Internet of Things

Introduction

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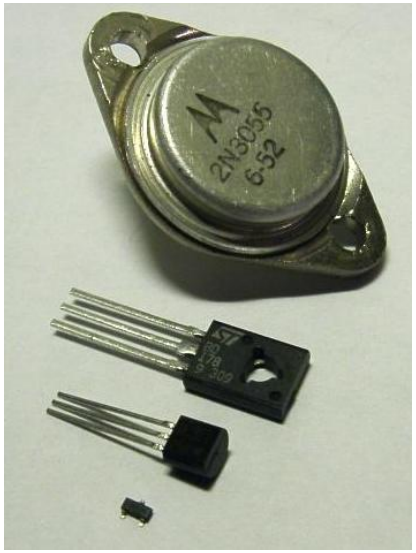
Lecture 1:
Introduction

From Vacuum Tubes . . .

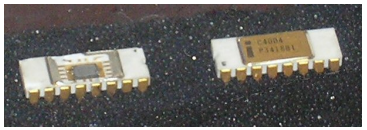
First half of the 1900s

. . . to transistors . . .

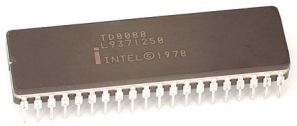


1950s

. . . to microprocessors . . .

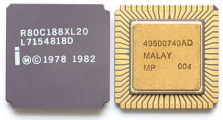


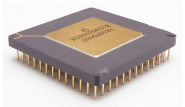
On November 15, 1971, Intel released the world's first commercial microprocessor, the 4004 operating at 740 kHz.



The Intel 8088 introduced on July 1, 1979, an 8-bit processor operating at 5 MHz.

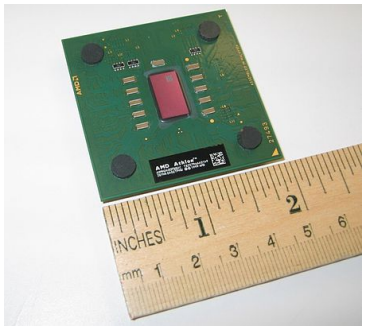
In the 1980s quick progress

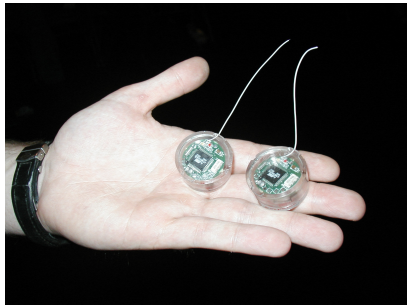


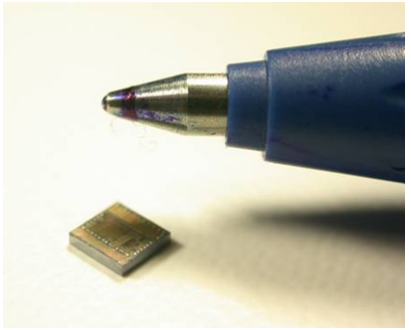


. . . to multi-chip processors . . .

In the 1990s: new designs, new developers, . . .





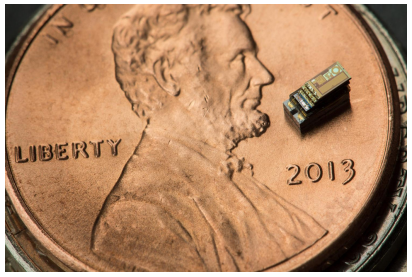


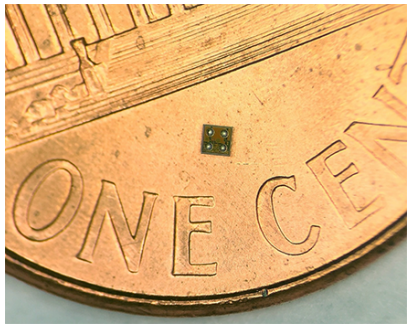
. . . to systems-on-chip . . .

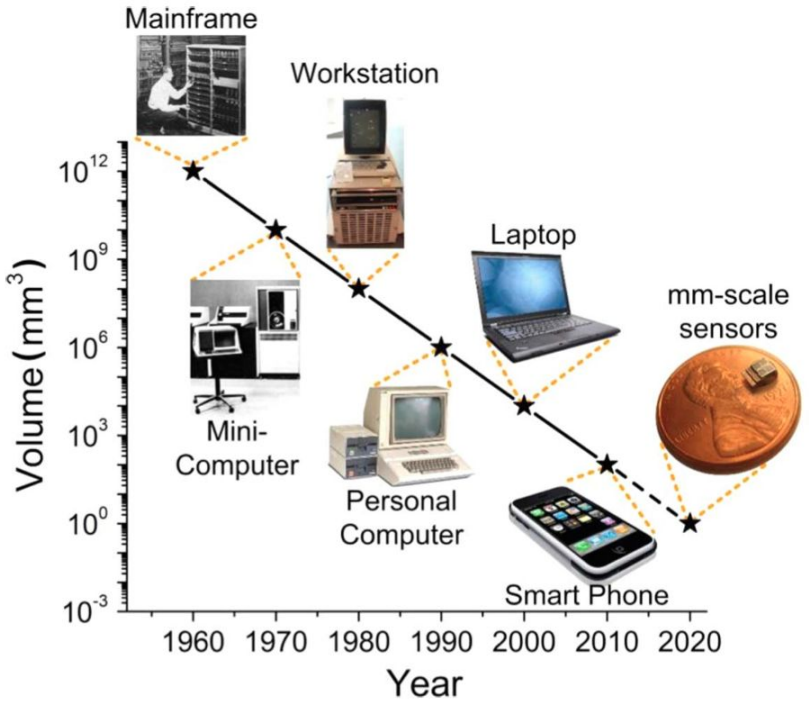
- Typically include a CPU, memory and secondary storage,
- digital and analog Input-Output ports,
- radio frequency signal processing functions,
- networking technologies

. . . to millimeter-scale micro motes

- Combining CPU, memory, I/O, battery, sensors, networking . . .

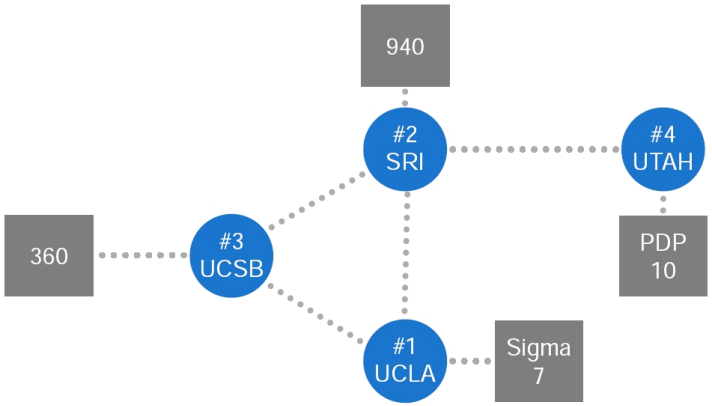




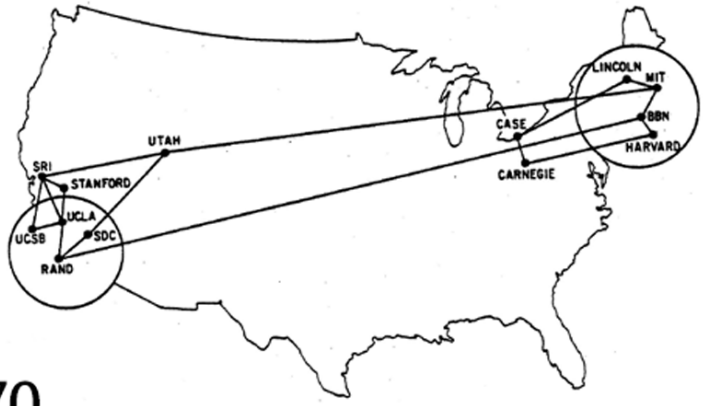


The beginning of Internet (ArpaNet)

