LAU
الجامعة اللبنانية الأميركية
Lebanese American University

CSC 498R: Internet of Things

Lecture 01: Introduction, Challenges and Opportunities

Instructor: Haidar M. Harmanani

Fall 2017

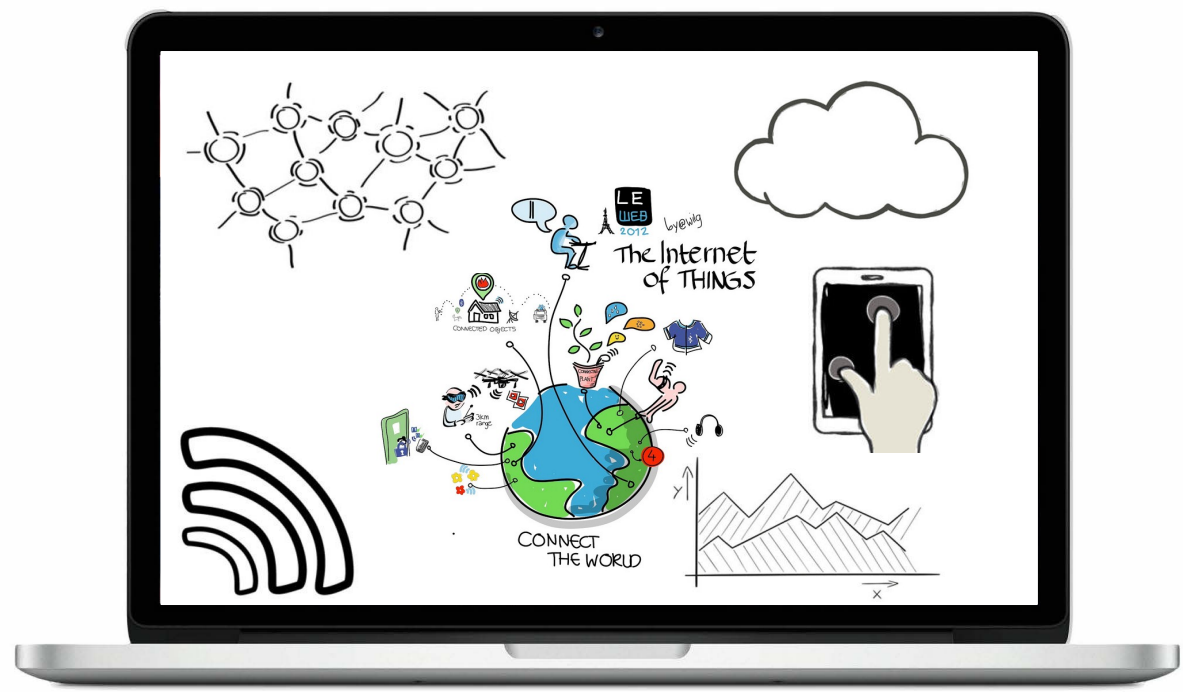
A multidisciplinary domain that covers a large number of topics from purely technical issues such as routing protocols and semantic queries to a mix of technical and societal issues such as security, privacy, and usability, as well as social and business themes

Internet of Things

A network of physical objects or 'things' that can interact with each other to share information and take action

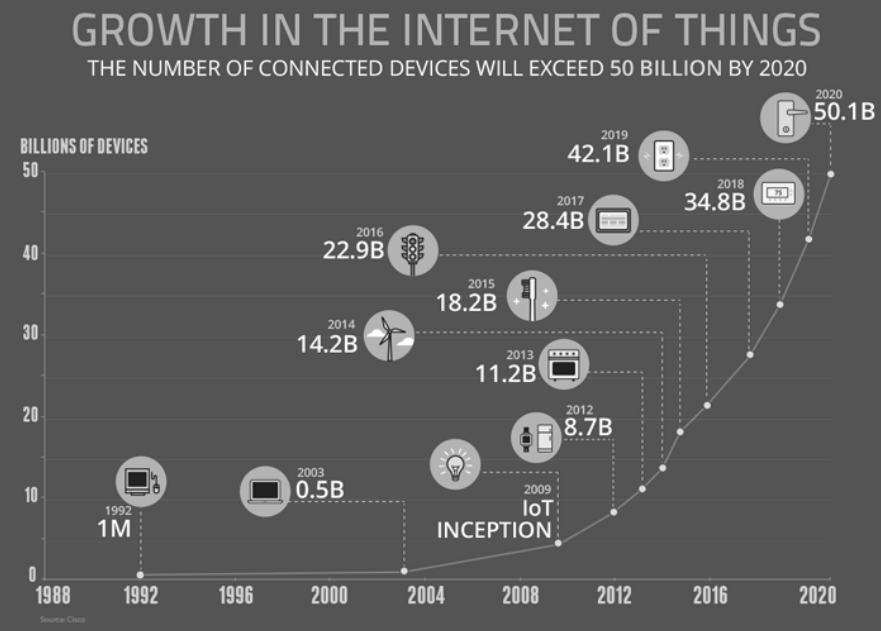
The interconnection of uniquely identifiable embedded computing devices within the existing Internet infrastructure

