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Topic Title 11: Future/ Contemporary Themes AKA (New Types Of Computer Systems)

ICT170: Foundations of Computer Systems

Overview

- Introduction
- Cloud and Utility Computing
- Internet of Things
- Ubiquitous computing
- Some of my ideas
- Some of the experts ideas

Objectives

The focus of this topic is on future themes of computer systems. As such, it will assist you with attainment of the following unit learning objective:

- Demonstrate an understanding of the context in which computer systems exist and the purposes for which they are designed and built

In order to achieve the unit learning objectives, on successful completion of this topic, you should be able to:

- Understand the range of themes of computer systems.

Introduction

- Technology isn't useful in isolation
- Different technologies need to be combined
- Computer Systems comprise many technologies
- New types of Computing Systems lead to innovation

Today we'll look at three areas that have emerged due to improvements in systems technology…

- The first has led to massive change
- The second and third promise even more…

Cloud and Utility Computing

What exactly is the Cloud?

If you read the tech news you might see:

- Social Media
- Web 2.0.
- Performing computing remotely rather than locally.
- Outsourcing I.S. to someone else's computers.
- Treating Computing as a traditional Utility.
- Paradigm shift to online computation.
- Changing Internet infrastructure.
- A place to store celebrity photos.
- Lots and lots more views.

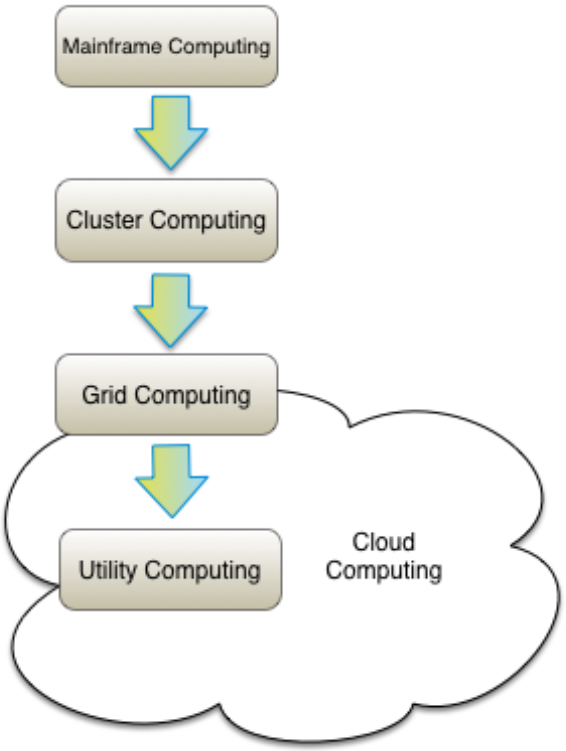
All of the above are used to describe the Cloud in public usage.

Lets look at the Cloud from a technical point of view.

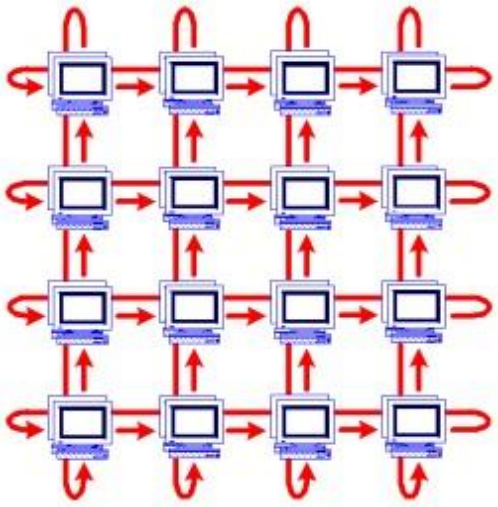
Evolution of Large-Scale Computing

Cloud Computing is part of a wider evolution of Large-Scale Computing

- Mainframe Computing
- Cluster Computing
- Grid Computing
- Utility Computing



Evolution of Large-Scale Computing



Mainframe Computing (1960s-present)

- Generally scaled-up single computers.
- Carrying out many calculations of a single task in parallel.
- Encourages tasks to be divided into smaller ones
- Used by large companies to crunch numbers.
- Great for businesses with constant needs:
  - Engineering firms
  - Banks
  - Large payroll systems

Evolution of Large-Scale Computing

Cluster Computing (1970s-present)

- For when a single mainframe isn't enough!
- Tightly linked group of computers, that can work on complex tasks.
- Connected using specialised buses.
- Originated from Military and Scientific computing.
- Can be local area (LAN) or wide area (WAN).
- Good for High-availability, Load-Balancing Computing.

