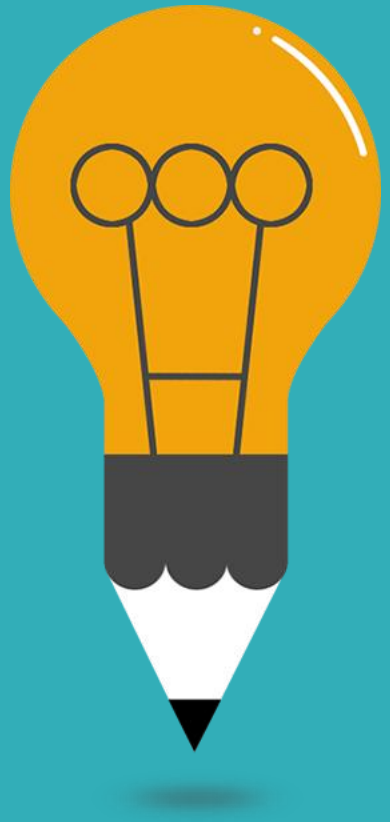


IoT and Mobile Sensing

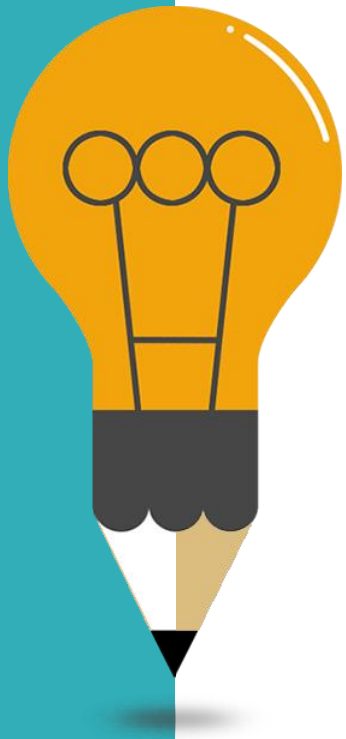
Qian Zhang

Tencent Professor of Engineering, Chair Prof. of Dept. CSE

HKUST

2018-9-7

Agenda



01 Logistics/Course Structure

02 Introduction to the IoT

03 Paper Presentation and Class Project Guidelines

Who's Who

- Instructor:

  Prof. Qian Zhang, qianzh AT ust domain
  - Rm. 3533, Tel: 2358-7688
  - Office hours: by appointment

- TA:

- Course web site:

  http://home.cse.ust.hk/~qianzh/MSBD6000F/index.html

Grading

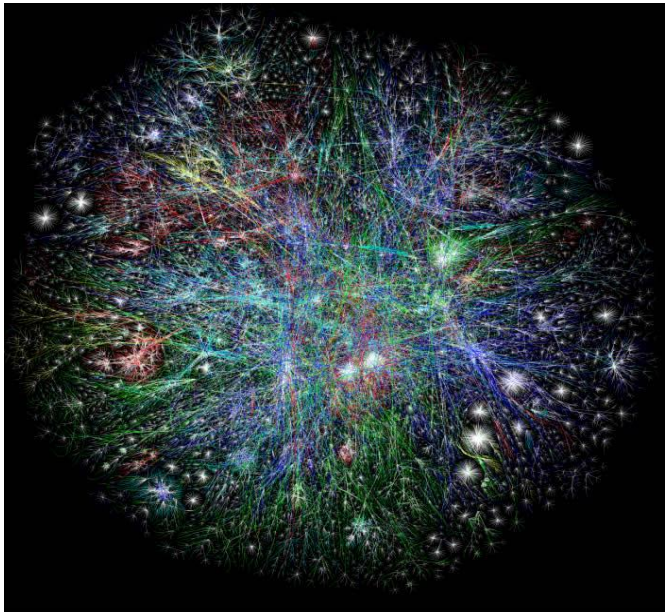
- Paper review and presentation 20%
- Exam (Mid-term) (individual) 35%
  - Survey (individual)
- Class Project (group project, each group can have at most 2 students)
  - Project Report 45%

Topics to be Covered

- Introduction of IoT (0.5 week)
- RFID (0.5 week)
- Localization (2 weeks)
  - GPS, and drone related applications
  - Indoor positioning systems
- Personal sensing (2 weeks)
  - Activity and gesture recognition
  - Acoustics sensing and communication
- Urban sensing (Exploiting the Crowd) (1 week)
- Energy efficient wireless networking for IoT devices (1 week)
- Battery free networking for IoT devices (1 week)
- Security and privacy (1 week)
- Student presentation (3 weeks)

Introduction to the IoT

Starting from the Internet



- Internet appears everywhere in the world
- but it is still a connection between people and people

What is the Internet of Things?