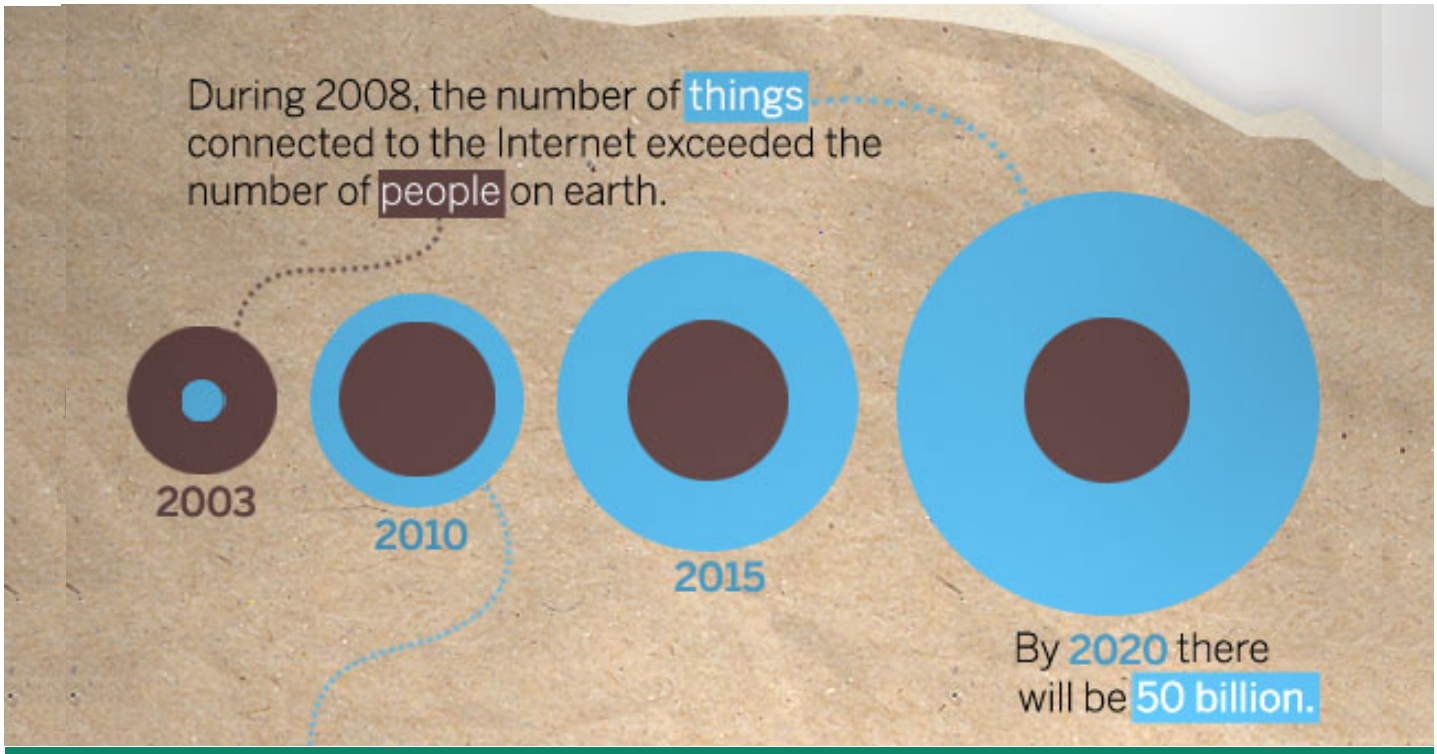
Other Definitions



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





Sensor Devices are Widely Available

IoT Characteristics

- The *things* should be:
  - Distinguishable and have unique identification
  - Able to detect the presence of other objects
  - Able to capture data autonomously.
  - Interoperable among various communication technologies
  - Have a secure and fail-safe operation
  - Operate at low power.
  - Programmable by the user
  - Contextual in nature.

IoT Characteristics

- There would be more value added if the *things*
  - Have a service–based operation
  - Cooperate autonomously with others *things*.

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

IoT Building Blocks

- Sensors
  - The front end or the things of the system
- Processors
  - Process the data captured by the sensors and provide intelligence
  - Real-time basis
  - Controlled by applications which are also responsible for securing the data
- Gateways
  - Route the processed data and send it to proper locations for proper analysis and utilization.
- Applications
  - Form another end of an IoT system
  - Typically cloud-based
  - Controlled by users

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 …

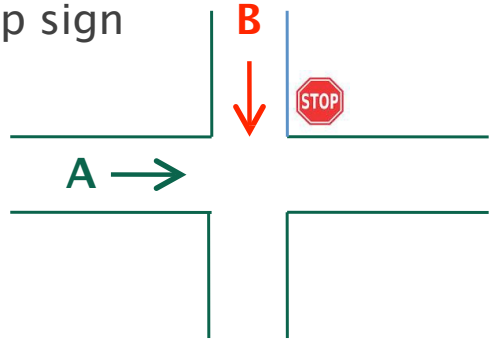
- Understand key IoT concepts;
- Explore IoT technologies, architectures, standards, and regulation;
- Understand how to develop and implement own IoT technologies, solutions, and applications;
- Analyze data collected from IoT sensors and devices using modern analytics approaches;
- Demonstrate understanding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