Evolution of Large-Scale Computing

Grid Computing (1990s-present)

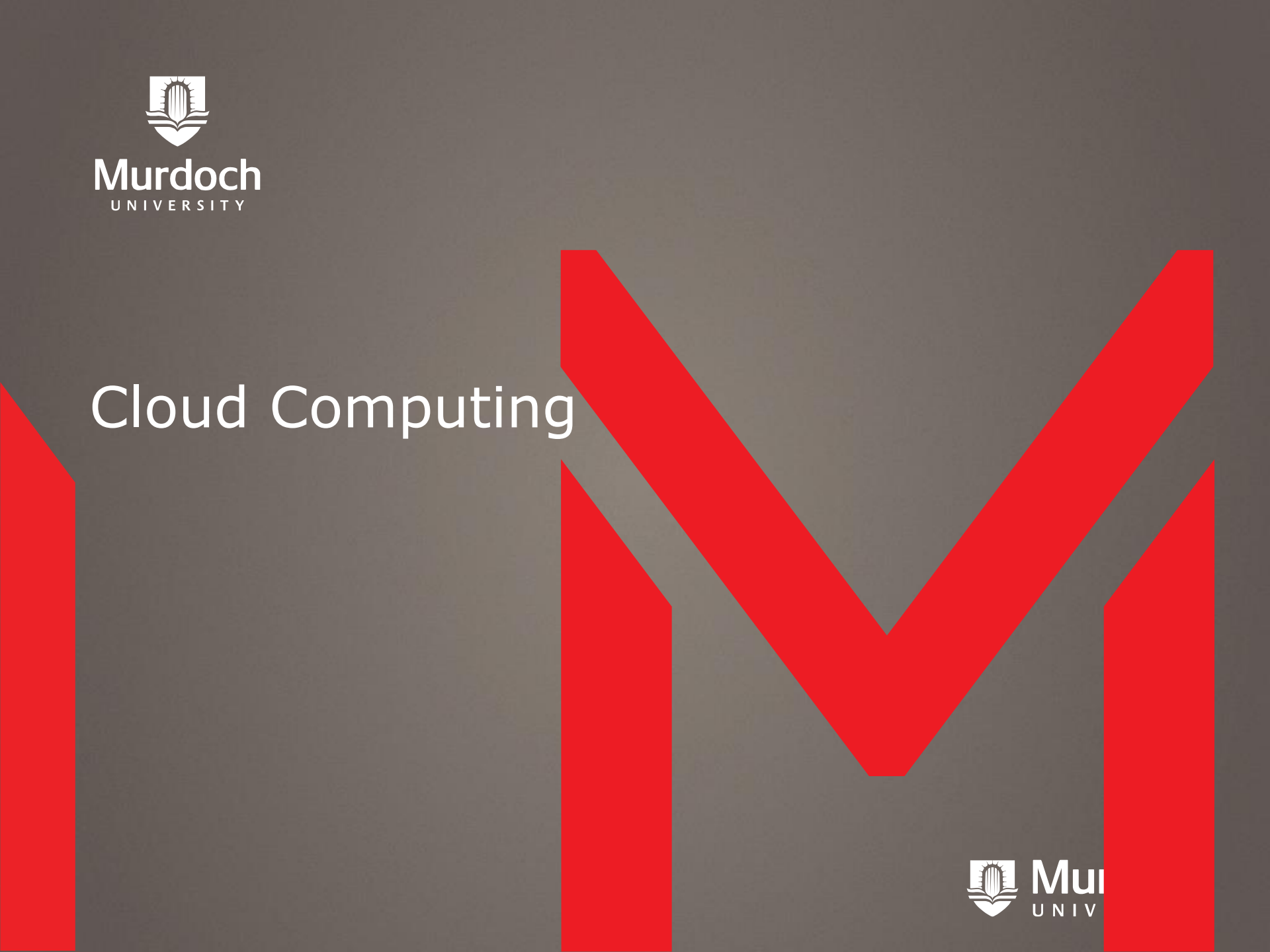
- When your own computing isn't enough!
- Combination of computing resources from multiple administrative domains.
- For tasks involving large amounts of computer cycles or data to process.
- Made up of multiple clusters.
- Customised submission and security software per grid.
- Examples include Teragrid/XSEDE (USA), D-GRID (De), GridPP(UK), EGEE (EU).

