

Smart Health – CSE 40816

University of Notre Dame
Spring 2020



Health Technology @ CES

- Nurvv's Run Insoles have 32 sensors that capture data 1,000 times per second. You can see how far you walked or ran, your cadence, balance, stride, and more.



Health Technology @ CES

- Colgate's Plaqless Pro has a sensor right below the bristles that looks for plaque and know when it's gone as you brush. Light is blue when plaque detected and white when clear.
- Sensors create a “map” of your mouth and transmit that data back to your phone so you can see exactly where you've brushed and what spots you've missed.



Health Technology @ CES

- The BH51M Neo Helmet by Livall has sensors to detect acceleration and deceleration, turning on the helmet's built-in front lights and taillights as needed.
- Also designed to sense a fall and will automatically send your location (via GPS) to your emergency contacts.



Health Technology @ CES

- Omron HeartGuide
- Blood pressure sensing
- Informs wearer about factors increasing/decreasing blood pressure



Health Technology @ CES

- Dario personalized, pocket-sized, all-in-one glucose meter that lets you monitor blood sugar levels wherever you are in seconds



Health Technology @ CES

- ScanWatch checks heart rate and delivers heart health notifications when heart rate is atypical (too low or high) and if irregular rhythms are detected.
- Monitor oxygen saturation all night long via SpO2 sensor to detect apneic episodes.



Health Technology @ CES

- Measure blood glucose with light (prick free)



Homeostasis

- Jason went to school in a short sleeve shirt. A cold front blew in while he was in school. While waiting for his bus he started shivering. Jason decided to skip the bus and run home. After he started running his shivering stopped. How would you explain this?
 - Jason started to shiver to keep his body temperature from falling too low. Running generated heat so he no longer needed to shiver.
-

Allostasis

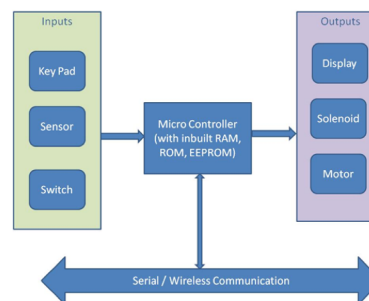
- John has finished his exercise routine. While exercising his blood pressure increased to supply more oxygen and nutrients to his muscle cells. Now that the exercise is over his body will return his blood pressure to normal. How will this happen?
 - Blood pressure receptors in John's carotid arteries will send a message to the brain to indicate the blood pressure is high. His brain will then determine that there is no longer a need for an elevated blood pressure since the exercise has stopped. The brain will send a message to the heart to beat slower. The slower heart rate will decrease John's blood pressure.
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Smart Systems

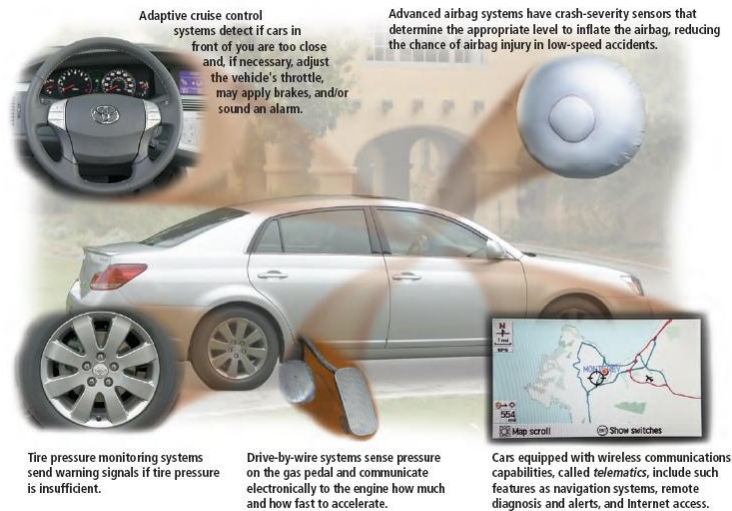
- Embedded Systems
 - A computing system designed for a specific function and embedded as a part of a complete device
- Real-Time Systems
 - Functional and temporal correctness are equally important
- Cyber-Physical Systems
 - Focus on integration of physical and virtual world
- (Wireless) Sensor Networks
 - Large collection of connected sensors
- RFID (Radio Frequency Identification)
- Virtual/Augmented Reality
- Smart Things/Objects, Web of Things
- Ubiquitous/Pervasive Computing
 - Computer always present, but invisible
- **Internet of Things**