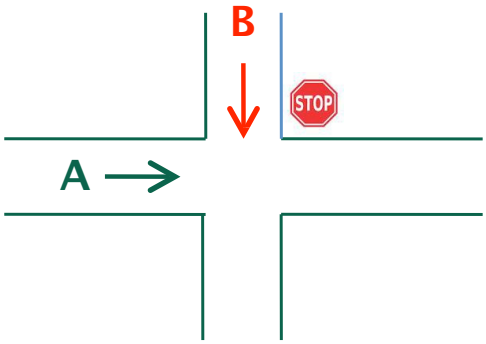
Internet of Things Challenges

- 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

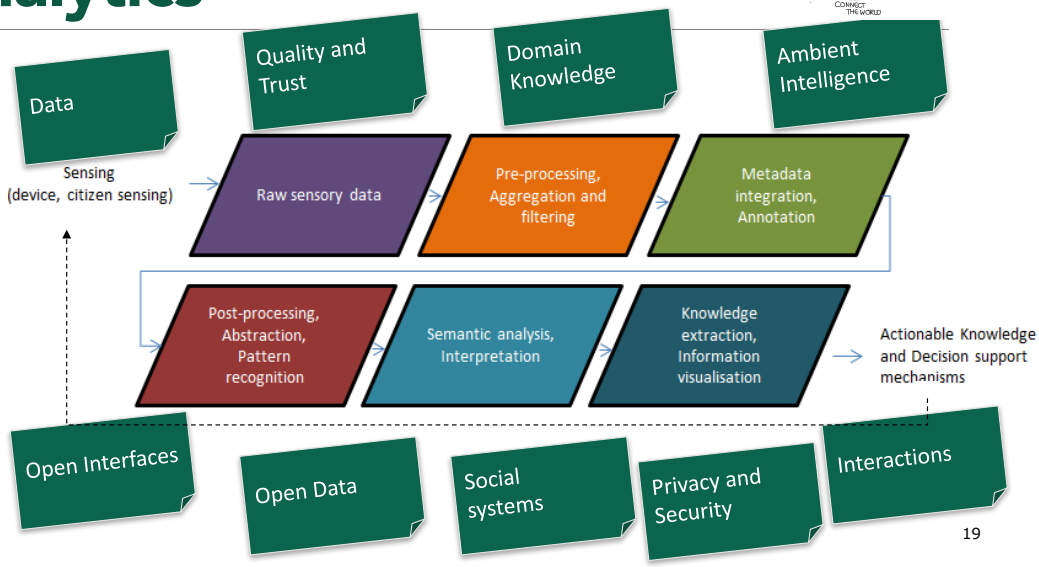
- A wants to predict if B will run stop sign
- Method 1
  - Watch out for juvenile drivers
  - Insurance companies usually charge a higher premium on these drivers
- Method 2
  - Watch out those drivers who have run stop signs or red lights in the past thirty minutes
- Which method do you think will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

