Background

• Ph.D., Yale University (computer science, 1978)
• J.D., Duquesne University (law, 1981)
• Carnegie Mellon computer science faculty (1975 - )
  – Institute for Software Research
  – Language Technologies Institute
• Director, Universal Library
• Director, Master’s Program in eBusiness Technology
• Visiting Professor, University of Hong Kong (2001- )
The Internet of Things
Things Connected to Things
IOT + Internet of People

Physical Graph much larger than the Social Graph

Friend of a Friend (FOAF)

Friend of a Thing (FOAT)
I THINK MY NEST SMOKE ALARM IS GOING OFF. GOOGLE ADWORDS JUST PITCHED ME A FIRE EXTINGUISHER AND AN OFFER FOR TEMPORARY HOUSING.
“Bad news - the scale is threatening to cut off our access to the fridge...”
Smart Home

- Home automation expected to grow to US$50B by 2018
Smart Manufacturing

- Dynamic plant configuration, readiness
- Dynamic product configuration
- Dynamic inventory minimization

Source: Robert Graybill
Smart City Infrastructure

Transit-Oriented Development
Integrated City Management

City Management Infrastructure
- Energy Management
- Water/Sewer Management
- Mobility Management
- Communication Management

City area
(City infrastructure)

Various infrastructures co-exist in the same geographical areas

SOURCE: HITACHI CONSULTING
How RFID Works

- Tag enters RF field
- RF signal powers tag
- Tag transmits ID, plus data
- Reader captures data
- Reader sends data to computer
- Computer determines action
- Computer instructs reader
- Reader transmits data to tag

SOURCE: PHILIPS
Radio Frequency ID (RFID)
Retail Applications

Garment Tracker
How Wal-Mart’s ‘electronic product code’ system works

1. Suppliers add RFID (radio-frequency ID) sensors to jeans at the point of manufacture.

2. Workers scan the garment with electronic readers and build a database detailing all the sizes and custom fits available.

3. Workers scan the stacks of jeans to discover which sizes have sold out and need to be replenished.

4. Customers who purchase the jeans take the sensors home when they leave the store, but throw them in the trash along with other packaging before wearing them.

Privacy advocates worry this tags exposes consumers to the possibility that criminals or unscrupulous marketers will scan their garbage to learn their purchasing behavior.

Source: the company
Hitachi μ-chip

- 0.4 mm square
- 128-bit storage
- Range: 1 foot
- Embedded antenna
- Small enough to put in currency
Euro Banknotes

- European Central Bank announced plans to implant RFID tags in banknotes

- Uses
  - Anti-counterfeiting
  - Tracking money flows
Hitachi RFID “Powder”

• 1/64 the size of a μ-chip!

Source: SCIENTIFIC AMERICAN
Electronic Product Code (ePC)

- Extension of barcode
- Every item in the world has a distinct serial number
- Capacity for 200 billion serial numbers per item (on a 96-bit tag)
Cheap and ultraslim circuits could make the internet of things a reality

From medicine to legal documents, small integrated circuits promise revolutionise how we interact with everyday objects

In Scott White’s vision for the supermarket of the near future, there would be no irritating interruption, no barcodes to scan and no check-outs. Instead shoppers would simply load their trolleys and walk out of a supermarket with wireless technology registering all of the items they have bought from tiny flexible circuits embedded on the food packaging.

“With something which is slimmer than a human hair and very flexible, you can embed that in objects in a way that is not apparent to the user until it is called upon to do something. But also the cost is dramatically lower than with conventional silicon so it allows it to be put in products and packaging that would never justify the cost of a piece of normal electronics,” said White.

One of the first possible uses which has emerged is in blister packets for medication. If combined with a printed battery, a light could show the right time to take the next pill in a packet and the packaging could communicate directly with a doctor.
No-power Wi-Fi connectivity could fuel Internet of Things reality

Imagine a world in which your wristwatch or other wearable device communicates directly with your online profiles, storing information about your daily activities where you can best access it – all without requiring batteries. Or, battery-free sensors embedded around your home could track minute-by-minute temperature changes and send that information to your thermostat to help conserve energy.

This not-so-distant “Internet of Things” reality would extend connectivity to perhaps billions of devices. Sensors could be embedded in everyday objects to help monitor and track everything from the structural safety of bridges to the health of your heart. But having a way to cheaply power and connect these devices to the Internet has kept this from taking off.

Now, University of Washington engineers have designed a new communication system that uses radio frequency signals as a power source and reuses existing Wi-Fi infrastructure to provide Internet connectivity to battery-free devices. Called Wi-Fi backscatter, this technology is the first that can connect battery-free devices to Wi-Fi infrastructure.
Smartphone as Sensor

At least 14 sensors!

SOURCE: THEODOROS MICHALAREAS
WE WANT TO IMPLANT THIS RFID TAG IN YOU.

THAT VIOLATES MY RIGHTS!

WE WANT TO IMPLANT THIS RFID TAG IN YOU
AND IT'S ALSO A CELLPHONE,
DIGITAL CAMERA, AND
MP3 PLAYER.