- Internet connects all people, so it is called “the Internet of People”
- IoT connects all things, so it is called “the Internet of Things”

What’s the Internet of Things

- Definition

(1) The Internet of Things, also called The Internet of Objects, refers to a wireless network between objects, usually the network will be wireless and self-configuring, such as household appliances.

------Wikipedia

(2) By embedding short-range mobile transceivers into a wide array of additional gadgets and everyday items, enabling new forms of communication between people and things, and between things themselves.

------WSIS 2005

What’s the Internet of Things

- Definition

(3) The term "Internet of Things" has come to describe a number of technologies and research disciplines that enable the Internet to reach out into the real world of physical objects.

------IoT 2008

(4) “Things having identities and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental, and user contexts”.

-------IoT in 2020

More about the Definition

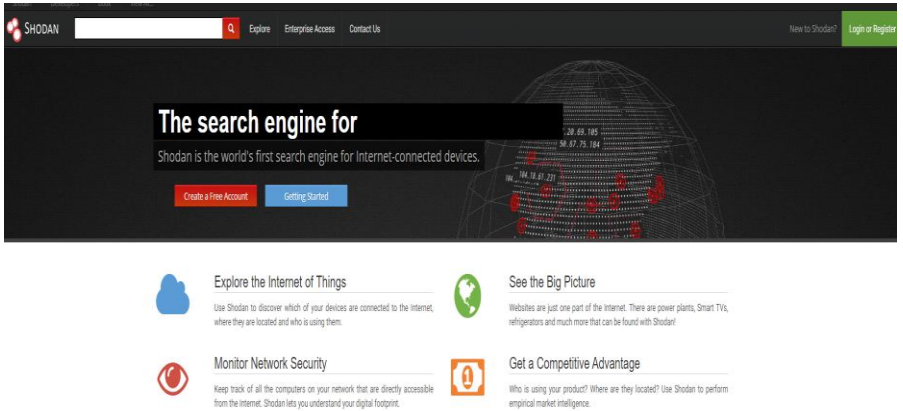
- Different synonyms
  - Network of things
  - Smarter planet
  - Industrial internet
  - Cyber-physical systems
- Only 1% of things are connected – refrigerator, car, washing machine, heater, a/c, garage door …
- Projection is 50 billion devices by 2020

World is becoming even smaller and closer!

Some Nitty-Gritties

- The term “Internet of Things” was added in Oxford Dictionary in August 2013 defined as
  - A proposed development of the internet in which everyday objects have network connectivity, allowing them to send and receive data
- National Intelligence Council (NIC) listed IoT in the six technologies with potential impact on US interests in next 10 years
- “Shodan”, World’s first search engine that finds connected ‘things’