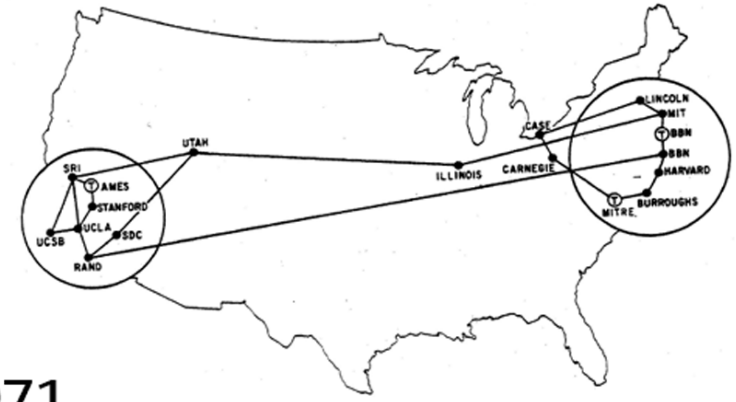
- The initial topology of the network on December, 1969
- 4 computers connected via a simple packet switching network



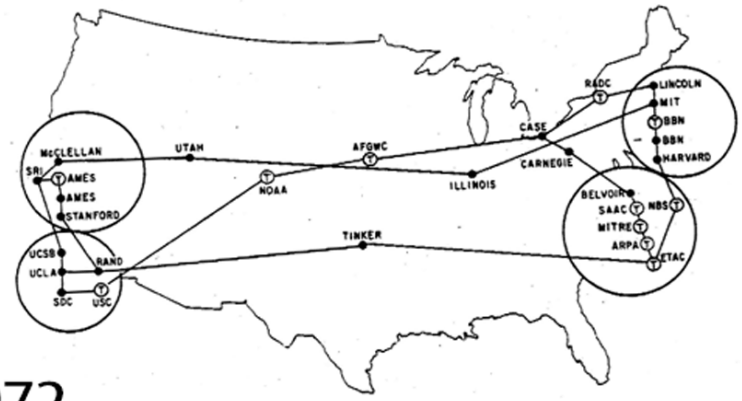
1969



1970



1971



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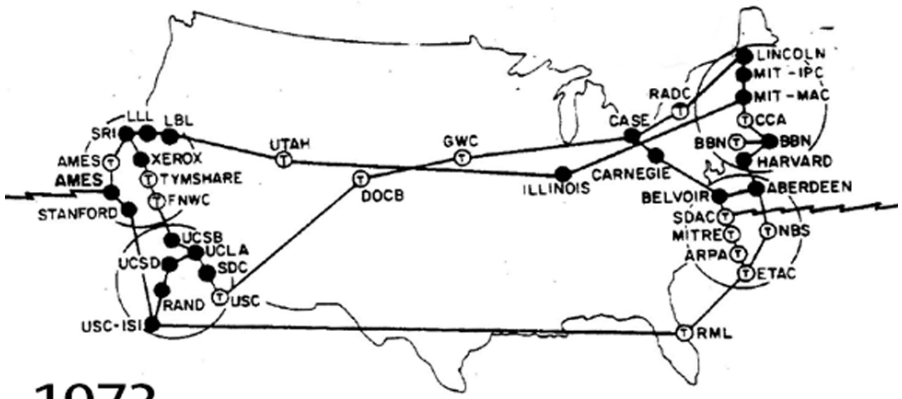
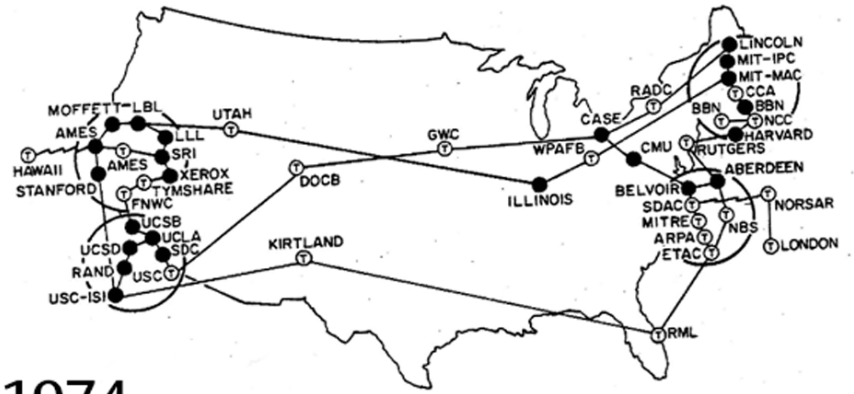
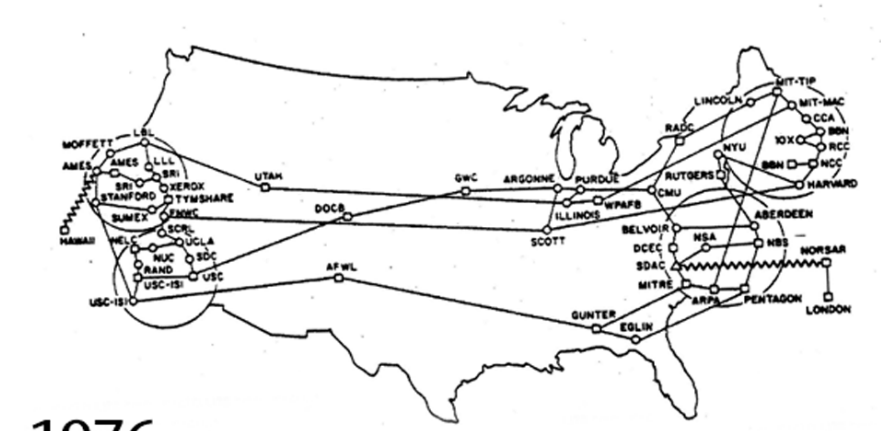


