

# CSC 498R: Internet of Things

Lecture 01: Introduction, Challenges and Opportunities

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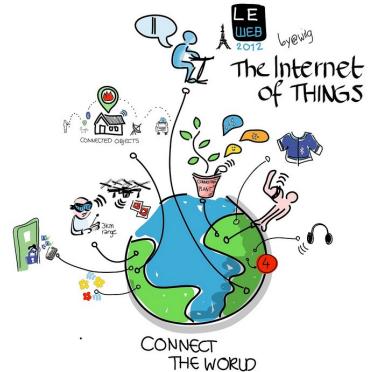
Fall 2017





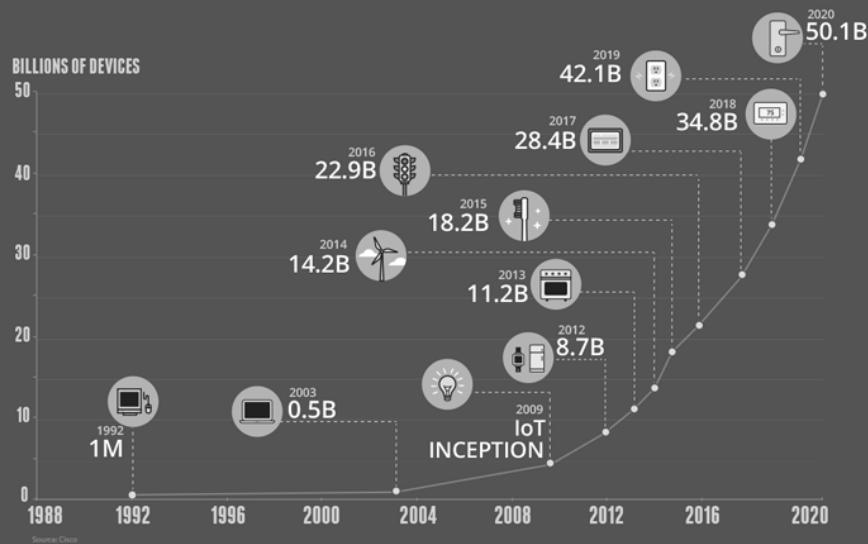
# Internet of Things

- Population of the world: 7 billion
- Population of Internet users: 3 billion
- Expected population of connected devices will be around 30 billion in 2020
  - 26 billion predicted by Gartner
  - 30 billion by ABI Research



## GROWTH IN THE INTERNET OF THINGS

THE NUMBER OF CONNECTED DEVICES WILL EXCEED 50 BILLION BY 2020



During 2008, the number of **things** connected to the Internet exceeded the number of **people** on earth.



2015

By **2020** there will be **50 billion**.

## Sensor Devices are Widely Available





# Internet of Things (IoT)

- Extending the current Internet and providing connection, communication, and inter-networking between devices and physical objects, or "Things," is a growing trend that is often referred to as the *Internet of Things*.
- "The technologies and solutions that enable integration of real world data and services into the current information networking technologies are often described under the umbrella term of the Internet of Things (IoT)"



# Internet of Things

- It connects things beyond people
  - Can track and control many devices
- It is physical beyond information
  - Can directly impact physical aspects of our life (comfort, health, safety, green, ... )
- It empowers devices to sense and reason about the environment
  - Can be an assistant or agent for human beings, or an autonomous decision maker
- All these mean new opportunities and challenges, in areas such as devices, networking, systems, machine learning, security and privacy



# Internet of Things

- IoT for enterprises
  - Smart meters (utility companies), smart vehicles (car companies), intelligent healthcare (insurance companies), ...
- IoT for consumers
  - Wearables such as smart watches, smart bands, and intelligent headsets
  - Smart homes which are open to various consumer IoT appliances
  - Tons of new devices every year!
- IoT for consumers is where market explosion could happen in the next 10 or 20 years



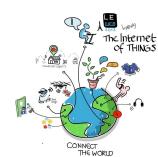
## The goals of this course are ...