  https://www.shodan.io/

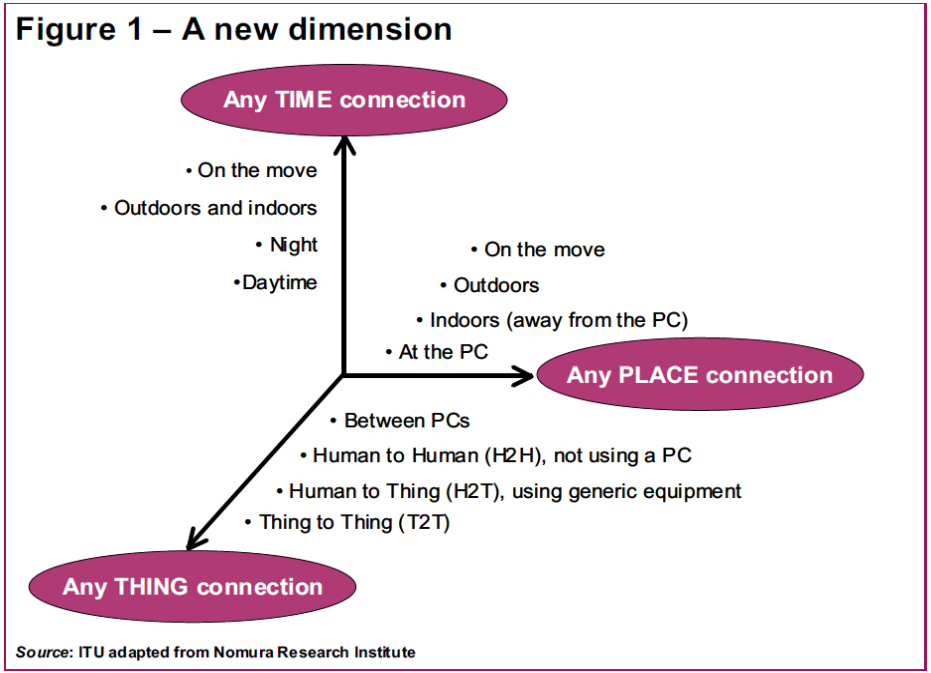


IoT

- IoT enables the embedded devices communicate with other devices through network infrastructure (e.g. Internet, Wi-Fi, BT)
- Innumerous smart sensors and actuators help devices capture data and transfer them to central decision maker
- Applications based on this technology will play an ever increasing role and are supposed to change both, industry and social life dramatically in the close future

IoT

From any time ,any place connectivity for anyone, we will now have connectivity for anything!

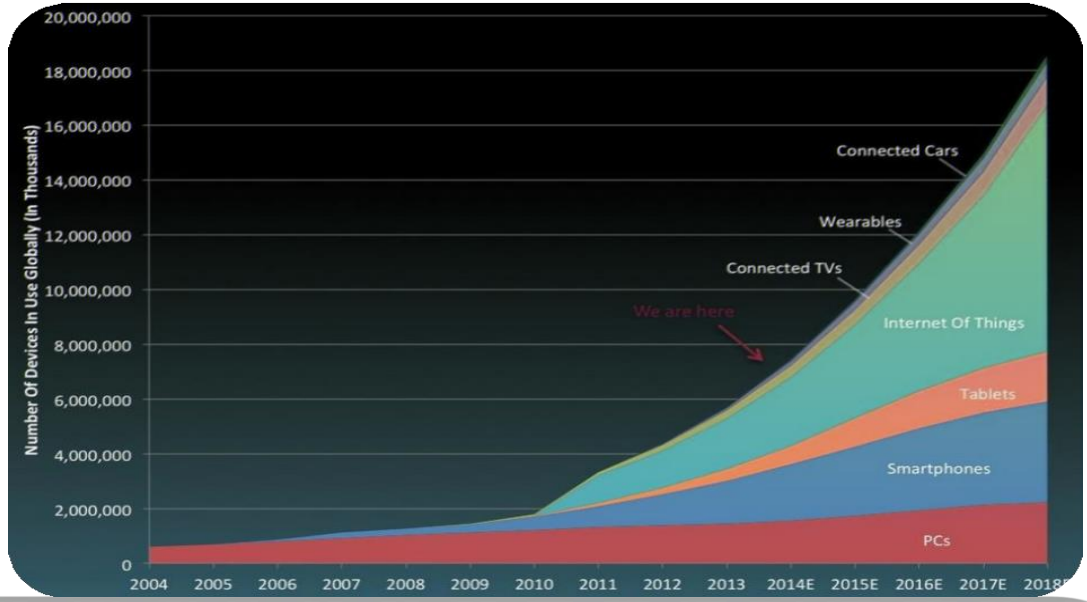


History of IoT

- History
  - 1997, “The Internet of Things” is the seventh in the series of ITU Internet Reports originally launched in 1997 under the title “Challenges to the Network”
  - 1999, Auto-ID Center founded in MIT
  - 2003, EPC Global founded in MIT
  - 2005, Four important technologies of the internet of things was proposed in WSIS conference, nano tech, wireless sensor, RFID and smart tech
  - 2008, First international conference of internet of things: The IOT 2008 was held at Zurich

Ref: Auto-ID labs, MIT http://autoidlabs.org/wordpress_website/

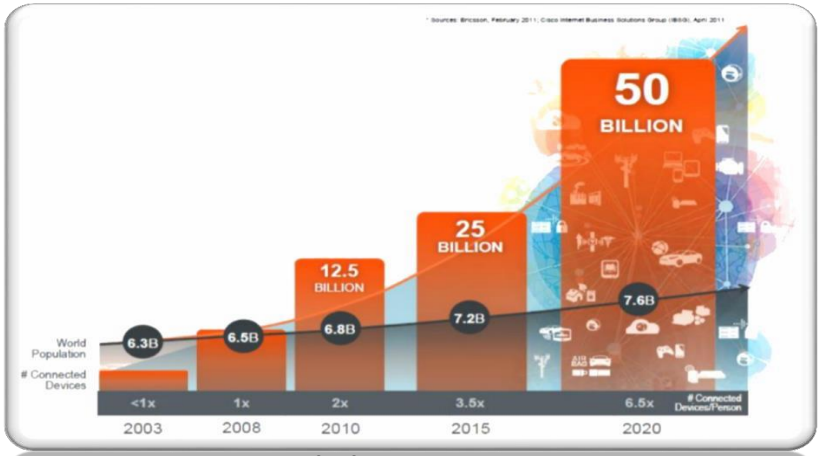
IoT Today



More than 7 billions, exceeding the earth's population

Some Statistics and Forecast

- Pew research center: “by 2025 the Internet will become like electricity – less visible, yet more deeply embedded in people’s lives”
- 50 billion connected devices by 2020
- More than 6 connected devices per person
- $1.7 trillion in value added to the global economy in 2019