1973

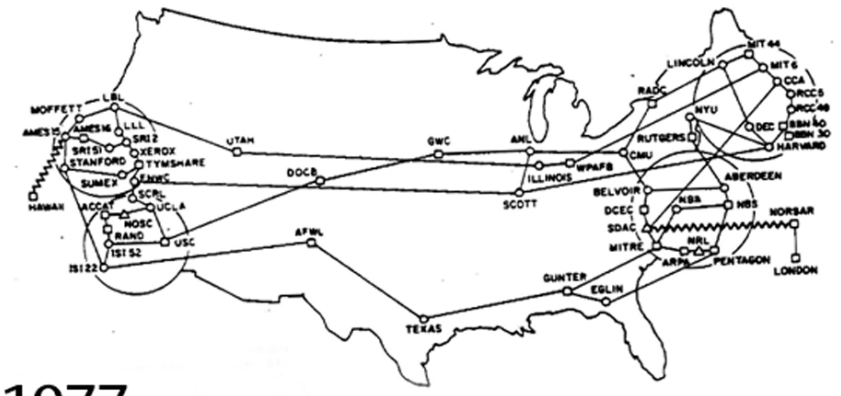


1974

1975



1976



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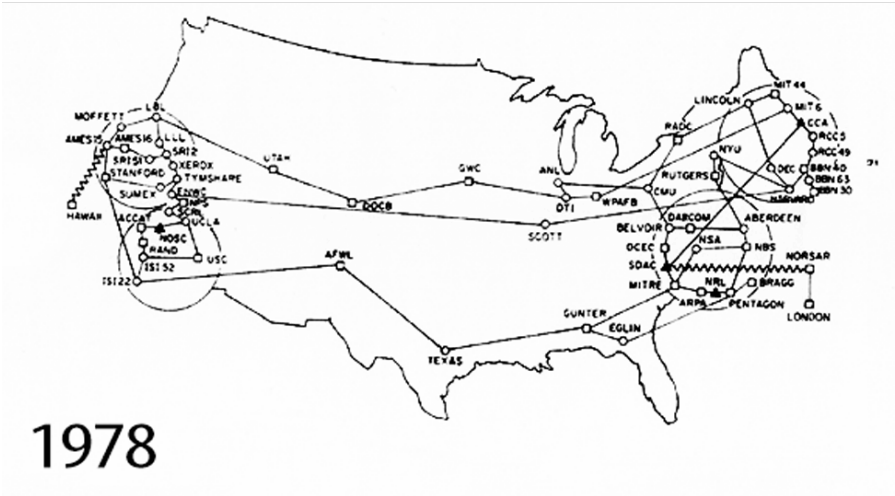
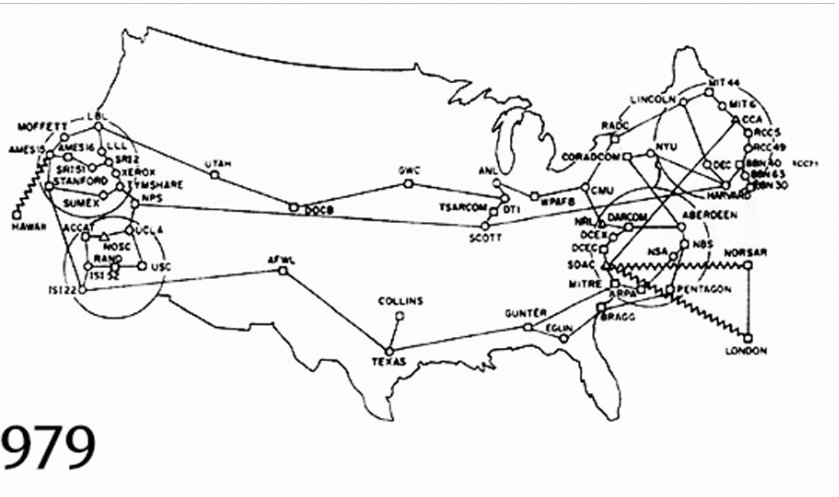
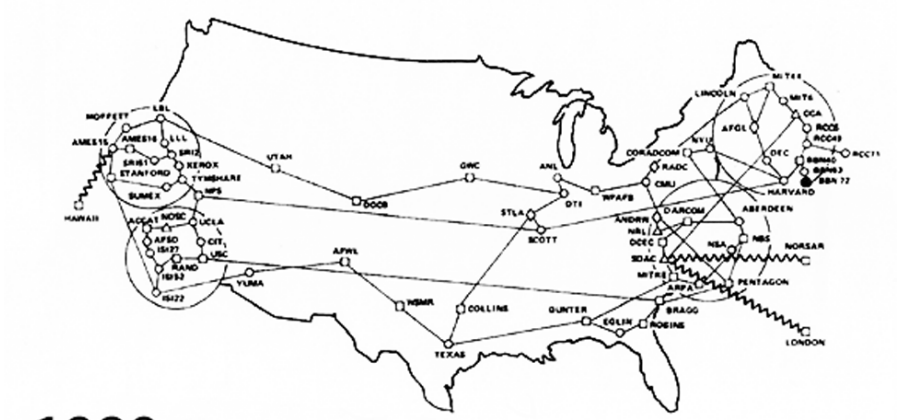