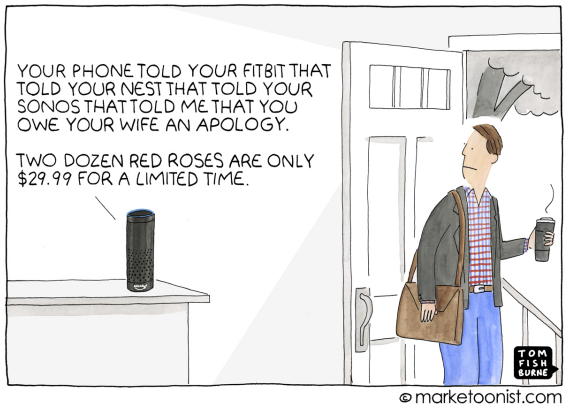
Data analytics



19

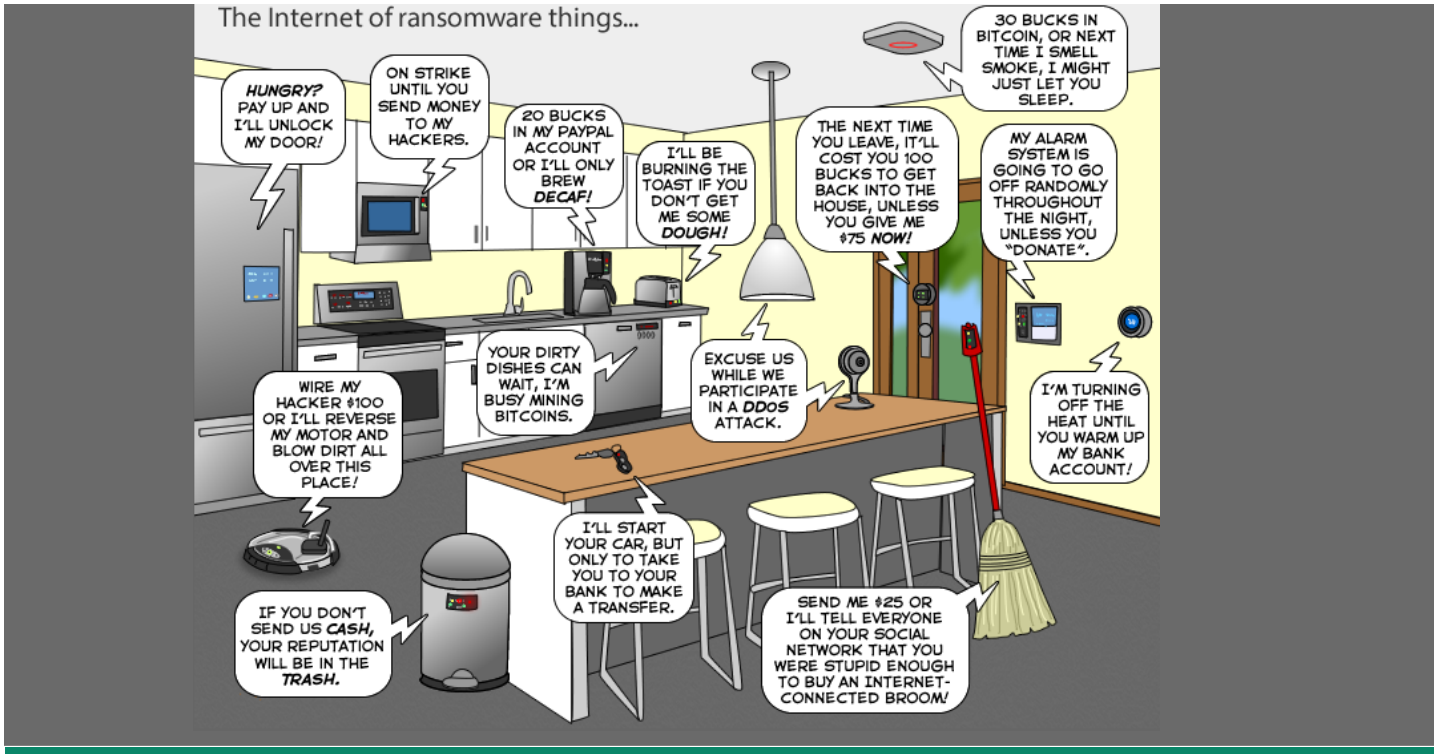
Internet of Things Challenges

- Challenge in security and privacy



Internet of Things Challenges

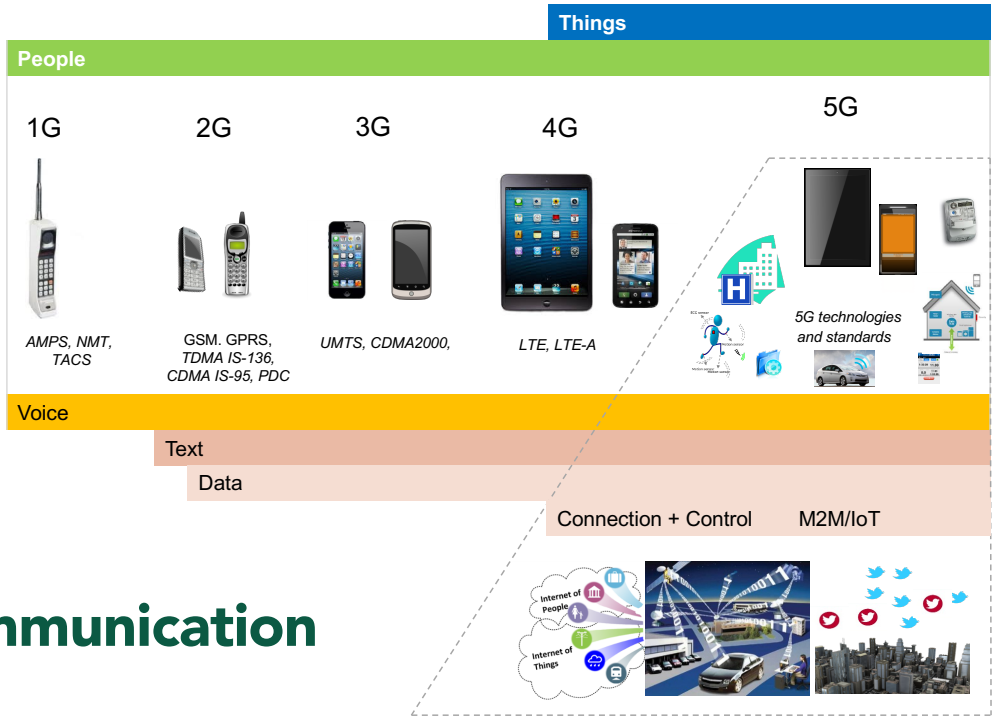
- Authentication is a major problem as current authentication procedures are not feasible in the IoT
- There are no current solutions in the IoT space for proxy attacks and man-in-the-middle attacks.
- Data integrity gets more complicated when you have unattended nodes like RFID tags