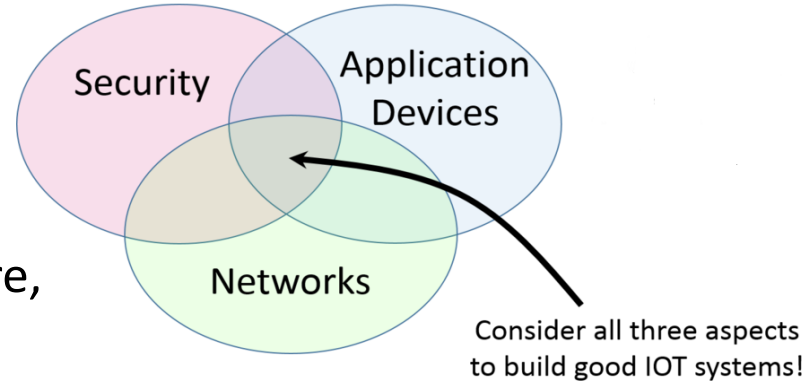
Connected devices grow up

- By 2020 IoT will be more than double the size of the smartphone, PC, tablet, connected car, and the wearable market combined
- Technologies and services generated global revenues of $4.8 trillion in 2012 and will reach $8.9 trillion by 2020, growing at a compound annual rate (CAGR) of 7.9%

Ref: Pew research, “How will the internet of things look by 2025”, http://www.pewinternet.org/2016/03/29/how-will-the-internet-of-things-look-by-2025/
Ref: “Gartner Identifies Top 10 Strategic Technologies,” http://www.cioinsight.com/it-news-trends/gartner-identifies-top-10-strategic-technologies.html

IoT Architecture

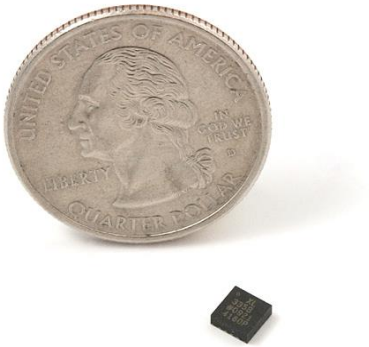
- Three major components for designing any IoT system
  - Application devices: Hardware architecture, smart sensors, cloud computing, energy efficient devices
  - Networks: Communication technology, advanced internet protocol, wireless technology, RFID technology
  - Security and privacy: Authentication procedure, secure device discovery, secure inter-device communication



Driving Forces of IoT

1. Sensor Technology – Tiny, Cheap, Variety
2. Cheap Miniature Computers
3. Low Power Connectivity
4. Capable Mobile Devices
5. Power of the Cloud

1. Sensor Technology



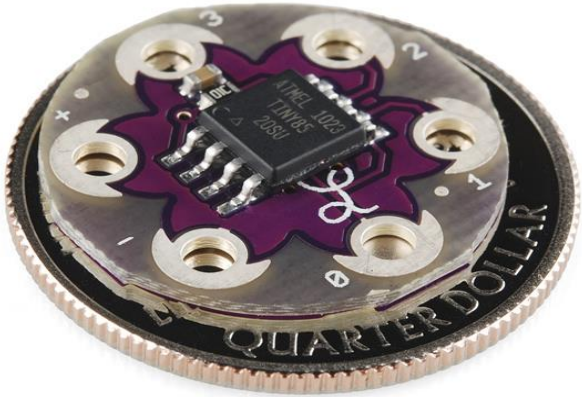
Accelerometer
(4mm diameter)

Force Sensor
(0.1N – 10N)