WRONG

RIGHT

David Farley, d-farley@ibiblio.org
Under China’s totalitarian system, the government watches our every move...

...and in a free country, that’s done by the private sector?
The Internet of Food

- Smart appliances, smart pantry
Smart Refrigerator Data Model
The Internet of Sports

X-Cell: Measures quickness, reaction speed, intensity of play, jump height and heart rate

Speed cell: on-shoe sensor records speed, distance and stride rate

Smart run: personalized, realtime coaching

Smart ball: records speed and rpm
The Internet of Health

- Proteus Pill Consumption Tracking
- AgaMatrix Glucometer
- Continuous blood chemistry patch
- Wireless EEG
- Sotera Visi-Mobile
- iRhythm cardiac sensor
Intelligent Pharmaceuticals

- Ingestible RFID Pill
- Skin Patch Receiver
- Implantable Electronics at sub-millimeter scale
- EKG etc. on smartphone

SOURCE: PROTEUS
THE UNIVERSITY OF HONG KONG
MARCH 9, 2015
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Vehicles as Computing Platforms

- Weight, power, memory not limiting
- Vehicles as sensor platforms
  - GPS, video, pollution, radar, road conditions
- Onboard data processing (reduces server and communication load)
- Local vehicular ad hoc cloud

SOURCE: MARIO GERLA
WASHINGTON

NHTSA Proposes Mandating V2V Communications

Move would light fire under need to establish ability to share with cable Wi-Fi

8/18/2014

By: John Eggerton

The FCC has been studying whether cable Wi-Fi using unlicensed spectrum and widespread intelligent vehicle-to-vehicle (V2V) communications, which has a license to use the spectrum, can coexist in the 5.9 GHz band—the FCC thinks they can. The FCC may have to put the pedal to the metal.

The Department of Transportation’s National Highway Traffic Safety Administration has put out an Advance Notice of Proposed Rulemaking (ANPRM) proposing to require all new passenger cars and light trucks be capable of talking to each other to help avoid and mitigate crashes. NHTSA concludes that, without a mandate, the market would not develop on its own, or at least not fast enough, because there would not be any benefit to early adopters. “NHTSA believes that no single manufacturer would have the incentive to build vehicles able to ‘talk’ to other vehicles, if there are no other vehicles to talk to – leading to likely market failure without the creation of a mandate to induce collective action,” NHTSA said in the notice.
Sensors for Safe Driving

Vehicle type: Cadillac XLR
Curb weight: 3,547 lbs
Speed: 75 mph
Acceleration: +20m/sec^2
Coefficient of friction: .65
Driver Attention: Yes

Alert Status: None

Vehicle type: Cadillac XLR
Curb weight: 3,547 lbs
Speed: 65 mph
Acceleration: -5m/sec^2
Coefficient of friction: .65
Driver Attention: Yes

Alert Status: None

Vehicle type: Cadillac XLR
Curb weight: 3,547 lbs
Speed: 45 mph
Acceleration: -20m/sec^2
Coefficient of friction: .65
Driver Attention: No

Alert Status: None

Vehicle type: Cadillac XLR
Curb weight: 3,547 lbs
Speed: 75 mph
Acceleration: +20m/sec^2
Coefficient of friction: .65
Driver Attention: Yes

Alert Status: Inattentive Driver on Right
Alert Status: Slowing vehicle ahead
Alert Status: Passing vehicle on left

Vehicle type: Cadillac XLR
Curb weight: 3,547 lbs
Speed: 75 mph
Acceleration: +10m/sec^2
Coefficient of friction: .65
Driver Attention: Yes

Alert Status: None

Vehicle type: Cadillac XLR
Curb weight: 3,547 lbs
Speed: 75 mph
Acceleration: +20m/sec^2
Coefficient of friction: .65
Driver Attention: Yes

Alert Status: Passing Vehicle on left
The Connected Car

SOURCE: NATIONAL MUSEUM OF EMERGING SCIENCE AND INNOVATION
Internet of Everything

• Cisco: 99.4% of things that should be connected aren’t
• Prediction: 200-800 Billion Devices in 10 years

SOURCE: HARBOR RESEARCH
Beacons

- Transmitters that communicate with smart devices
- Connecting store offers with passers-by
Beacons

- Send out a low energy Bluetooth signal every second
- Signal range varies from 2-500 meters
- Signal contains a unique coded string which is usually the device ID. Billions of beacons have unique codes
- Plug in to wall or USB port of computer or battery-operated device
- (Not technically NFC because of longer range)
IoT “Empowering People in Their Daily Life”

In Downtown San Francisco 20-30% of all traffic congestion is caused by people hunting for a parking spot.

In Downtown San Francisco 20-30% of all traffic congestion is caused by people hunting for a parking spot.

40 million adults age 65 and over will be living alone in the U.S., Canada and Europe.
Top 10 Industries Investing in Sensors

33% Energy & Mining
32% Power & Utilities
31% Automotive
25% Industrial
22% Hospitality
20% Healthcare
20% Retail
18% Entertainment
17% Technology
13% Financial Services

SOURCE: PRICEWATERHOUSECOOPERS