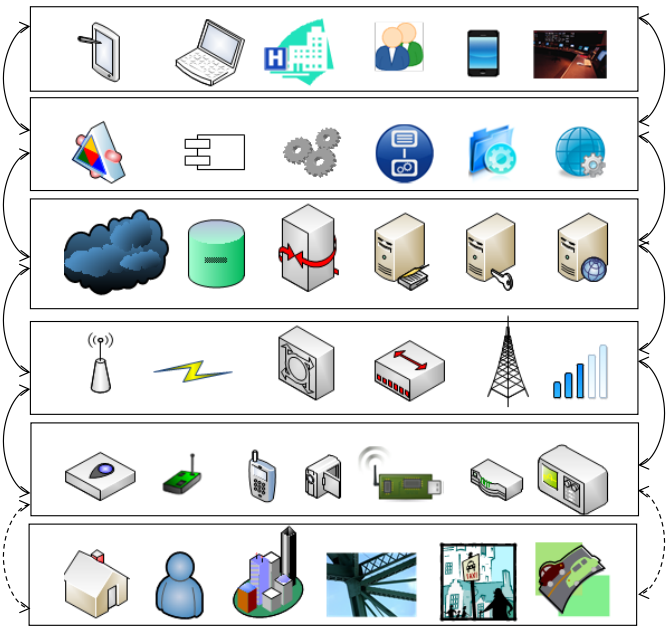


Internet of Things Challenges

- 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





Applications

Services/Interfaces

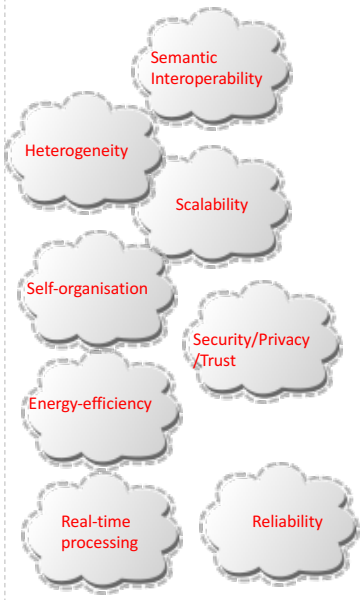
Cloud Infrastructure

Communication

Devices

Things

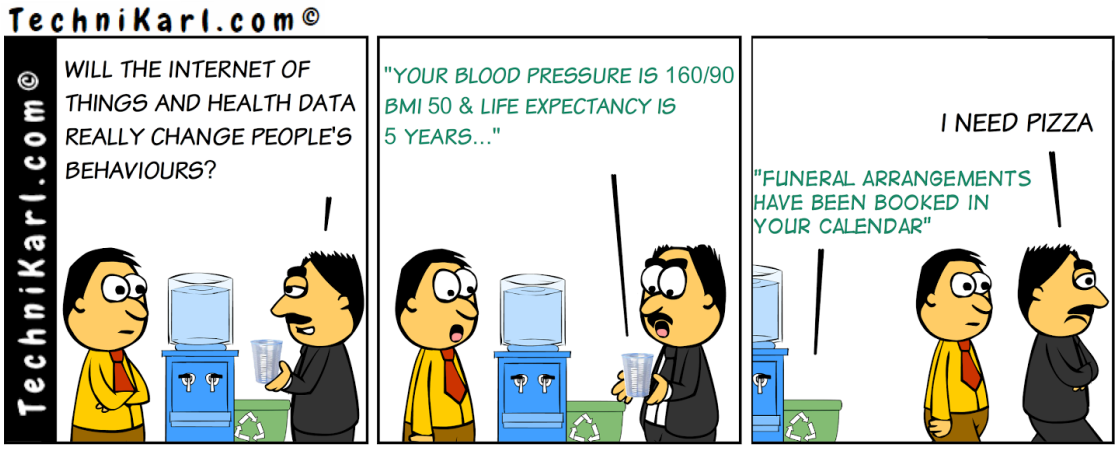
Applications	Heterogeneity, domain knowledge, re-usability, flexibility, maintainability, reliability, efficiency and scalability , ….
Services/Interfaces	Interface definition, identification, pub/sub, semantics, query, composition, process management, command and control, ….
Cloud Infrastructure	Back-end service, middleware/gateway solutions, discovery, access, directory services, security, access control, accounting, ….
Communication	Heterogeneity of underlying devices, QoS, different data patterns and requirements (bandwidth and delay measure are not sufficient), …
Devices	Various hardware/software platforms, heterogeneity of communication technologies, energy/resource constraints , …
Things	Describing the Things, Observation and Measurement and interaction attributes, …