Pulse Sensor
$25

https://www.sparkfun.com/
https://www.adafruit.com/

2. Cheap Mini Computers



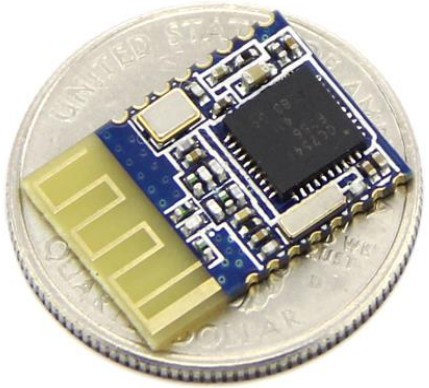
Lily Tiny

Key Parameters

Flash: 8 Kbytes
Pin Count: 8
Max. Operating Freq: 20 MHz
CPU: 8-bit AVR
Max I/O Pins: 6
Ext Interrupts: 6
SPI: 1
I2C: 1

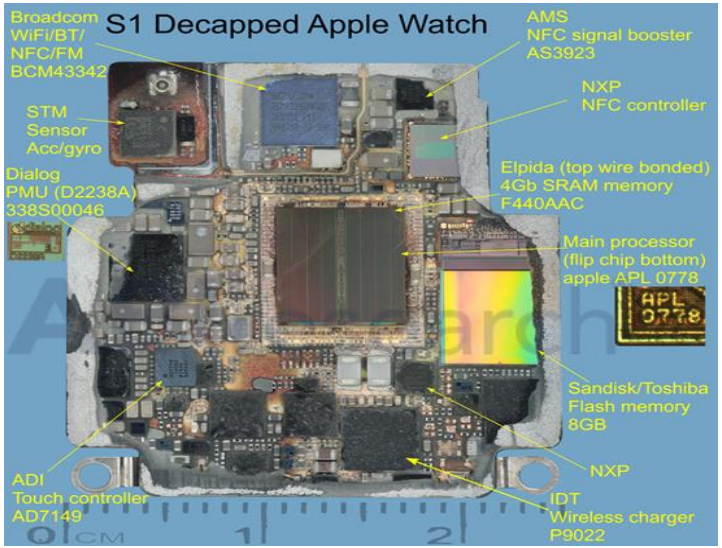
http://www.atmel.com/devices/ATTINY85.aspx?tab=parameters

3. Low Power Connectivity



Bluetooth Smart (4.0)
(Up to 2 years with a single
Coin-cell battery)

4. Capable Mobile Devices



Quad Core 1.5 GHz
128 GB Internal Memory
3 GB RAM
16 MP Camera
2160p@30fps video
WiFI, GPS, BLE