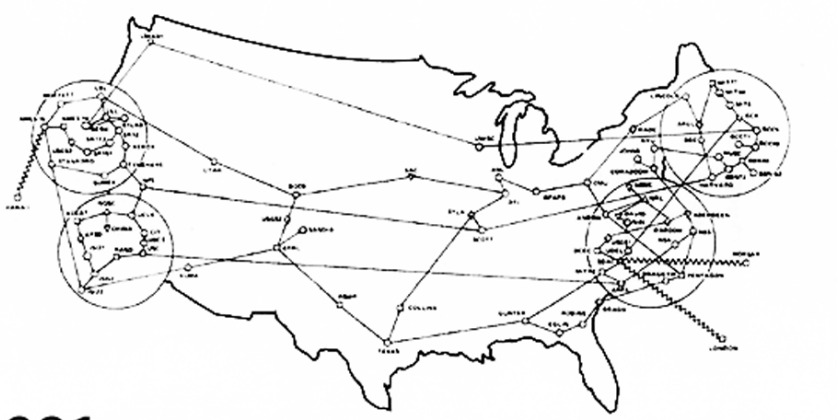
1978



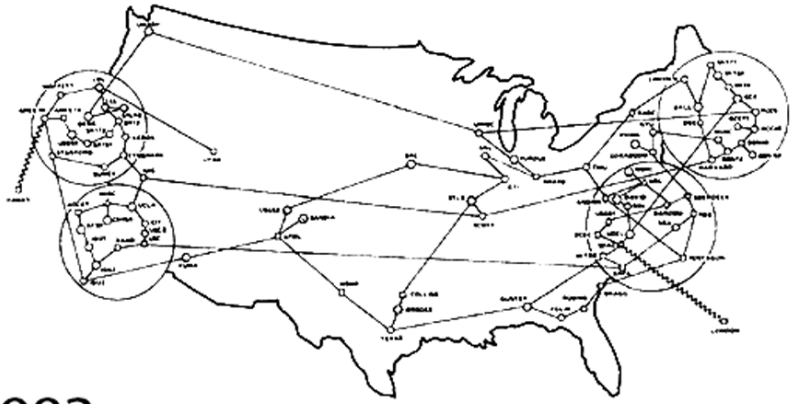
1979



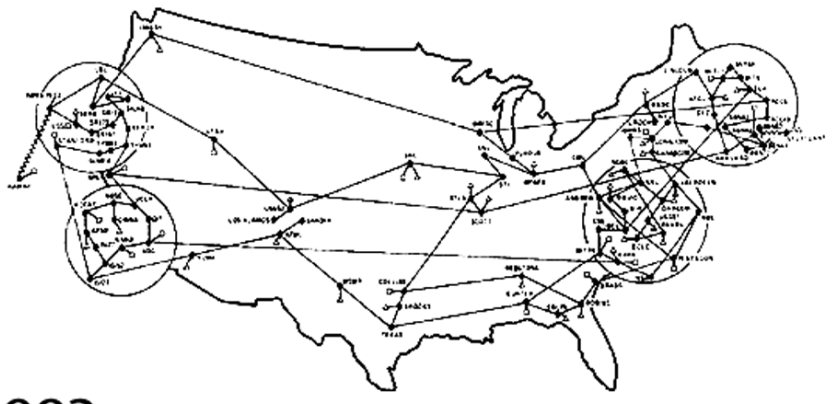
1980



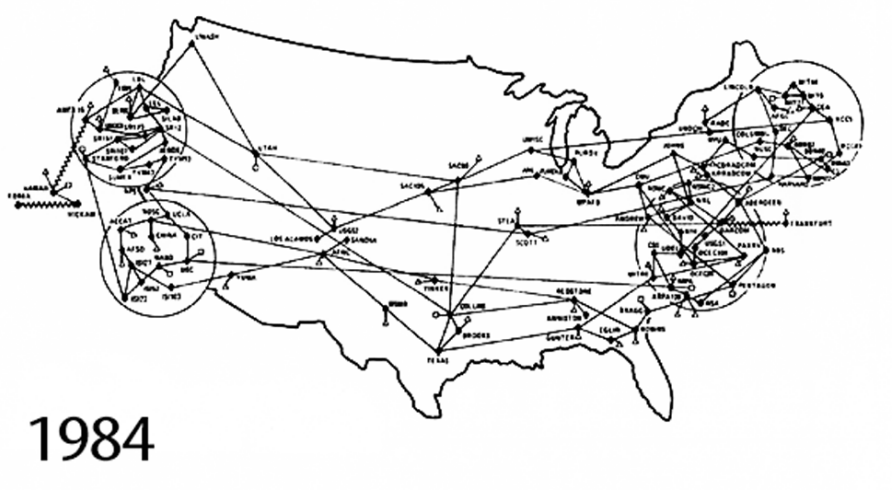
1981



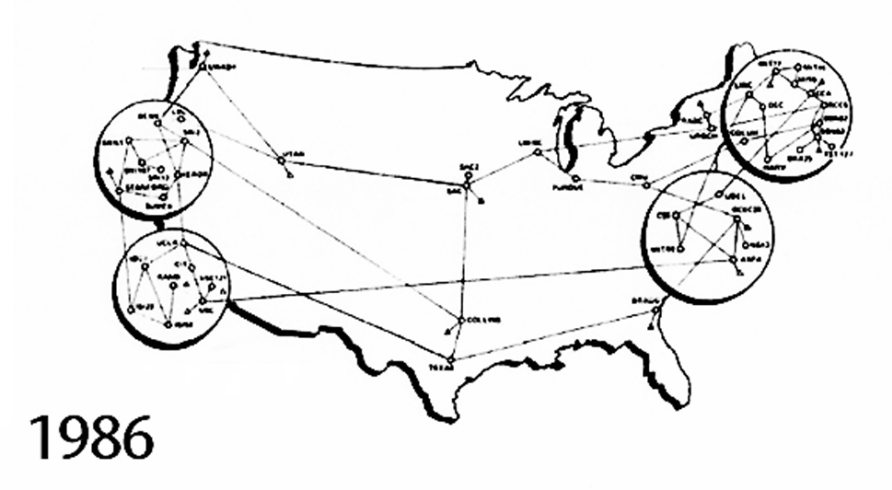
1982



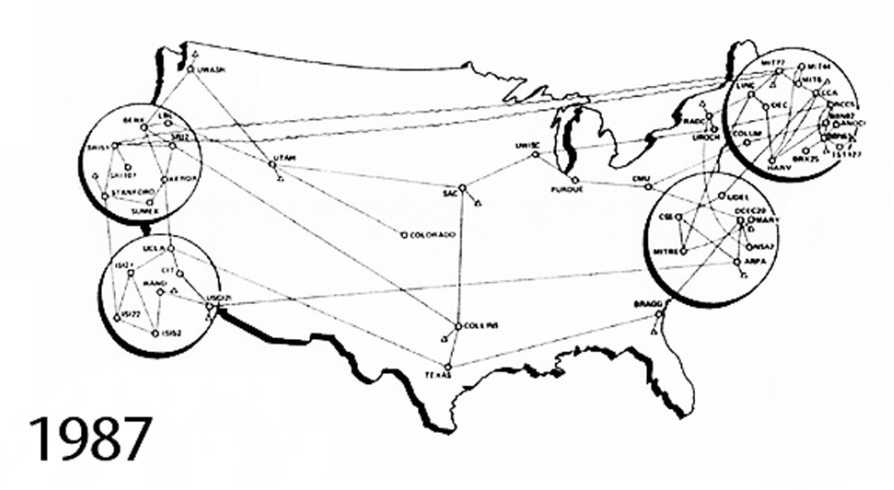
1983



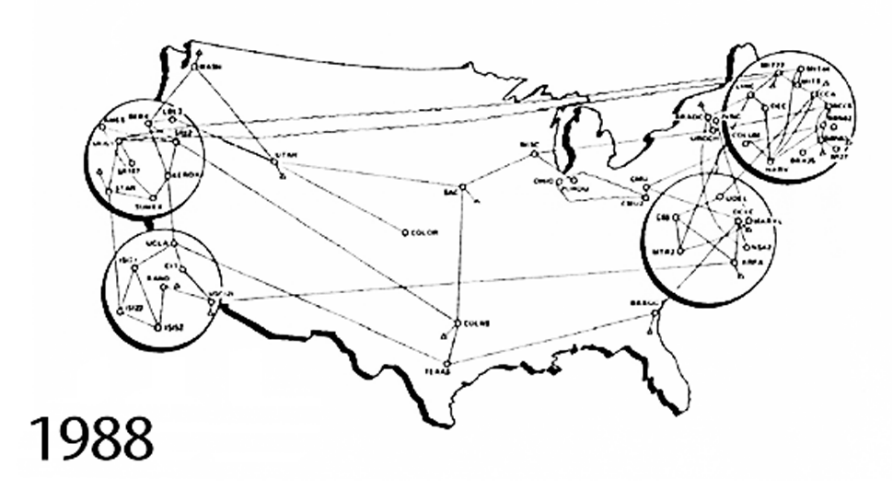
1984



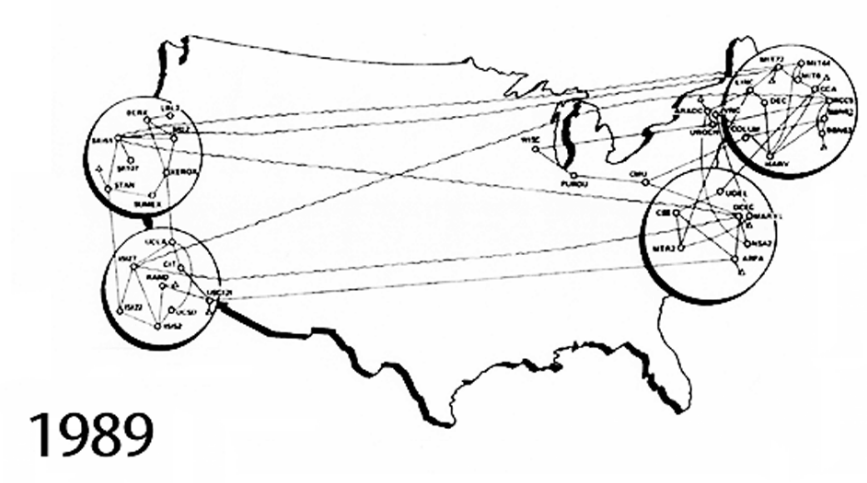
1986

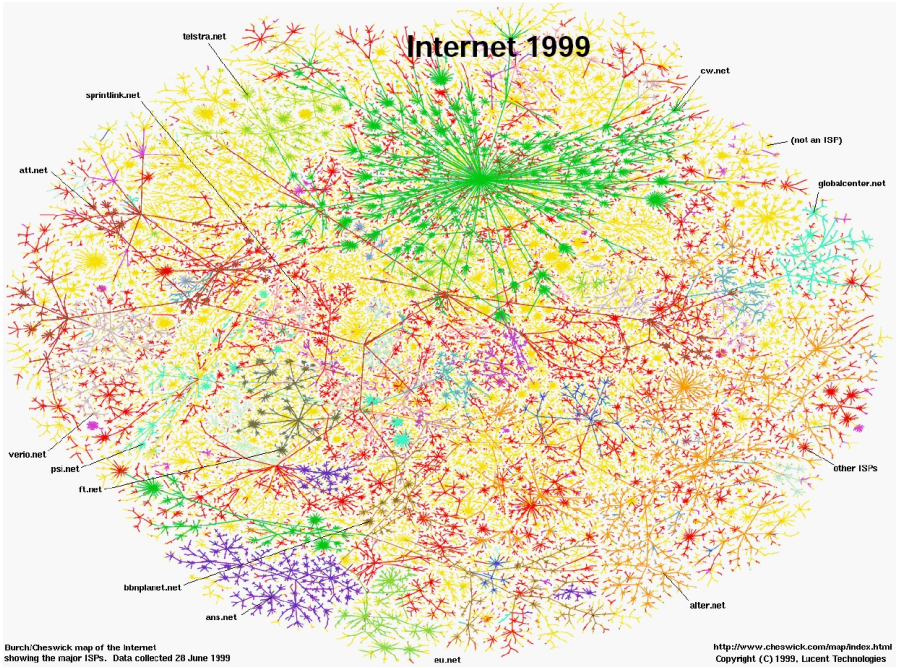


1987