- Understand key IoT concepts;
- Explore IoT technologies, architectures, standards, and regulation;
- Understand how to develop and implement own IoT technologies, solutions, and applications;
- Analyze data collected from IoT sensors and devices using modern analytics approaches;
- Demonstrate understanding of security and ethical issues inherent in IoT.



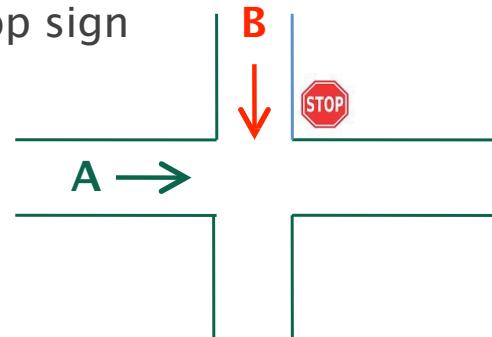
# Internet of Things Challenges

- Challenge in big and small data for prediction (real-time learning for intelligent devices)
- Challenge in security and privacy (intrusion, data theft, ...)
- Challenge in networking (addressing, low latency, low-cost, fine-grain virtualization)



# Internet of Things Challenges

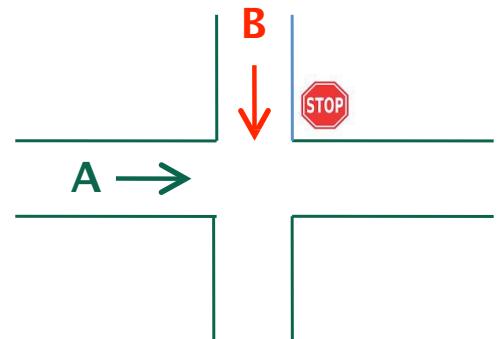
- Challenge in big and small data for prediction (real-time learning for intelligent devices)
  - A wants to predict if B will run stop sign





# Internet of Things Challenges

- A wants to predict if B will run stop sign
- Method 1
  - Watch out for juvenile drivers
  - Insurance companies usually charge a higher premium on these drivers
- Method 2
  - Watch out those drivers who have run stop signs or red lights in the past thirty minutes
- Which method do you think will work better? (think about rushing to wedding and hospitals)

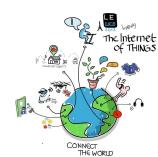
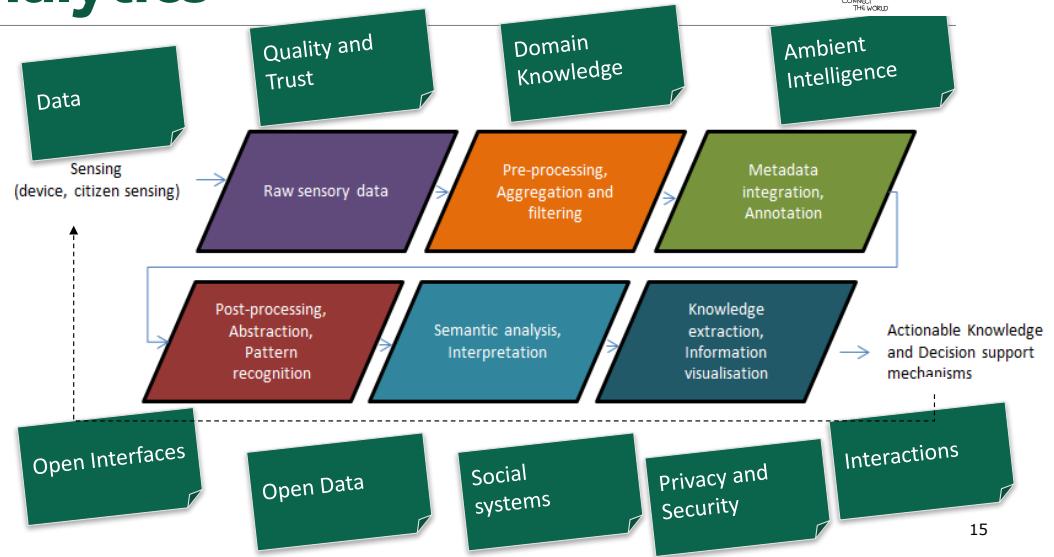