5. Power of the Cloud

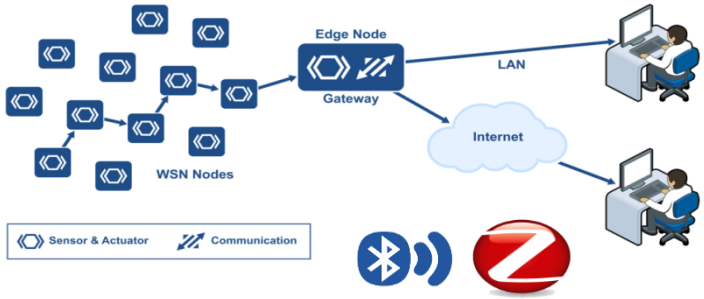
amazon web services™

ABCD's of IoT

Applications

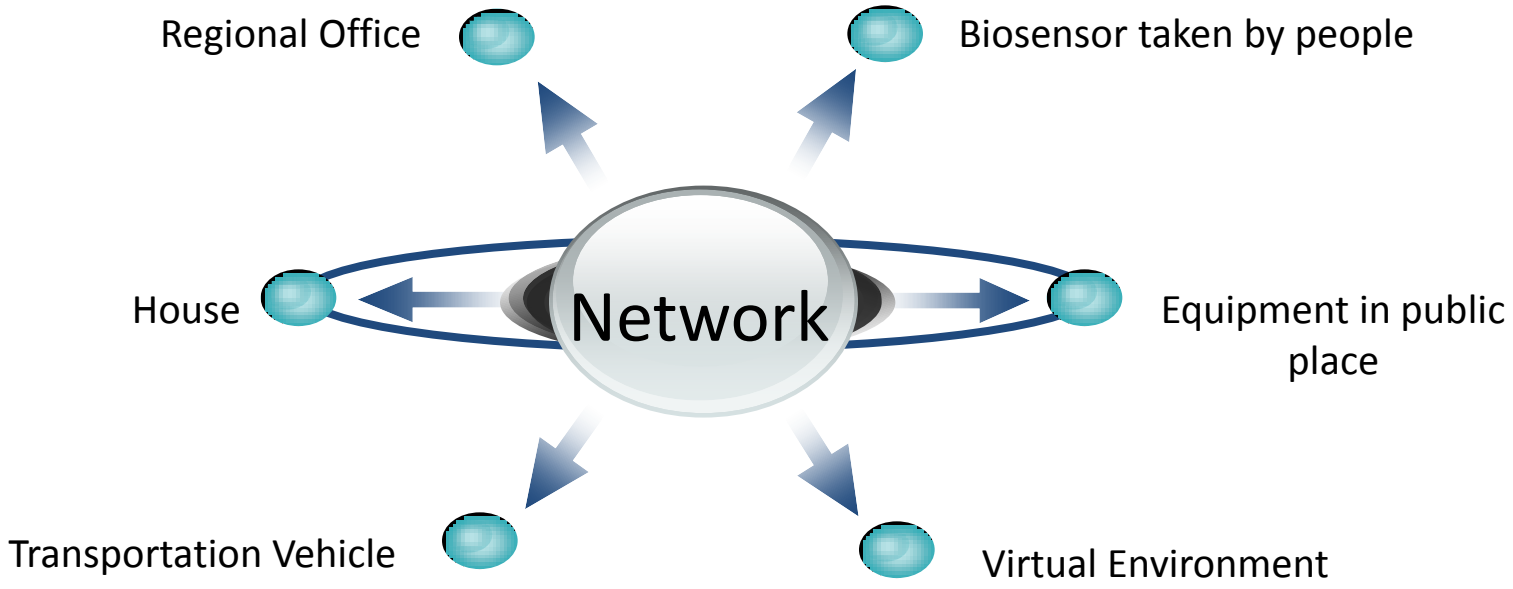
Big Data Analytics

Connectivity and Communication

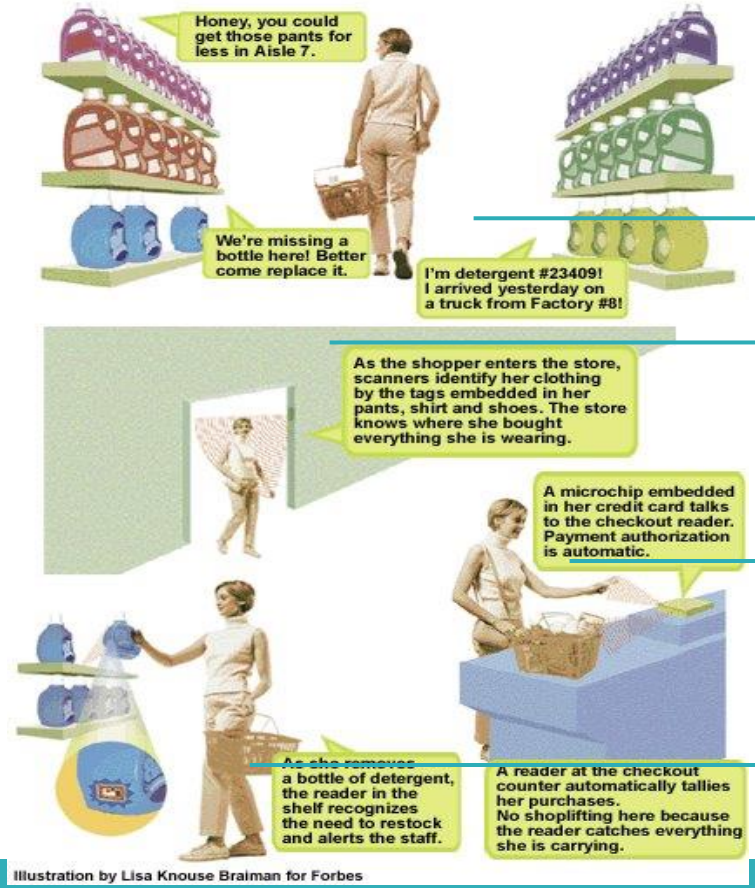


Devices – that are smart!

Applications



Applications (1)



Scenario: shopping

(2) When shopping in the market, the goods will introduce themselves

(1) When entering the doors, scanners will identify the tags on her clothing

(4) When paying for the goods, the microchip of the credit card will communicate with checkout reader.

(3) When moving the goods, the reader will tell the staff to put a new one

Applications (2)

Scenario: Health Care

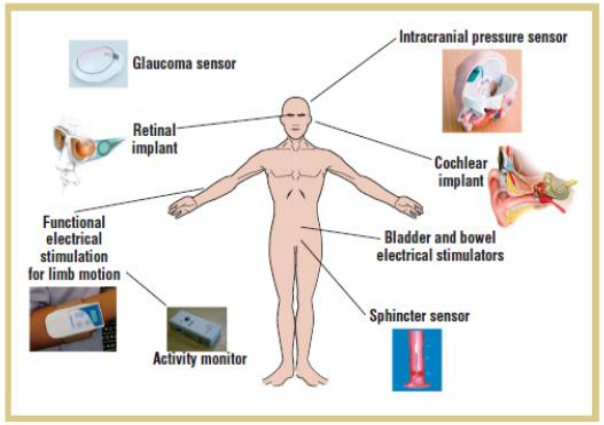


Figure 6. Fully implantable wireless sensor for the intracranial pressure monitoring system.