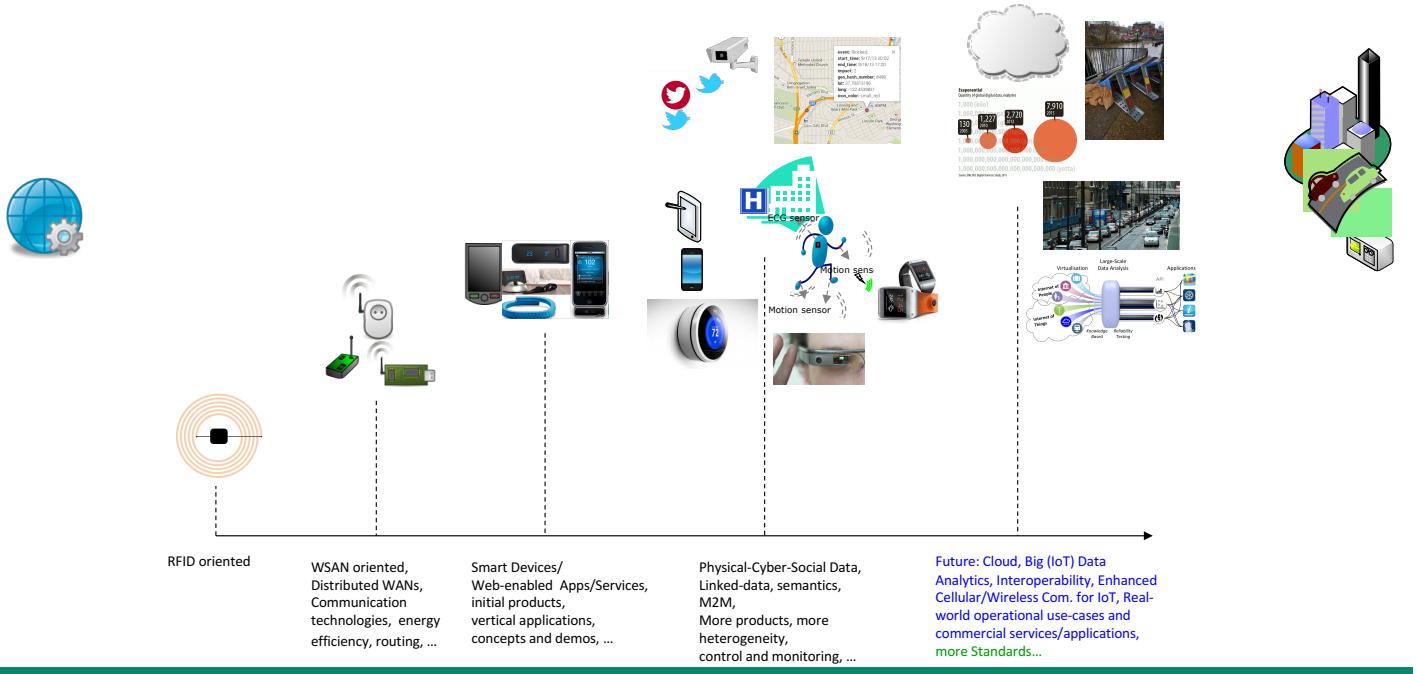


Emerging/existing standards

- 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
- 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
    - Receive and send data via standardized interfaces or API
    - Store the data
    - 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