# Internet of Things Challenges

- Not Only Big Data *but also* Small Data
- For personalized, context-adaptive, real-time prediction, we mainly work with relatively small data which was only available in the very recent past
- “Small data,” which covers only a small window of time, is a new area on which intelligent IoT technologies will need to focus
- Small data problems can still be tractable, by
  - Leveraging more constrained context (IoT devices are more special-purpose after all) and
  - Using many complementary IoT sensors. (This is an opportunity)

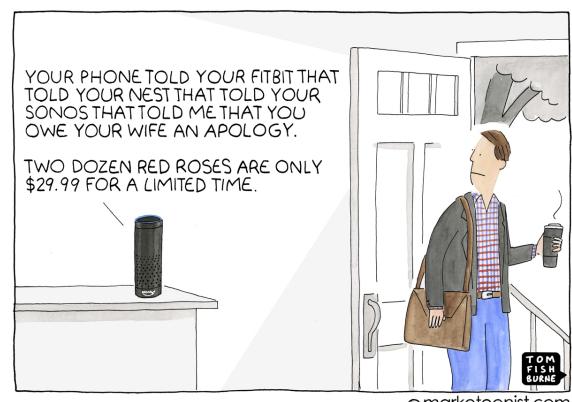


# Data analytics



## Internet of Things Challenges

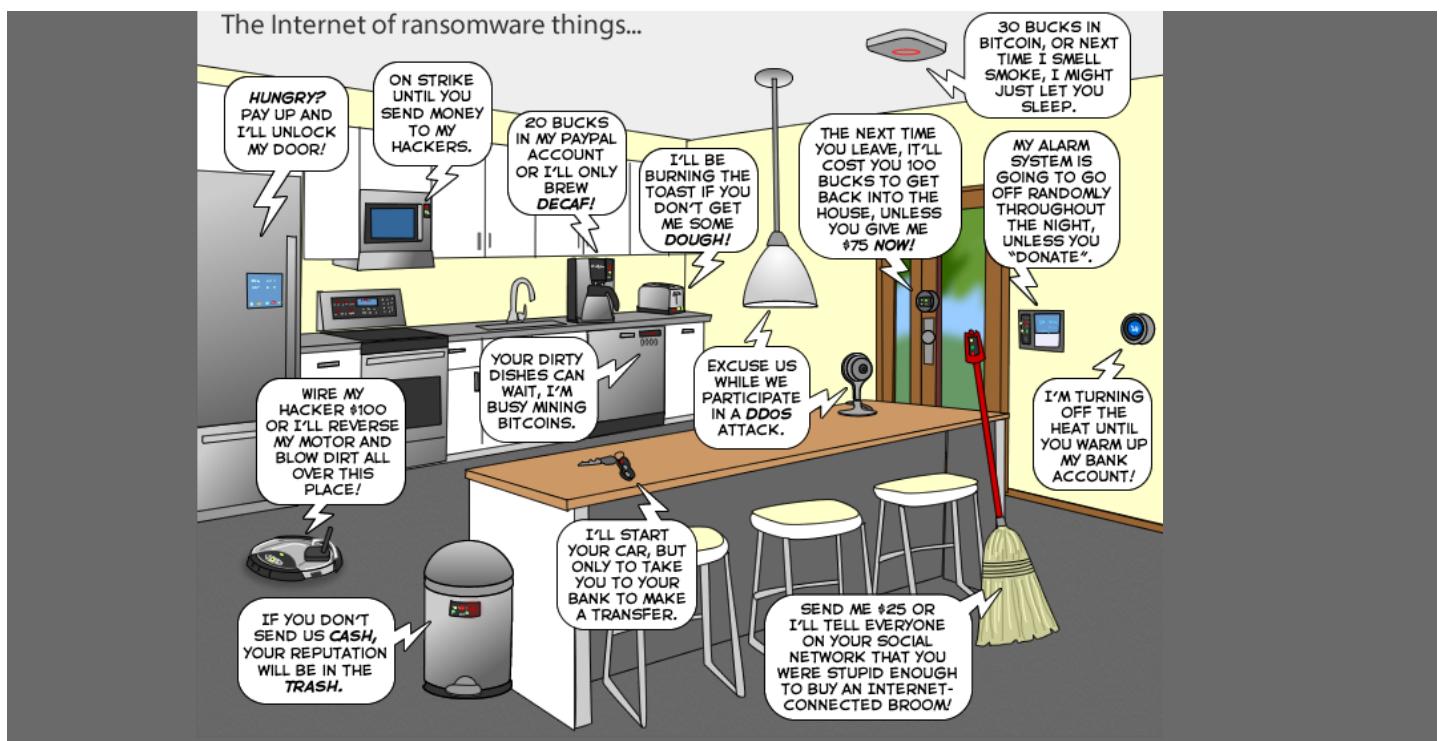
- Challenge in security and privacy





# Internet of Things Challenges

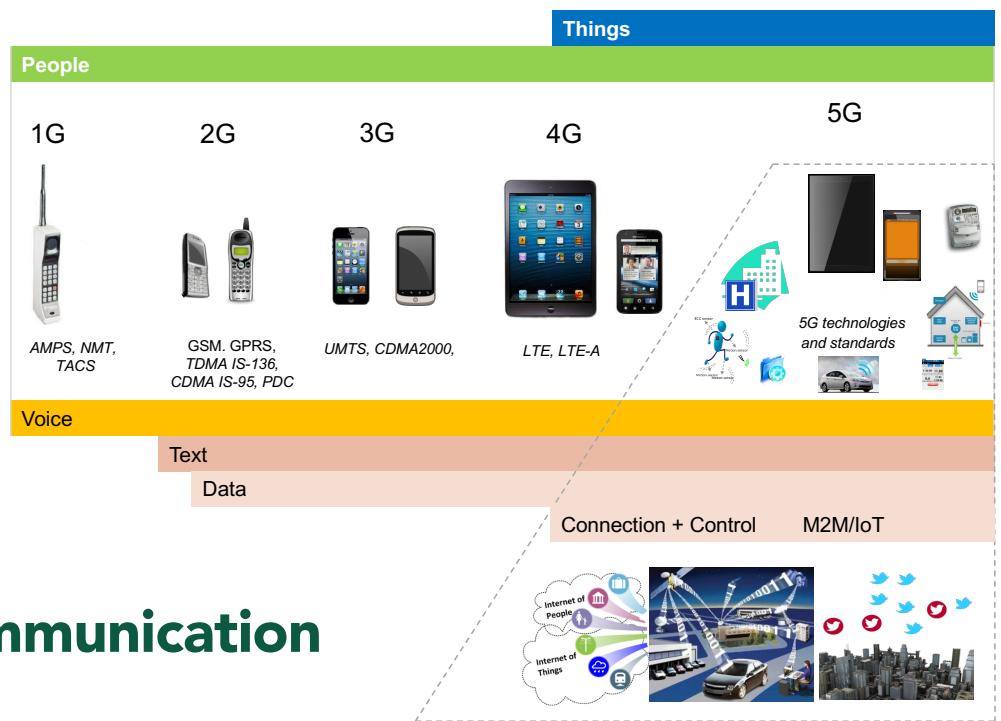
- Authentication is a major problem as current authentication procedures are not feasible in the IoT
- There are no current solutions in the IoT space for proxy attacks and man-in-the-middle attacks.
- Data integrity gets more complicated when you have unattended nodes like RFID tags