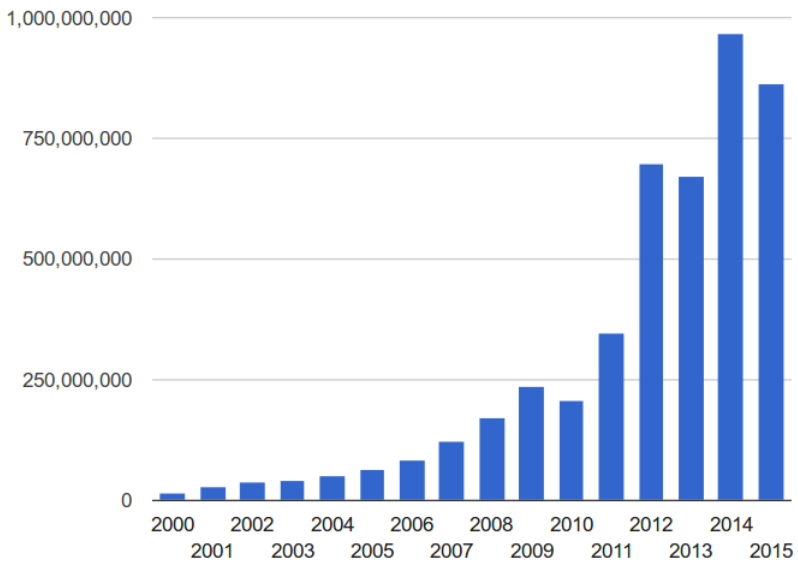


1988





Growth of web sites connected to the Internet

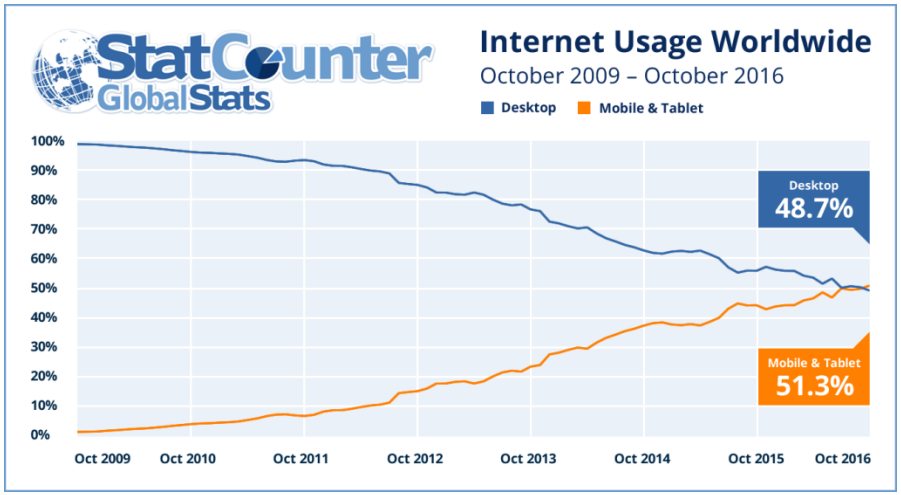


Worldwide Internet Users

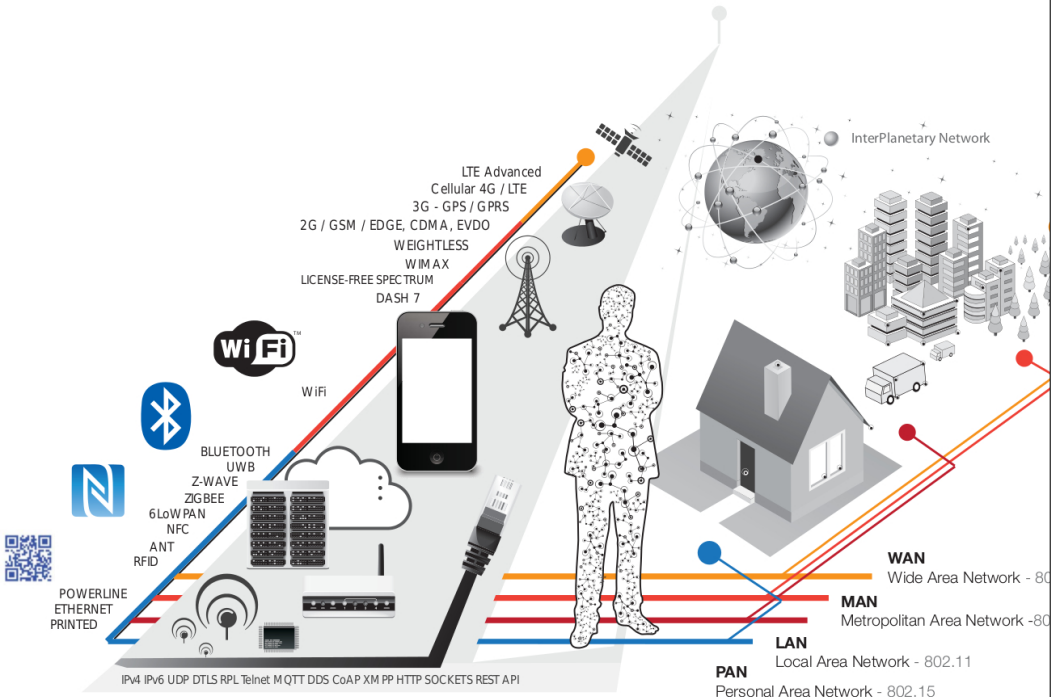
	2005	2010	2013	2016
World population	6.5 b	6.9 b	7.1 b	7.5 b
Not using the Internet	84%	70%	61%	54%
Using the Internet	16%	30%	39%	46%
Users in the developing world	8%	21%	31%	34%
Users in the developed world	51%	67%	77%	79%