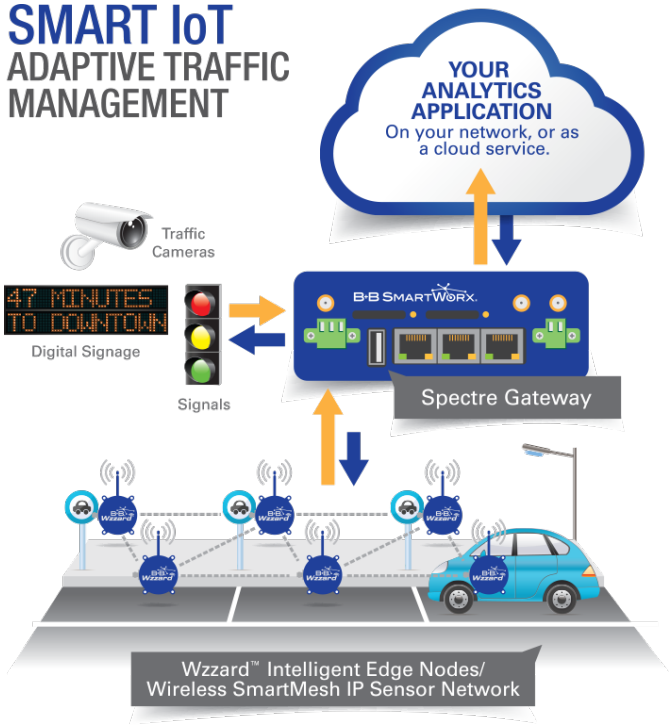
Project Devices

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

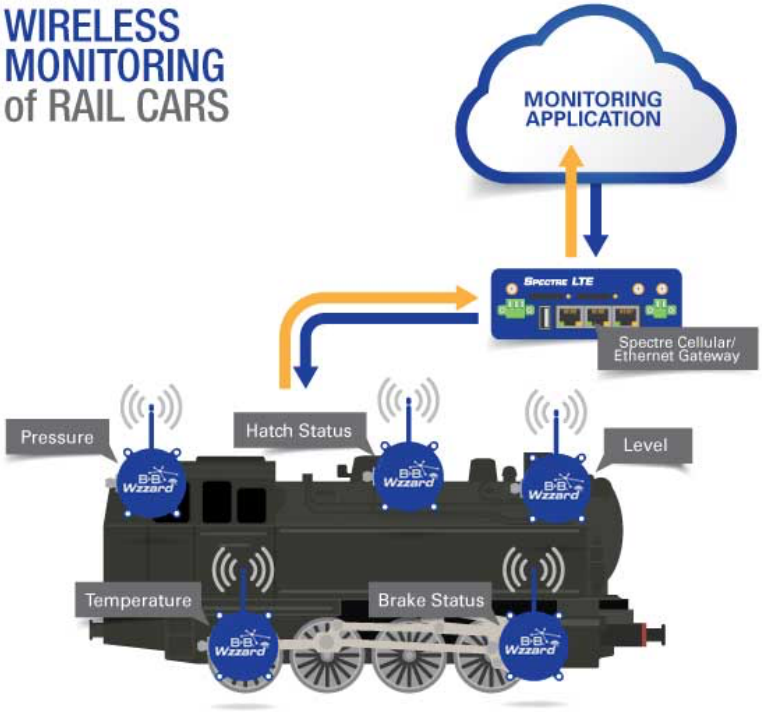
Grading

- 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%

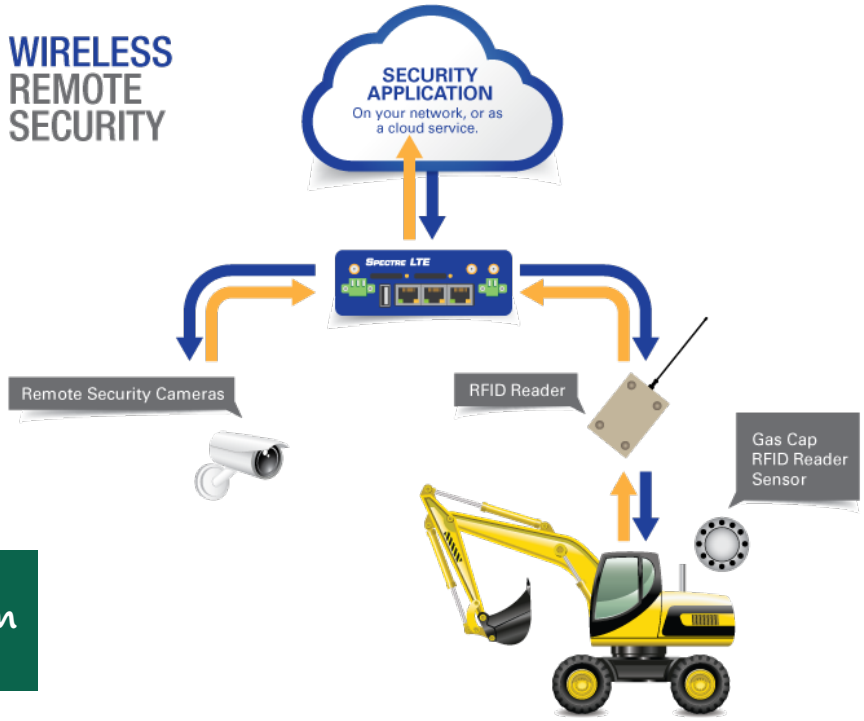
Success stories from B+B