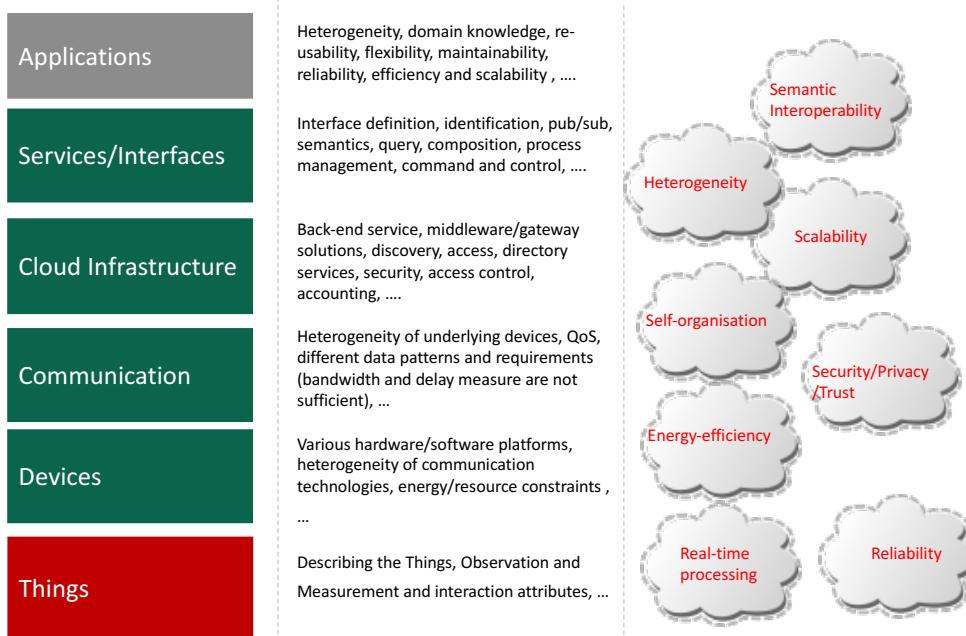
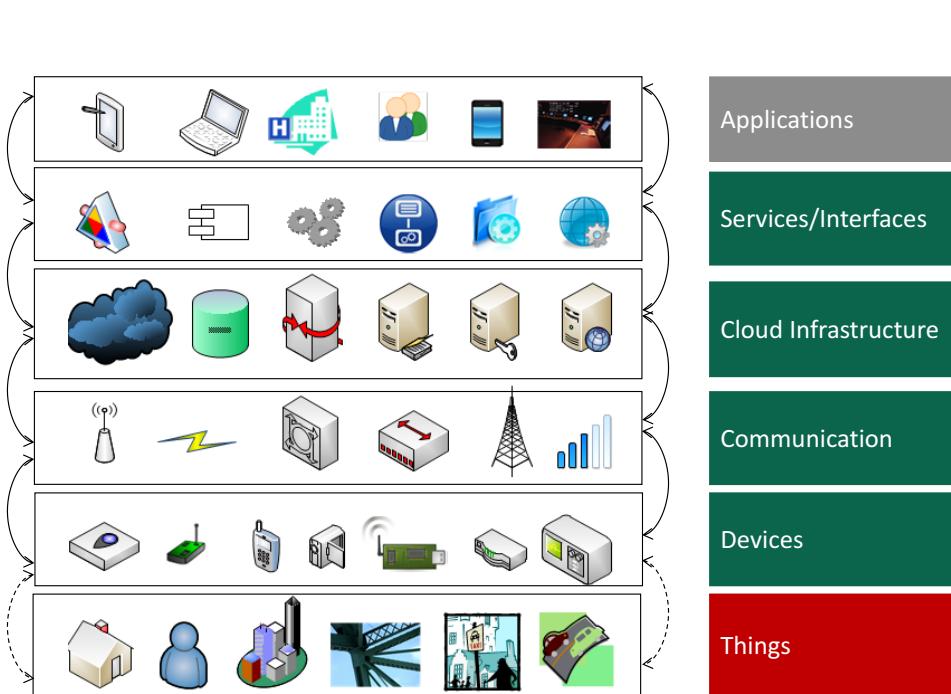


# Internet of Things Challenges

- Challenge in networking
- Object unique addressing and the representation and storing of exchanged information
  - Wireless: RFID, WSN, RFID Sensing Networks,
- TCP not very effective for IoT
  - CoAP with REST is an alternative