Embedded System/Computer

- “Any sort of device which includes a programmable computer but itself is not intended to be a general-purpose computer”
 - Wayne Wolf
- General purpose
- Dedicated



Automotive Embedded Systems



Automotive Embedded Systems

- Today's high-end automobile may have 100+ microprocessors:
 - Seat belt; dashboard devices; engine control; ABS; automatic stability control; navigation system; infotainment system; collision avoidance system; tire pressure monitoring; lane warning; adaptive cruise control; climate control; airbag control unit; electric window and central locking; parking aid; automatic wiper control; alarm and immobilizer; power seat; electric power steering; electronic transmission; active suspension

Embedded Systems

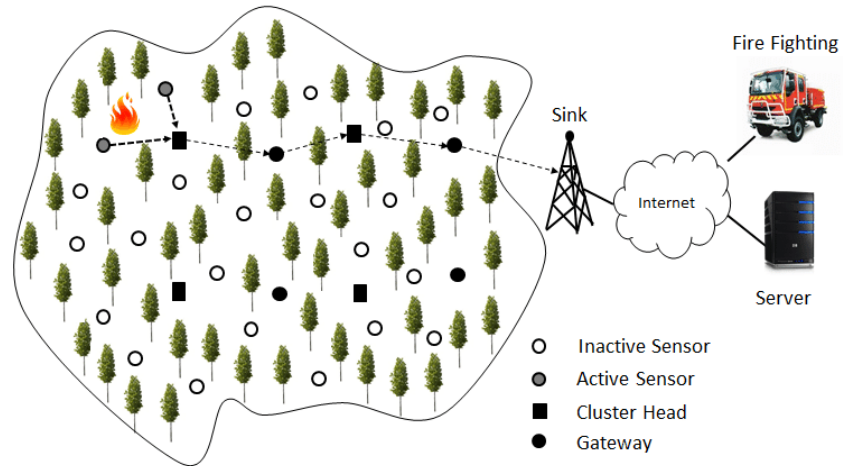
- A **dedicated** computing system **embedded** into a larger system.
- 80 million PCs every year
- 3 billion embedded CPUs every year
- Embedded systems market growing, while PC market mostly saturated

Real-Time Systems

- Functional and temporal correctness required

Illustration	Terminology
	Event Detected – When an outside event is detected by the hardware of the real-time system.
	Start Time- The time when the software process, handling the outside event, has started.
	Completion Time – The time when the software process, handling the event, has completed.
	Slack Time – The time between the software process completes and the task deadline occurs.
	Deadline - When the process MUST have generated a response to the event.

Wireless Sensor Networks



RFID

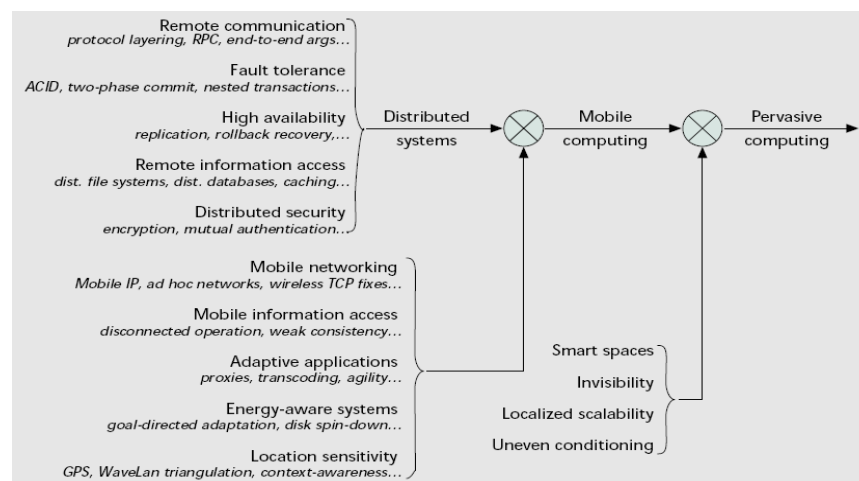


Ubiquitous Computing Concepts

- *“The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.”*, Mark Weiser 1991