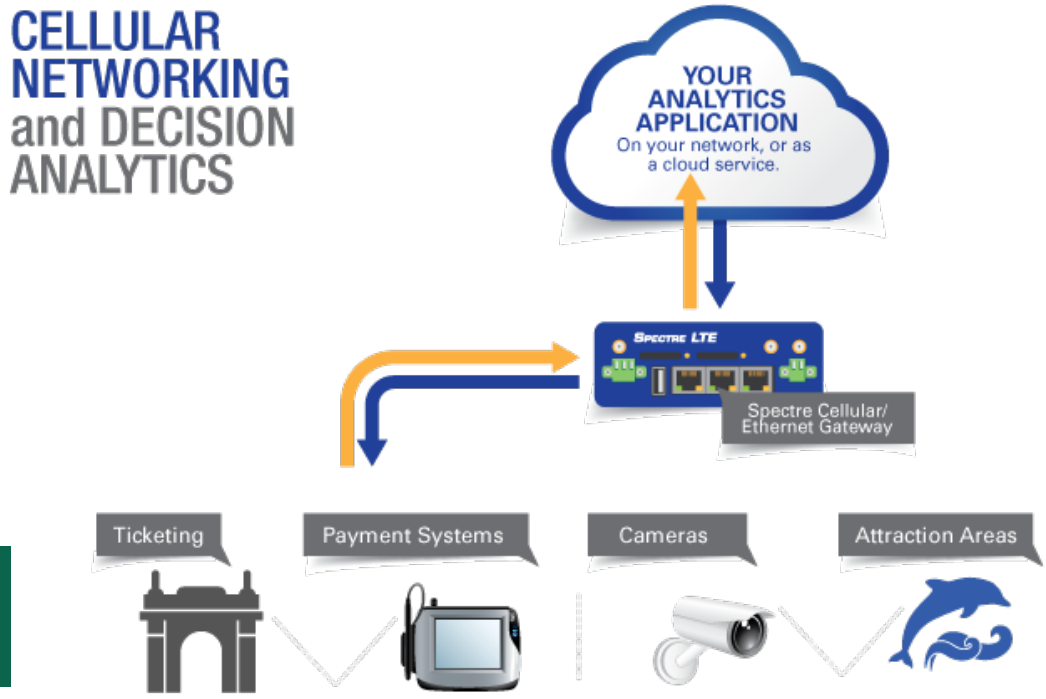
Success stories from B+B



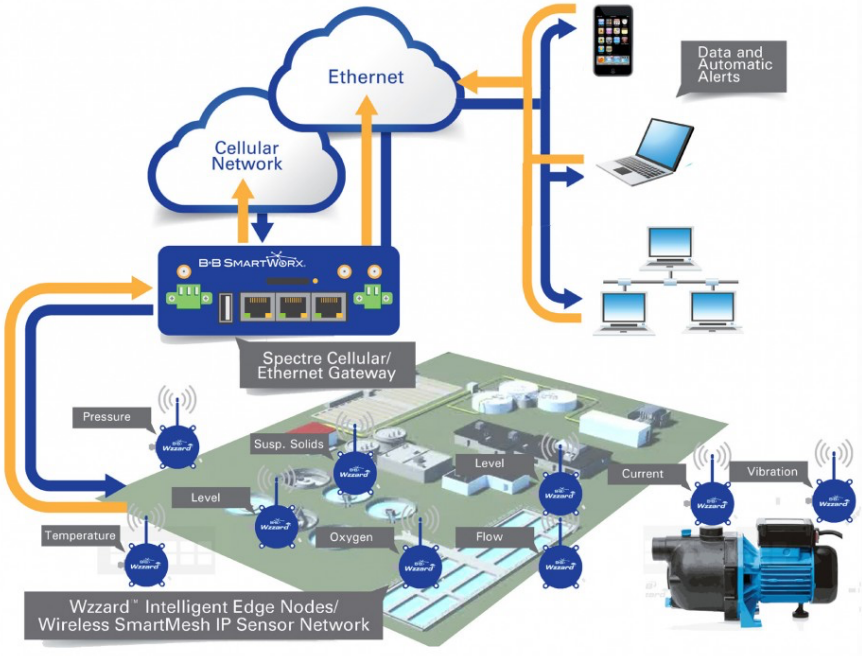
Success stories from B+B



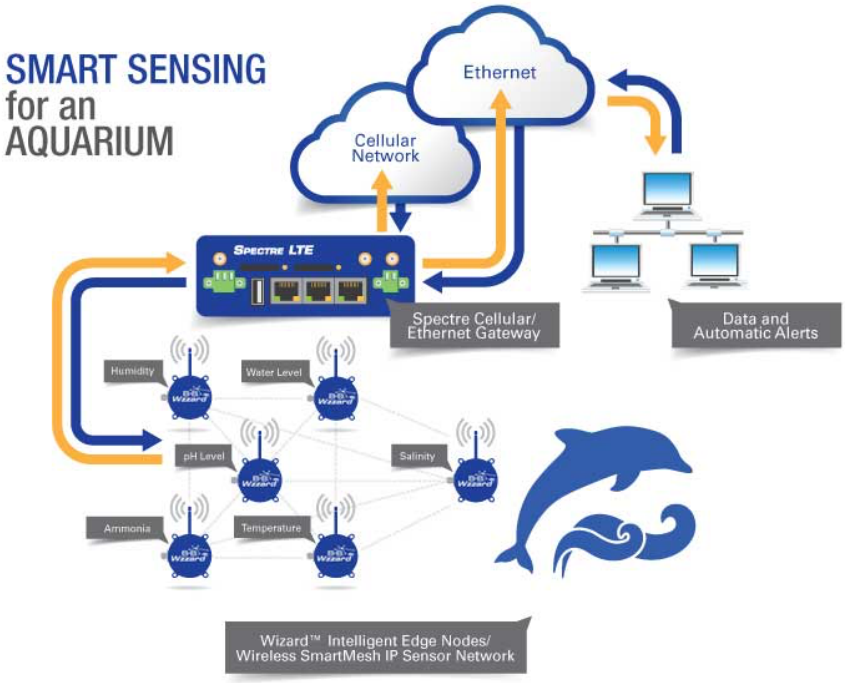
Success stories from B+B



Success stories from B+B



Success stories from B+B



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"