Source: International Telecommunication Union official website

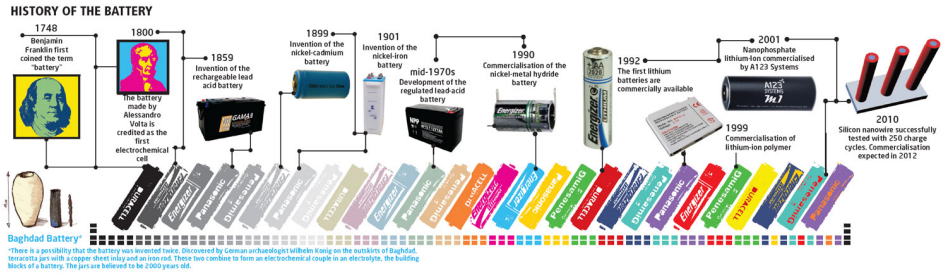
Mobile vs Static Internet Usage

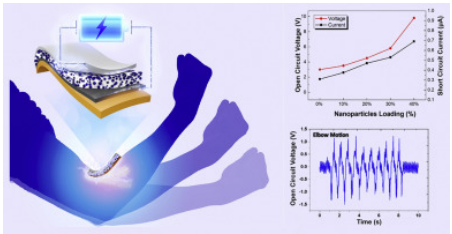


Broad range of connectivity options

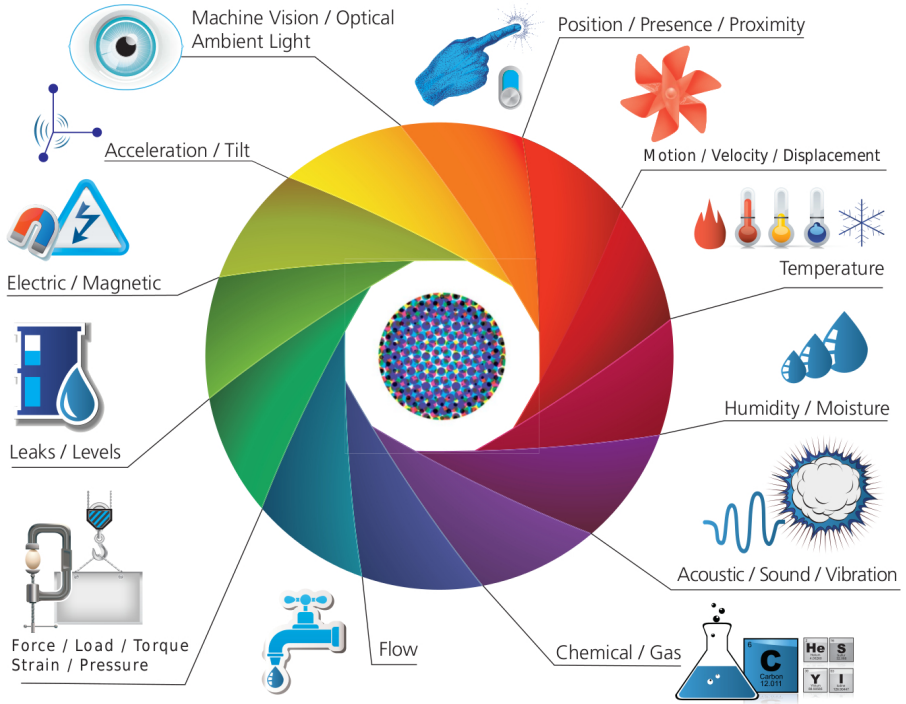


From batteries to energy harvesting, to nanogenerators

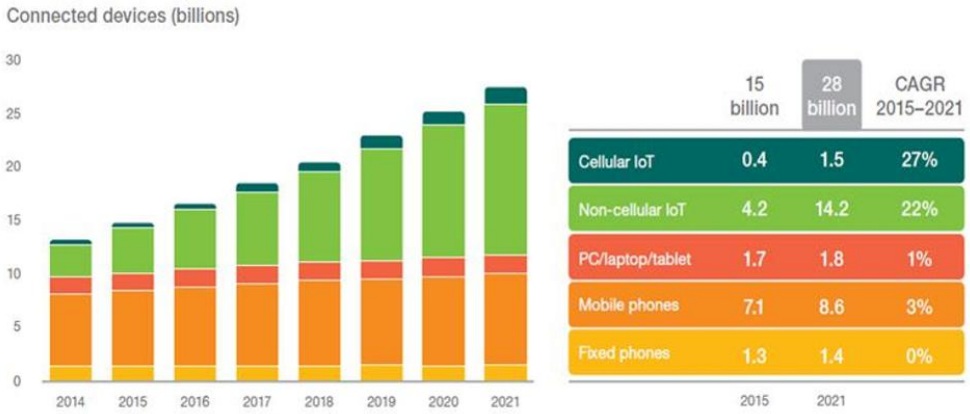




Sensors & Actuators: a digital nervous system

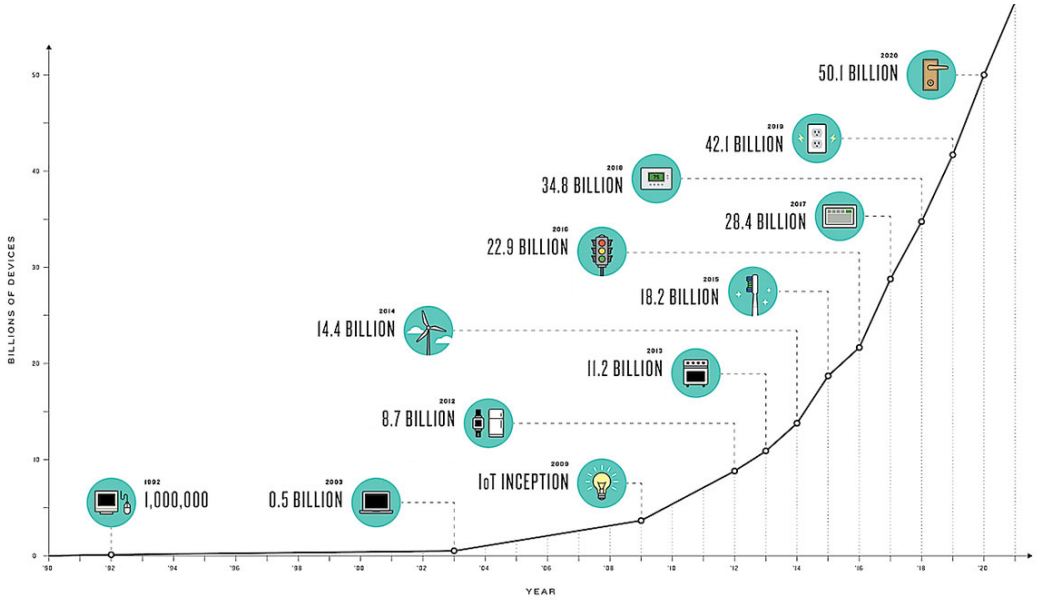


Things, People & Processes are becoming connected



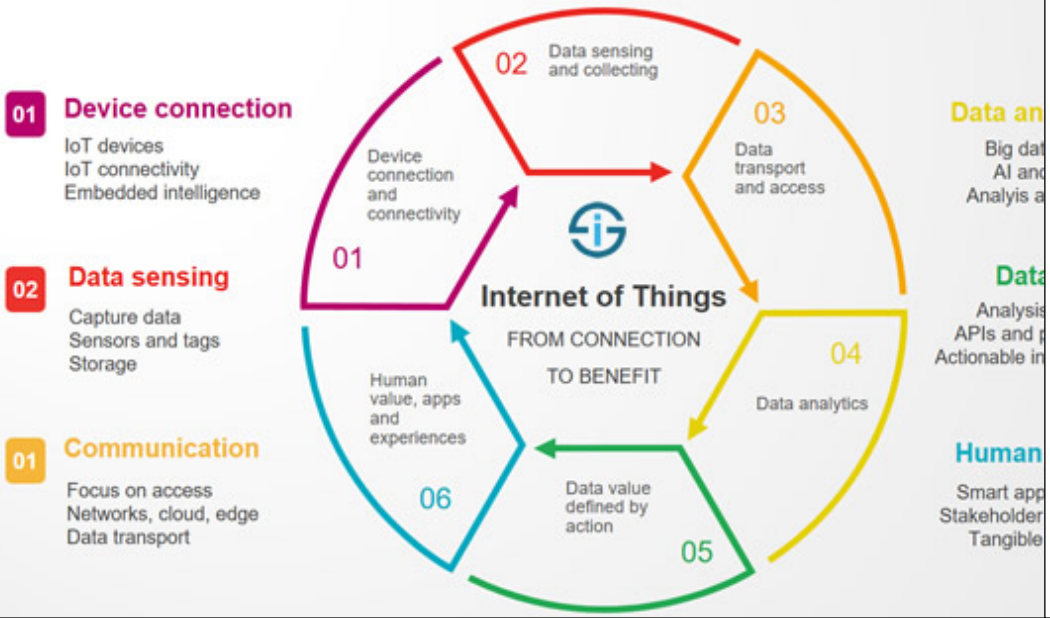
	15 billion	28 billion	CAGR 2015–2021
Cellular IoT	0.4	1.5	27%
Non-cellular IoT	4.2	14.2	22%
PC/laptop/tablet	1.7	1.8	1%
Mobile phones	7.1	8.6	3%
Fixed phones	1.3	1.4	0%