- Various sensors for various conditions
- Example ICP sensor: Short or long term monitoring of pressure in the brain cavity
- Implanted in the brain cavity and senses the increase of pressure
- Sensor and associated electronics encapsulated in safe and biodegradable material
- External RF reader powers the unit and receives the signal
- Stability over 30 days so far

Applications (2)

Scenario: Health Care

- National Health Information Network, Electronic Patient Record
- Home care: monitoring and control

  Pulse oximeters, blood glucose monitors, infusion pumps, accelerometers, …
- Operating Room of the Future

  Closed loop monitoring and control; multiple treatment stations, plug and play devices; robotic microsurgery
- Progress in bioinformatics: gene, protein expression, systems biology, disease dynamics, control mechanisms

Applications (3)

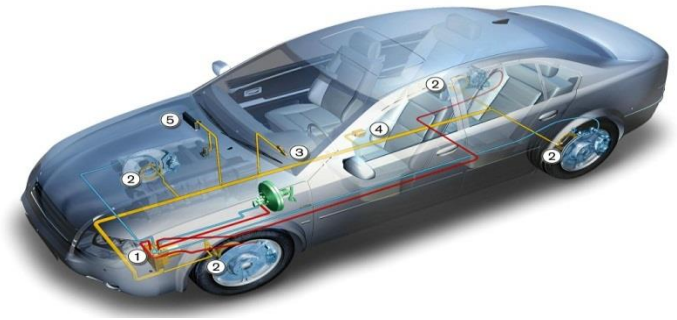
Scenario: Intelligent Home

- Remote monitor for smart house
- Remote control for smart appliance

Applications (4)

Scenario: Transportation

- A network of sensors set up throughout a vehicle can interact with its surroundings to provide valuable feedback on local roads, weather and traffic conditions to the car driver, enabling adaptive drive systems to respond
- This may involve automatic activation of braking systems or speed control via fuel management systems. Condition and event detection sensors can activate systems to maintain driver and passenger comfort and safety through the use of airbags and seatbelt pre-tensioning
- Sensors for fatigue and mood monitoring based on driving conditions, driver behaviour and facial indicators can interact to ensure safe driving by activating warning systems or directly controlling the vehicle



Applications (4)