Evolution of Pervasive Computing



Pervasive Computing

- During one of his talks, Weiser outlined a set of principles describing pervasive computing (also called ubiquitous computing):
 - The purpose of a computer is to help you do something else.
 - The best computer is a quiet, invisible servant.
 - The more you can do by intuition the smarter you are; the computer should extend your *unconscious*.
 - Technology should create calm.
- Calm technology
 - “A technology that which informs but doesn't demand our focus or attention”.

(Designing Calm Technology, Weiser and John Seeley Brown)

Pervasive Computing

- One does not need to continually rationalize one's use of a pervasive computing system.
- Having learnt about its use sufficiently well, one ceases to be aware of it.
- It is "literally visible, effectively invisible" in the same way that a skilled carpenter engaged in his work might use a hammer without consciously planning each swing.
- Similarly, when you look at a street sign, you absorb its information without consciously performing the act of reading.

Summary - Characteristics

- Minimal user distraction
- Collaborative interaction
- User mobility
- Context awareness (user/time/location)
- Resource and location discovery
- Ambient information, calm technology
- Event notification
- Adaptive interfaces
- Invisibility—everyday object augmentation
- Anytime/anywhere

Internet-of-Things



How Does My Fridge Do That?

- You are leaving the home (sense user)
 - There's no milk in fridge (sense object)
 - Use this information to make a decision (process)
 - Inform user of decision (communicate)
-

How Does My Fridge Do That?

- **You are leaving the home (sense user)**
 - What type of sensor?
 - Distinguish between parent and child
 - Identify reason for leaving home
 - Identify other contexts (e.g., store hours)
 - There's no milk in fridge (sense object)
 - Use this information to make a decision (process)
 - Inform user of decision (notify)
-

How Does My Fridge Do That?

- You are leaving the home (sense user)
 - **There's no milk in fridge (sense object)**
 - What type of sensor?
 - Is milk needed?
 - No milk or "little" milk? (prediction)
 - Use this information to make a decision (process)
 - Inform user of decision (notify)
-

How Does My Fridge Do That?

- You are leaving the home (sense user)
 - There's no milk in fridge (sense object)
 - **Use this information to make a decision (process)**
 - Where is processor?
 - What are the rules?
 - Fixed rules versus dynamic rules (learning)
 - Inform user of decision (notify)
-

How Does My Fridge Do That?

- You are leaving the home (sense user)
- There's no milk in fridge (sense object)
- Use this information to make a decision (process)
- **Inform user of decision (notify)**
 - How?
 - When?
 - Privacy?
 - Subtleness?
 - Information overflow?

Internet-of-Things (IoT)

Physical object (“thing”)

+

Controller (“brain”)

+

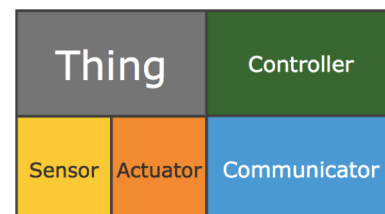
Sensors

+

Actuators

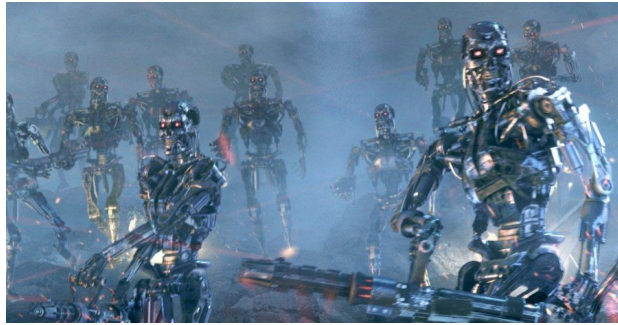
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Networks (Internet)



Related Areas

- Machine-to-machine (M2M) communications
- Internet of Everything (Cisco Systems)
- “Skynet” (Terminator movie)