An explosion of connected possibility

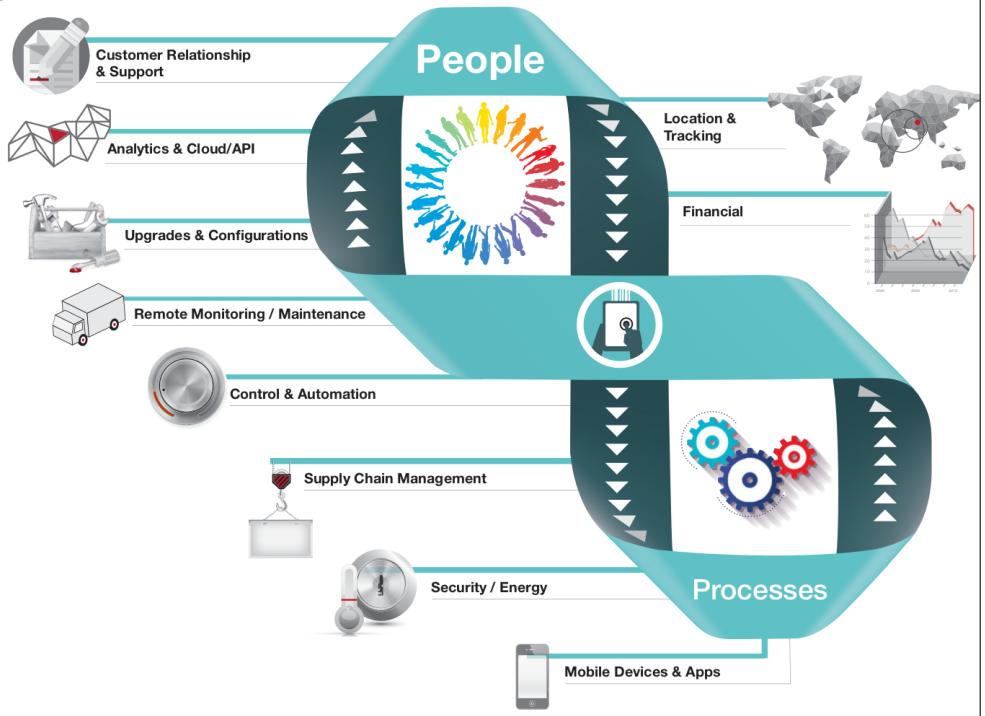


The Internet of Things

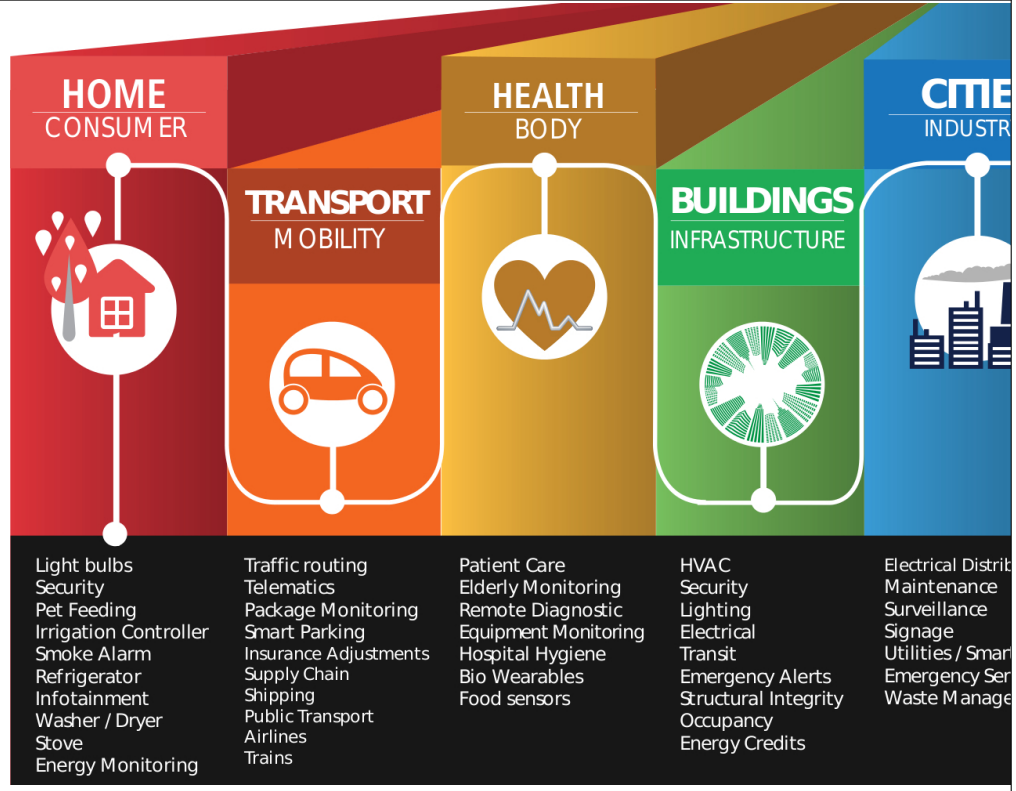
From connecting devices to human value

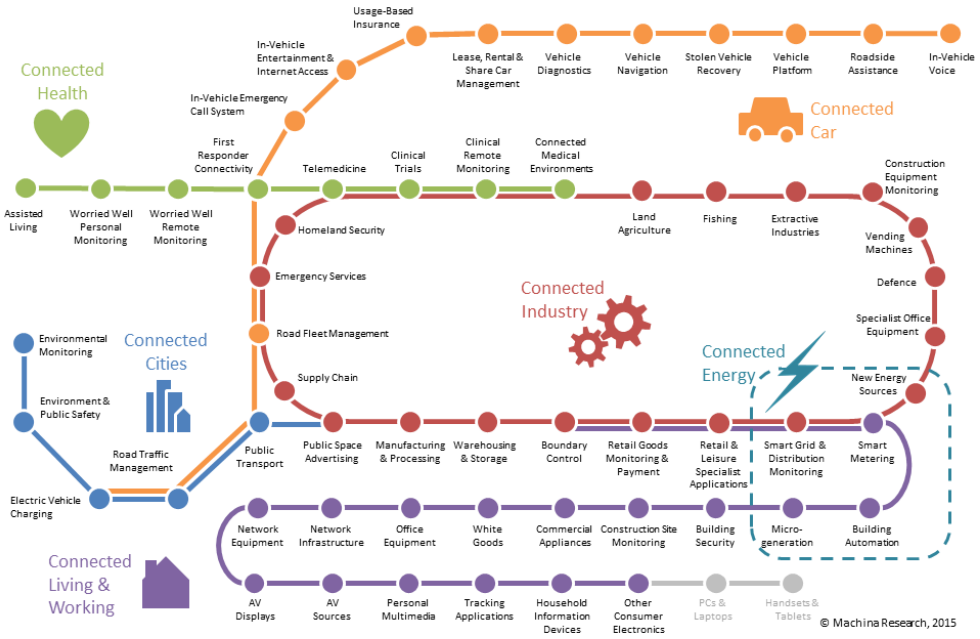


People & Processes: bi-directional systems

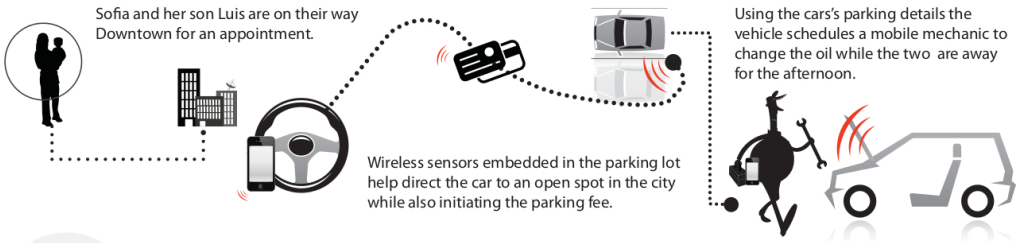


The interactions between these
SENSORS + CONNECTIVITY + PEOPLE + PROCESSES
entities are creating new types
of smart applications and services.





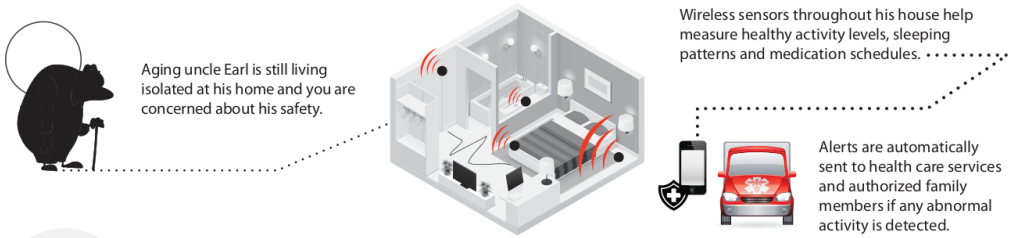
Transportation & Smart Cities



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

- San Francisco Municipal Transportation Agency (SFMTA)

Healthcare & Smart Home



Aging uncle Earl is still living isolated at his home and you are concerned about his safety.

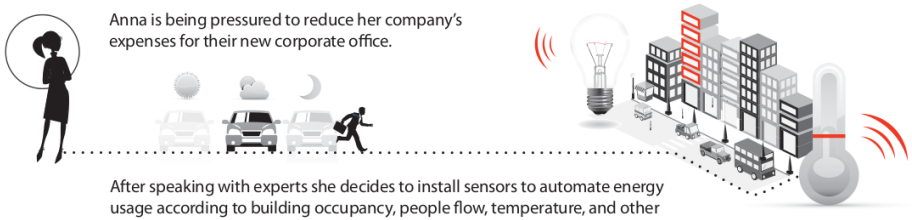
Wireless sensors throughout his house help measure healthy activity levels, sleeping patterns and medication schedules.

Alerts are automatically sent to health care services and authorized family members if any abnormal activity is detected.

40 million adults age 65 and over will be living alone in the U.S, Canada and Europe.

- U.S. Department of Health and Human Services: Administration for Community Living (ACL)

Mobility & Smart Buildings



Anna is being pressured to reduce her company's expenses for their new corporate office.

After speaking with experts she decides to install sensors to automate energy usage according to building occupancy, people flow, temperature, and other ambient conditions -- improving the building's overall efficiency.

Energy used by commercial and industrial buildings in the US creates nearly 50% of our national emissions of greenhouse gases.

- United States Environmental Protection Agency

REAL-TIME SERVICE NETWORKS

- Appliance Monitoring
- Predictive Maintenance
- Service Technician / CRM
- Waste Management / Recyding

R Hotel Denver,
Industrial Washer #GHS40-2608

Location: ID: *FC-RM #00243*
Manufacturer: *Appliance Park Louisville, KY* ID: *#45205343*
Materials: *FC / SUS*
Sensor: *Vibration*
Connectivity: *Wireless*

Connor, the Lead Maintenance Manager at the R Hot receives a sensor notification that the pump body O- washing machine #230243 is starting to fail in the ho laundry room.

On his mobile, Connor prompts the machine to orde This action triggers a bidding opportunity for local s technicians within the product's authorized mainten

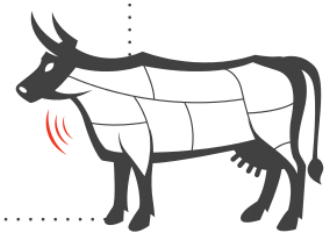
The request lays out:
- *Pricing parameters*
- *Timing requirements*
- *Machine history*
- *Part specs*
- *Predictive se measuremen*

Tom from IA Appliances bids on the service request a notification a few moments later that his bid was acc

Within 1.5 hours, a service technician from IA Appliar (Using a temporary facility access code for the wireless door l the water pump. Connor sends a brief note on the se quality and IA Appliances releases a bid request for t materials to local recycling centers.