Scenario: Transportation

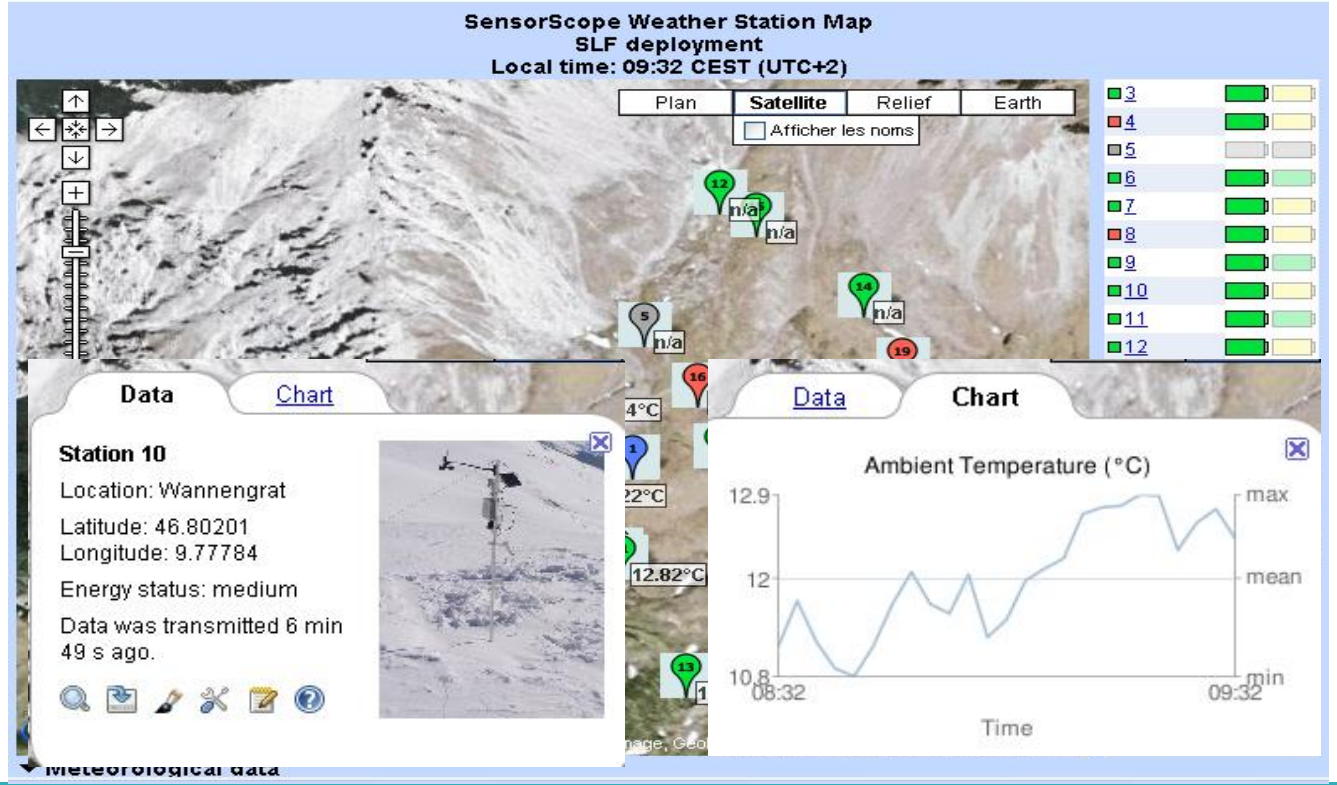
- In 2005, 30 – 90 processors per car

  Engine control, Break system, Airbag deployment system, Windshield wiper, Door locks, Entertainment system
- Cars are sensors and actuators in V2V networks

  Active networked safety alerts, Autonomous navigation
- Future Transportation Systems
  - Incorporate both single person and mass transportation vehicles, air and ground transportations
  - Achieve efficiency, safety, stability using real-time control and optimization

Applications (5)

Scenario : Monitoring the Environment



Big Data Analytics

- Map-Reduce
- Frequent Item-sets
- Similarity
- Clustering
- Dimension Reduction
- Streaming Data

Connectivity

- M2M
- Wireless Sensor Networks
- IPv6 and 6LowPAN
- Bluetooth LE and ZigBee
- WiFi and LTE
- Backscatter

Devices and Platforms

- Mobile Systems
- Sensor Systems
- Wearables
- Energy Harvesting
- Security and Privacy

IoT Components: Security and Privacy

- IoT network resilience to cyber attacks
- Privacy
- Influencing human behavior

IoT in the Research Community

- Mobile Systems (MobiSys, MobiCom)
- Sensor Systems (SenSys, IPSN)
- Real-Time Systems (RTSS, RTAS)
- Human-Computer Interaction (CHI)
- Applications (UbiComp, PerCom)
- ML/Data Mining (ICML, KDD)
- … and more

Topics to be Covered

- Introduction of IoT (0.5 week)
- RFID (0.5 week)
- Localization (2 weeks)
  - GPS, and drone related applications
  - Indoor positioning systems
- Personal sensing (2 weeks)
  - Activity and gesture recognition
  - Acoustics sensing and communication
- Urban sensing (Exploiting the Crowd) (1 week)
- Energy efficient wireless networking for IoT devices (1 week)
- Battery free networking for IoT devices (1 week)
- Security and privacy (1 week)
- Student presentation (3 weeks)

Paper Presentation Outline

1. Broader Context
2. Claims/Problem Statements
3. Prior Work
4. Approach/Algorithms/System
5. Experimental Design
6. Results
7. Your Own Comments

Paper Presentation Skill

Learn from the best

- https://www.youtube.com/watch?v=2-ntLGOyHw4

Paper Review Outline

- Summary (claims and arguments)
- Pros
- Cons
- Your Comments

Potential Project Ideas

(not limited to this)

- App: New sensing applications enabled with IoT devices
- App: New localization technologies design for IoT devices
- App: blockchain design with IoT transactions
- App: New type of IoT based applications/services
- Data: More irrelevant data makes it harder to find a pattern
- Data: Real-Time processing of large amount of IoT data
- Net: Redesign access network to accommodate things
- Net: Heterogeneous interfaces – Things don’t talk same language
- Net: App layer protocol for M2M communication
- Security and Privacy: Detection, Prevention, Secure pairing

End of This Chapter