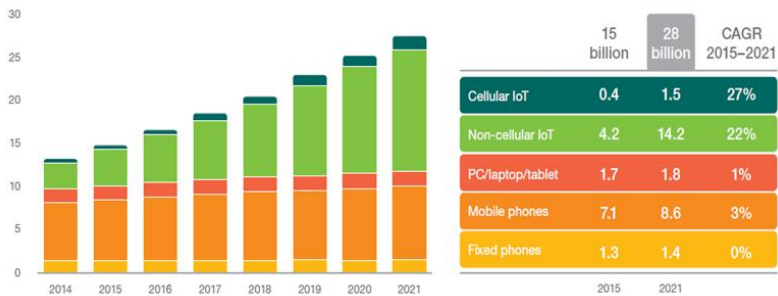
“Internet-of-Things”

- Term coined by British entrepreneur Kevin Ashton, while working at MIT Auto-ID Labs
- Referred to (and envisioning) a future global network of objects connected specifically by RFID (radio-frequency identification)
- Complete automation of data collection
- Article about IoT in 2004 from MIT; called “Internet 0”

Internet-of-Things Vision & Growth

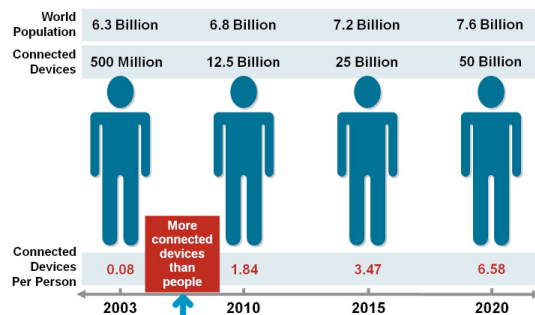
THE INTERNET OF THINGS

Connected devices (billions)



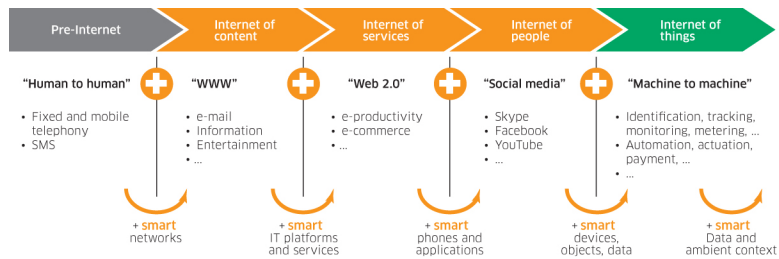
Internet-of-Things Vision & Growth

Figure 1. The Internet of Things Was "Born" Between 2008 and 2009



Source: Cisco IBSG, April 2011

Internet-of-Things Vision & Growth



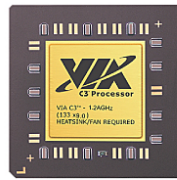
Portability

- Reducing the size of hardware to enable the creation of computers that could be physically moved around relatively easily



Miniaturization

- Creating new and significantly smaller mobile form factors that allowed the use of personal mobile devices while on the move



50mm x 50mm



35mm x 35mm



15mm x 15mm

Connectivity

- Developing devices and applications that allowed users to be online and communicate via wireless data networks while on the move



Bluetooth®

Convergence

- Integrating emerging types of digital mobile devices, such as Personal Digital Assistants (PDAs), mobile phones, music players, cameras, games, etc., into hybrid devices



Divergence

- Opposite approach to interaction design by promoting information appliances with specialized functionality rather than generalized ones



Digital Ecosystems

- The emerging wave of *digital ecosystems* is about the larger wholes of pervasive and interrelated technologies that interactive mobile systems are increasingly becoming a part of



Example: Smartphone

- Portability: carry it anywhere you want
- Miniaturization: make it possible to build device to fit in your pocket
- Connectivity: Wi-Fi, LTE/4G, cellular, Bluetooth
- Convergence: phone, camera, gaming device, movie streaming, music player, ...
- Divergence: ?
- Digital Ecosystem: social networks, distributed gaming, video streaming, work apps, ...