## Change in Communication Technologies



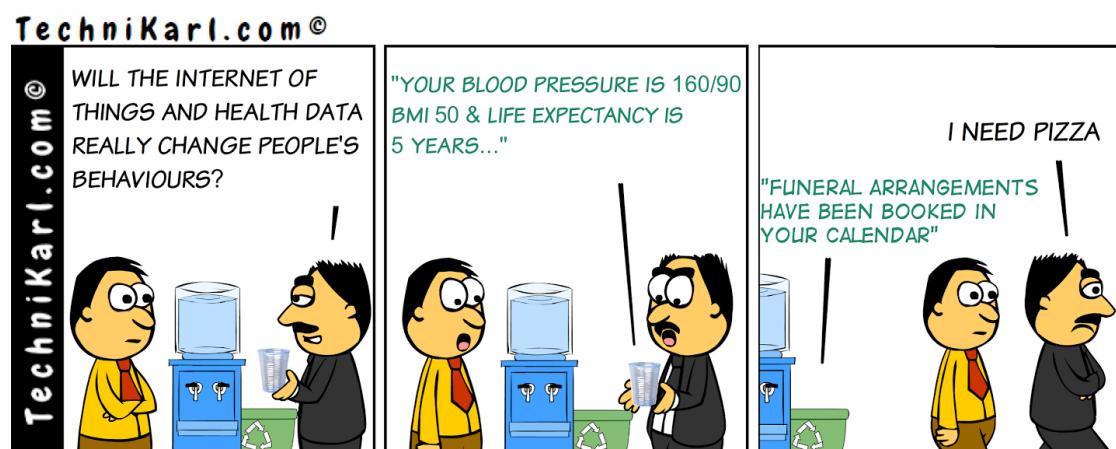


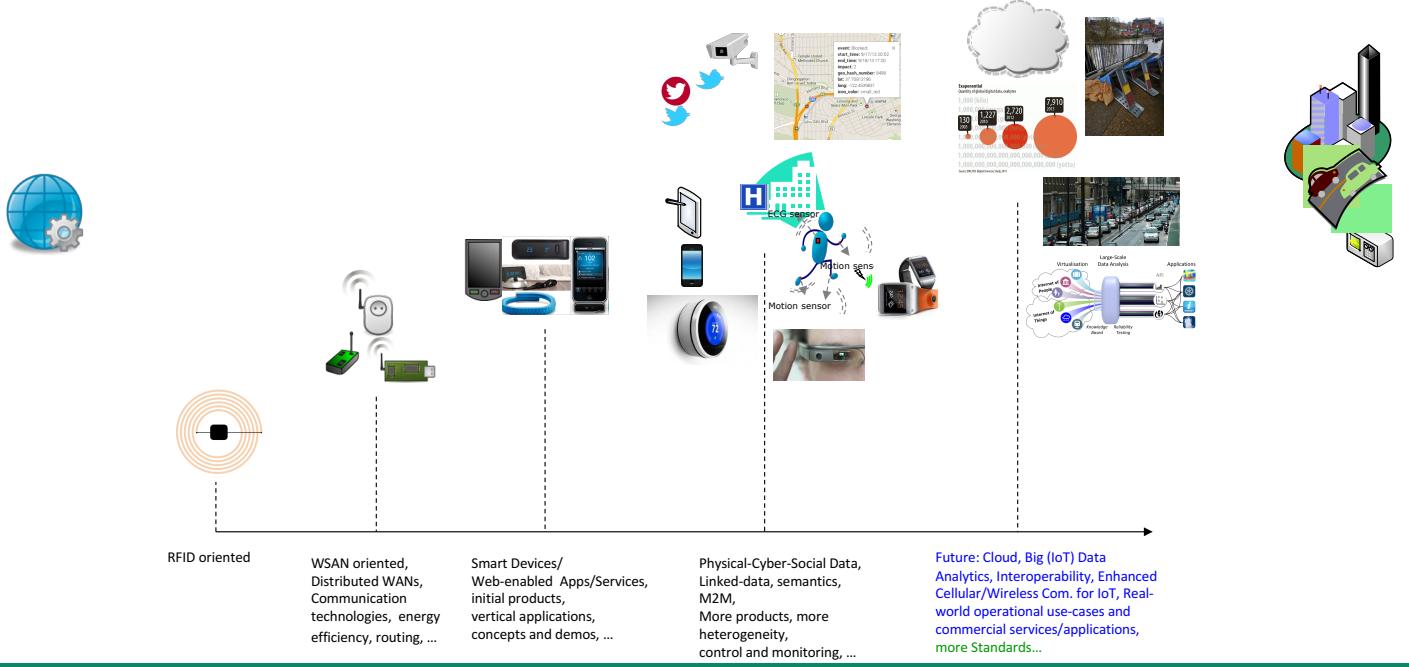
## Emerging/existing standards

- ETSI M2M, OneM2M (architecture, gateway, ...  
– <http://www.etsi.org/technologies-clusters/technologies/m2m>
- IETF CoAp, 6LowPAN,...  
– <http://tools.ietf.org/wg/core/>
- IEEE 802.15.x, IEEE P802.x, ...  
<http://standards.ieee.org/innovate/iot/projects.html>
- OMA/NGSI (interfaces, context description,...)  
– [http://forge.fiware.org/plugins/mediawiki/wiki/fiware/index.php/OMA\\_NGSI\\_10](http://forge.fiware.org/plugins/mediawiki/wiki/fiware/index.php/OMA_NGSI_10)
- W3C (semantic sensor networks, SSN Ontology  
– <http://www.w3.org/2005/Incubator/ssn/>



## Internet of Things Implications





## Conclusion: Challenges/Opportunities

- Providing infrastructure
  - Publishing, sharing, and access solutions on a global scale
  - Heterogeneity and interoperability at different layers
  - Indexing, query and discovery (data and resources)
  - Aggregation, integration and fusion
  - Trust, privacy and security
  - Data analytics and creating actionable knowledge
- Integration into services and applications in e-health, the public sector, retail, manufacturing and personalised apps.
  - Mobile apps, location-based services, monitoring control etc.
- New business models



# Course Logistics

- Give a research presentation on papers or textbook chapters to prepare your course projects
- Attend classes, labs, and participate in discussion
- Do a course project in a two-person team:
  - Formulate a project proposal
  - Design, implement and evaluate the resulting system or application
  - Do a presentation on project results
  - Write a final project report

# Course Logistics

- Sensors or actuators
  - Things we connect
- Connectivity
  - Medium we use to connect things
- Platform
  - Processing and storing collected data