DIGITAL FARM TO TABLE

- Farm & Livestock ID & Sensors
- Food packaging sensors
- Retail Supply Chain Monitoring
- Health Services



Cattle
AIN: 840 003 123

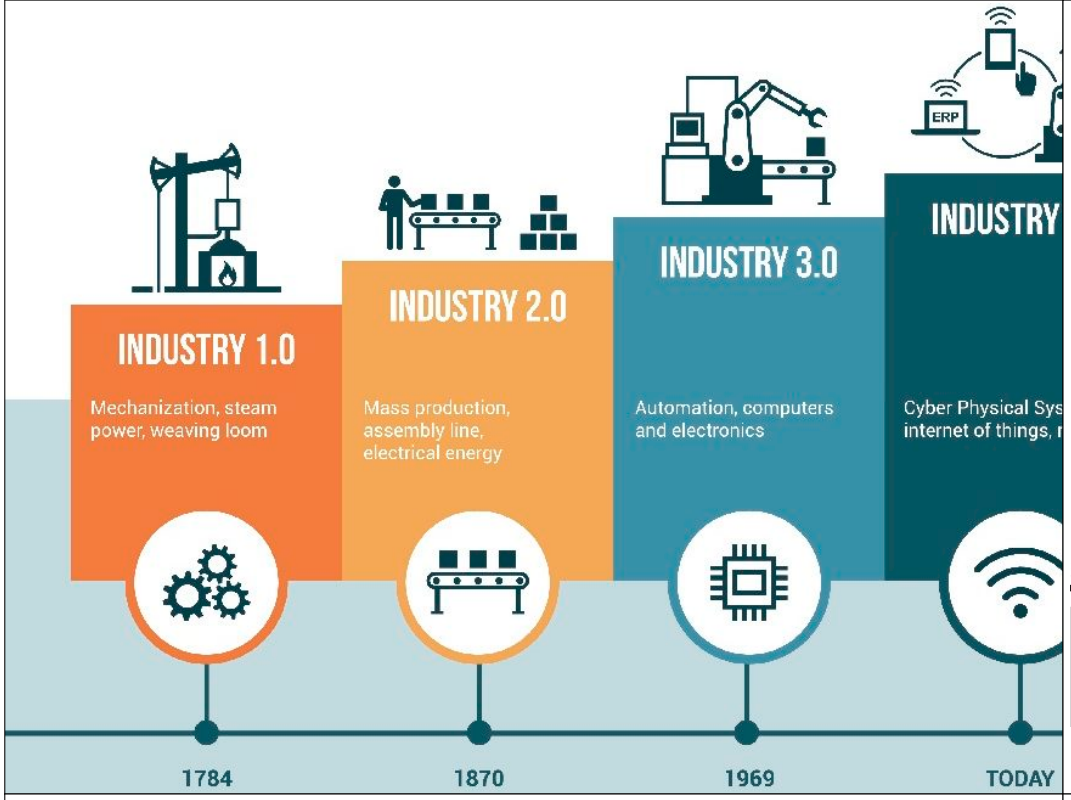
Location: ID: Braymea *#00285453543*
Slaughterhouse ID:
Sensor: *Temperature, A*
Connectivity: *RFID, N*

Maria and her daughter are picking up groceries for the packaging with printed sensors, the two can make sure beef they are purchasing has never reached unsafe tem while on the shelf or being transported.

The packaging also contains a QR code which they can the cow's RFID tag and bring up its history:

- *Where it was raised*
- *What it was fed*
- *Where it was slaughtered*
- *How it was transported*
- *Where it was*
- *The last time i*

A week later the U.S. Department of Agriculture's Food S determines ground beef from originating from a region company and sold at a neighboring store is contaminat O157:H7. All packages from this distributer change thei color and notification messages are sent to those shopp have been impacted.



A interesting era

- The Internet gave us the opportunity to connect in ways we could never have dreamed possible.
- The Internet of Things takes us beyond connection to become part of a living, moving, global nerbous system.
- Whether you are an individual, technology developer, or adopter of these technologies, the Internet of Things streches the boundaries of today's systems.
- Are you prepared for the changes in the way we learn, work and innovate?

New Era, Great Opportunities, Join in + be a part of it!

Goal of Course

- Introduce emerging application scenaria.
- Study characteristic design approaches of Internet of Things.
- Examine essential distributed computing paradigms.
- Engineer algorithms in open-design.
- Conduct real-world experimentation.

Part 1: Technological Foundations

1. Embedded Programming
   - STM Nucleo Platform
   - Arm MBed
2. Large scale experimentation
   - IOT-Lab facilities
3. Operating system for the Internet of Things
   - Riot OS
4. Machine-to-Machine Communication
   - IPv6LoWPAN (RPL), MQTT
5. Low-Power Wide-Area Networks
   - LoRA, TheThingsNetwork
6. Security and Cryptography
   - Eliptic Curve Cryptography, Blockchains

Part 2: Enabling Technologies

1. Hardware Prototyping Platforms
2. Wearables and Other devices
3. NFC Beacon Technologies
4. Back-end Infrastructure and Middleware
5. Cloud Services
6. Machine Learning on Chip

Part 3: Intelligent Environments

1. Interaction Design for Pervasive & Ubiquitous Computing
2. End-user driven development
3. UX Design for Ambient Intelligence
4. Smart Cities
   - Social Smart Cities
5. Collective Intelligence
   - Participatory Sensing
6. Delay-Tolerant Computing

Projects & Exams

1. Group Mini-project:
   - 3 people per project.
   - Technology oriented.
   - Development of a Proof-of-Concept.
   - Presentation of PoC in class.
   - Presentation of technologies in class.
2. Group Project:
   - 3 people per project.
   - Design an application utilizing the Internet of Things.
   - Develop the system using appropriate technologies.
   - Test & Evaluate in real-world conditions.
   - Open-source – Open-design.

Group Mini-project

1. Hardware Prototyping Platforms
   - Genuino 101
   - Nucleo64
2. Wearables
   - Huawei Watch 2 - Wear OS
   - Amazfit Bit
   - Polar HR Sensor
3. NFC Beacon Technologies
   - Estimote
   - Sensoro
   - AltBeacon

Group Mini-project (cont)

4. Cloud Services
   - AWS IoT
   - Azure IoT Hub
   - IBM Watson Internet of Things
   - Elastic Search
5. Time-series DB
   - InfluxDB
   - OpenTSDB
6. Edge Analytics
   - Apache Edgent
   - OpenTSDB

Group Mini-project (cont)

4. Machine Learning on Edge
   - Tensorflow Lite
   - uTensor
5. Visual Analytics
   - Grafana
   - Kubana
   - Tableau
   - Graphite
   - Mango Mirror

Group Mini-project Topics

1. Monitoring Workers' stress levels
   - Polar HR Sensor, Tensorflow Lite, AWS IoT, Kibana
2. Monitoring Elders
   - Amazfit Bit, Apache Edgent, Azure IoT Hub, Mango Mirror
3. Attendance Monitoring
   - Beacons, Azure IoT Hub, Graphana
4. Workflow Monitoring
   - Wear OS, Jasper, AWS IoT
5. Car Monitoring
   - OBD, Apache Edgent, IBM Watson IoT, Kibana

Group Mini-project Topics (cont)

6. Product Monitoring
   - Nucleo, TheThingsNetwork, Elastic, Graphite
7. Air Quality Monitoring
   - Atmospheric Sensors, uTensor, TheThingsNetwork, InfluxDB, Tableau
8. Smart Acquaponics
   - Genuino 101, TheThingsNetwork, OpenTSDB, Graphana

Personal Mini-project Timeline

1. Topic Assignment
   - Friday, March 8, 2019
2. PoC Presentations – Each group a 30' presentation
   - Tuesday, April 9, 2018
   - Thursday, April 11, 2018
   - Tuesday, April 16, 2018
3. Technologies Technologies Presentations – Per technology category a 30' presentation
   - Thursday, May 9, 2018
   - Tuesday, May 14, 2018
   - Thursday, May 16, 2017

Group Project Topics

1. Group Formation
   - Friday, March 9, 2018
2. Topic Selection
   - Friday, April 5, 2018
3. End-user Driven Design
   - Friday, April 30, 2018
4. MVP / Evaluation / Field-Trials
   - Friday, May 7, 2018
5. Final Presentation / Demo
   - Thursday, May 30, 2018