- At the computer

Any THING communication

- Between computers
- Human to human, not using a computer
- Human to thing, using generic equipment
- Thing to thing

*International Telecommunication Union, Overview of the Internet of Things, June 2012.*
Physical vs Virtual THINGS

- **Physical** things exist in the **physical** world and are identified, connected, sense, and/or actuate
- **Virtual** things exist in the **information** world and can, but not necessarily, be associated with physical things

### Physical world

- Building 1 Room 221
- Building 2 Room 132

### Information world

- Give me the temp. of Room 221
- Obtain temp from sensor 356
- Set the temp. of Room 221 to 21 °C
- Turn on actuator 487
- Obtain user preferences for Room 221
- Give me the light level of Room 132
- Read light level from sensor 12
- Set the temp. of Room 221 to 21 °C
IoT System Basic Organization

IoT - Edge
Comprises a disparity of things that perform sensing, actuating, monitoring

IoT - Network
Internet
Gateway

IoT – Back end
Cloud platform – APIs – Cloud Applications
IoT Devices

- A device is composed of one or more THINGS
- The minimum requirement of a device is the capability to communicate
  - It can also be augmented with sensing, data capturing, actuation and other capabilities
- Communication between devices
  - Directly, i.e. device-to-device
  - Through the communication network via a gateway
  - Through the communication network without a gateway
  - Combinations of the above methods
IoT Services

- Another noteworthy feature of IoT systems is services related to things
- IoT services can be categorized under four classes
  - Identity-related Services
  - Information Aggregation Services
  - Collaborative-Aware Services
  - Ubiquitous Services
Primary Characteristics of IoT Systems

- **Interconnectivity**
  - Anything is connected virtually to “any THING”

- **Heterogeneity**
  - Different hardware platforms and networks

- **Dynamic changes**
  - Devices have many more power states compared to state-of-art-devices (sleep, wake-up, connected, disconnected)
  - Location and speed of the device

- **Scale and complexity**
  - Several billions(!) of devices connected. These devices should be managed and communicate with each other
Basic Requirements of IoT Systems

- **Identification-based connectivity**
  - A thing is connected to the IoT through a unique identifier of that thing (e.g., think of your ID getting access to a service/space)
  - But different type of ID’s may exist

- **Interoperability**
  - Needs to be ensured among heterogeneous and distributed systems for provision and consumption of diverse information and services

- **Security**
  - Typical threats towards confidentiality, authenticity, and integrity of both data and services

- **Privacy**
  - THINGs have owners and users. Privacy should be protected during data transmission, aggregation, storage, mining, and processing
From Data to Information and Knowledge

Data
• Raw and (un)processed data from IoT devices

Information
• Data is processed, classified, condensed, and put in context

Knowledge
• Inferred from organizing and structuring information and is applied to achieve specific objectives

Application Domains driven by IoT

- Route generation and scheduling
- Fleet tracking
- Shipment monitoring

- Smart irrigation
- Green house control

- Inventory management
- Smart payments
- Smart vending machines

- Smart lighting
- Smart appliances
- Intrusion detection
- Smoke/gas detectors

- Smart parking
- Smart roads
- Emergency response

Some Facts and Predictions

- Traffic monitoring of a cellular network in the U.S. also showed an increase of 250% for M2M traffic volume in 2011 [1]
- By 2022, M2M traffic flows are expected to constitute up to 45% of the whole Internet traffic [2]
- McKinsey Global Institute reported that the number of connected machines (units) has grown 300% over the last 5 years [3]
The IoT smart objects are expected to reach 212 billion entities deployed globally by the end of 2020.

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IoT for eHealth

- IoT enabled Healthcare can
  - Provide more accurate diagnosis at point of care (POC)
  - Promote research on disease treatments
  - Speed up development of new medicines

- These goals require
  - Data from multiple tests
  - Data are time-stamped and location-tagged
  - Information (meta-data) of testing environment
  - Patient information, age, height, weight...
IoT-Driven eHealth Vision

The IoT eHealth

- Cost Reduction
- All-Encompassing
- Resiliency
- Seamless fusion with other technology
- Big Data Analytics
- Personalized Forecasting
- Ease of Use
- Lifetime Monitoring
- Physician Oversight
- Availability and Accessibility
- Efficient Healthcare Management
- International Impact
IoT – eHealth Challenges
Security and Privacy Challenge in eHealth

- Privacy relates mainly to data from sensors
- Security relates mainly to data for actuators
- A Multi-layer strategy is required with security built in all layers
  - Device layer (“Things”)
  - Network layer
    - AES, DES, Blowfish, Skipjack, Rabins Scheme, NtruEncrypt, and Elliptic Curve Cryptography
  - Cloud layer
    - Typical vulnerabilities include Denial-of-service (DoS) attacks, SQL injections, malicious code injection
  - Human layer
IoT eHealth Ecosystem
IoT eHealth Devices

- A long list of eHealth devices exists, including
  - ECG/EKG monitors
  - Heart rate, glucose, blood pressure monitors
  - Body temperature, activity monitors
  - Pulse oximeter
  - Hemoglobin monitor
  - Smart shoes, garments or e-textiles
  - Knee sensor, skin conductance sensor
  - Medication management
  - Food contamination detection device
  - .......
IoT Edge Nodes

- An Edge node (sometimes nicknamed Fog node) is defined as a device with integrated computing, storage, and networking.
- The edge node is inserted between the cloud and all IoT eHealth devices adds two important features to the system:
  - Real-time analytics and decision making
  - Traffic reduction on overburdened networks
Communication a Key IoT Aspect

- There is a vast variety of Personal Area Networks (PAN) and WSN protocols.
Maximum Throughput, Range, and Power source
Multi-Layer Architecture of eHealth Cloud


Thank you and see you next year!