    - o Receive and send data via standardized interfaces or API
    - o Store the data
    - o Process the data.
- Analytics
  - Get insights from gathered data
- User Interface





## Prerequisites

- Programming experience (CSC 245 should be fine)
  - With the will to learn new technologies and languages
- A lot of reading
- Being innovative
- Thinking deeply about issues
- Interest in *making* things



## Labs

- The course will have tutorial sessions as well as lab sessions
  - Tutorials will be provided to give extra support
  - Labs will be provided to give extra instruction on topics covered in the course
    - Sensors
    - Machine Learning using TensorFlow
    - Networking
    - Programming tools
    - Web Programming

# Project Devices

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- Raspberry Pi III, Model B
- Raspberry Pi Sensors
- Altera FPGAs (for the hardware die-hards)

# Grading

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- Small programming Labs [4-6]: 20%
- Classroom discussions: 10%
- Research presentation [One each]: 15%
- One written exam [15%]
- Project [40%]
  - Formulation and idea: 10%
  - Presentation: 5%
  - Report: 5%
  - Final Implementation: 20%

# Project Milestones

- Formulation and idea
  - September 19
- Monthly updates
  - Presented orally in the class on the first Tuesday of every month
- Final implementation including presentation, report, and demo
  - November 27
  - December 5

# Final Remarks

- Start sketching out your own IoT product or service idea
- Having reflected on the amazing opportunities offered by the Internet of Things, are you inspired to think of a new and innovative IoT product or service?
- Be creative and think about a new or enhanced IoT product or service.
- Think about your idea throughout the course, and in the final week of the course you will learn how to base your product and business activities on the well-proven method of the “Lean Business Model Canvas”