Evolution of Large-Scale Computing

Utility Computing (2010s-future)

- Computing as a traditional Utility.
- `Plug' in the wall delivers your Computing Utility.
- Metered like a traditional utility.
- No local computing, storage or software.
- "Software as a service", "Hardware as a service"
- We are at the beginning of this.

- Cloud is a bridge to this ideal…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Cloud Computing

What is Cloud Computing?

Some Definitions:

> *.. a style of computing in which **dynamically scalable** and often virtualized resources are provided as a **service over the Internet***

Wikipedia

> Cloud computing is a model for enabling **ubiquitous, convenient, on-demand access to a shared pool of configurable computing** resources…
>
> *Clouds are hardware-based services offering compute, network and storage capacity where: Hardware management is highly abstracted from the buyer, **Buyers incur infrastructure costs as variable OPEX**, and Infrastructure capacity is highly elastic*

McKinsey & Co. Report: Clearing the Air on Cloud Computing

What is Cloud Computing?

What is Cloud? Some definitions…

Definitions:

> "Cloud computing has the following characteristics: (1) **The illusion of infinite computing resources.**.. (2**) The elimination of an up-front commitment by Cloud users..**. (3).**The ability to pay for use…as needed…"**

UCBerkeley RADLabs

> "... a **pay-per-use model** for enabling available, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."

National Institute of Standards and Technology (NIST)

What is Cloud Computing?

What is Cloud? Some definitions…

Definitions:

> "Clouds are **a large pool of easily usable and accessible virtualized resources** (such as hardware, development platforms and/or services).These resources can be dynamically re-configured to adjust to a variable load (scale), allowing also for an optimum resource utilization. This pool of resources is typically exploited by a pay-per-use model in which guarantees are offered by the Infrastructure Provider by means of customized SLAs."

A break in the clouds: towards a cloud definition, Vaquero et al, ACM SIGCOMM Computer Communication Review 2009.

What is Cloud Computing?

What is Cloud? Some definitions…

Definitions:

> "you can **scale your infrastructure on demand** within minutes or even seconds, instead of days or weeks, thereby avoiding under-utilization (idle servers) and over-utilization (blue screen) of in-house resources..."

Jeremy Geelan. Twenty one experts define cloud computing. Virtualization, August 2008

> "A Cloud is a type of parallel and distributed system consisting of a collection of interconnected and virtualized computers that are **dynamically provisioned and presented as one or more unified computing resources** based on service-level agreements established through negotiation between the service provider and consumers "

Rajkumar Buyya, Chee Shin Yeo, and Srikumar Venugopal. Market-oriented cloud computing: Vision, hype, and reality for delivering it services as computing utilities. CoRR, 2008.

What is Cloud Computing?

Cloud Computing (2000s-present)

- Is a style of computing that offers:
- The illusion of infinite computing resources…
- The elimination of an up-front commitment by Cloud users...
- The ability to pay for use...as needed…

Cloud Computing Definition

A clean technical definition:

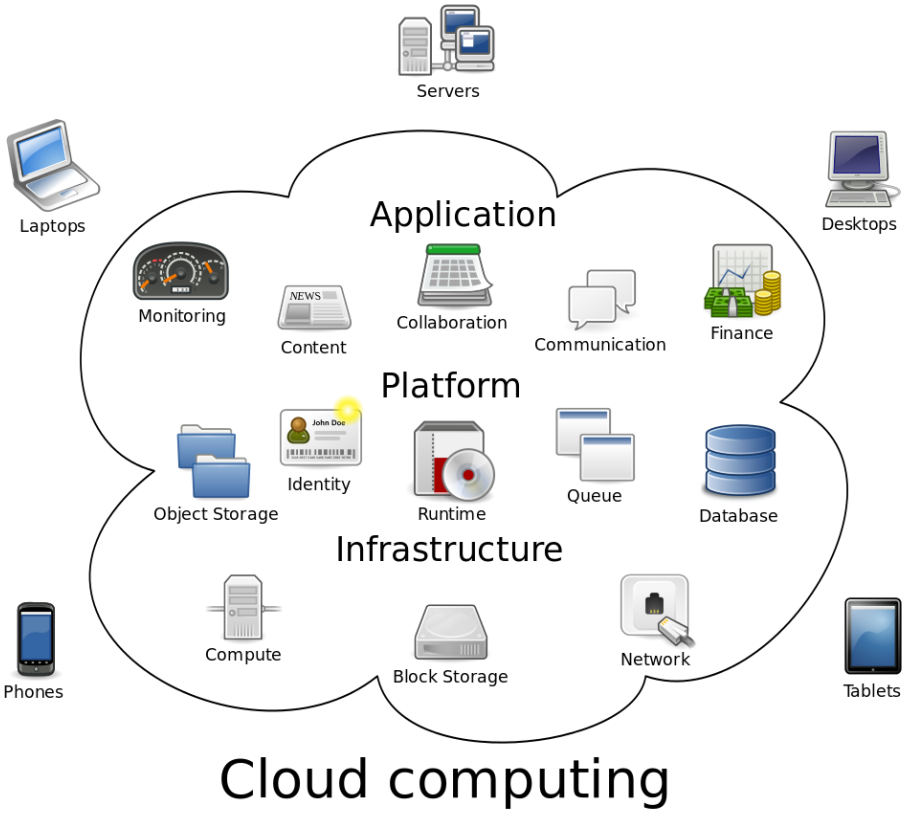
- Pay-per-use (no commitment, utility prices)
- Elastic capacity - scale up/down on demand.
- Self-service interface.
- Resources are abstracted / virtualised.

(Note that this is very much more than just virtual machines)

Cloud Computing Technologies (1/2)

- Several important technologies have matured after many years that form the essential parts of Cloud Computing:
- Virtual Machines
  - Emulation of Computer Systems
  - Many Virtual Machines on a single real computer
  - Allows averaging of peak loads
  - Enables very efficient use of computing resources
- Virtualised Storage
  - Emulation of many file systems on a real file system
  - Many users sharing the same physical storage
  - Very efficient use of storage

Cloud computing (cont.)

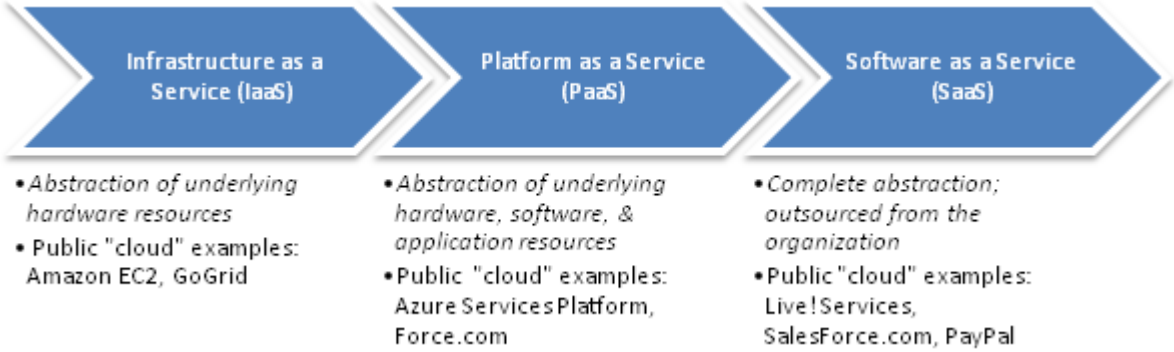


Cloud Computing Technologies (2/2)

- Several important technologies have matured after many years that form the essential parts of Cloud Services:
- Web Services
  - Enables Machine-Machine communication over the Internet – based on web standards
  - Uses machine readable/processable formats
  - Allows the automated interaction with Cloud services
- Infrastructure Advances
  - Reduction in cost of Processing and Storage technologies
  - Growth of International Fiber links
  - Enabling cheap computing in cheap locations

- We'll cover these technologies in more detail in your degree

Cloud and Utility Architectures



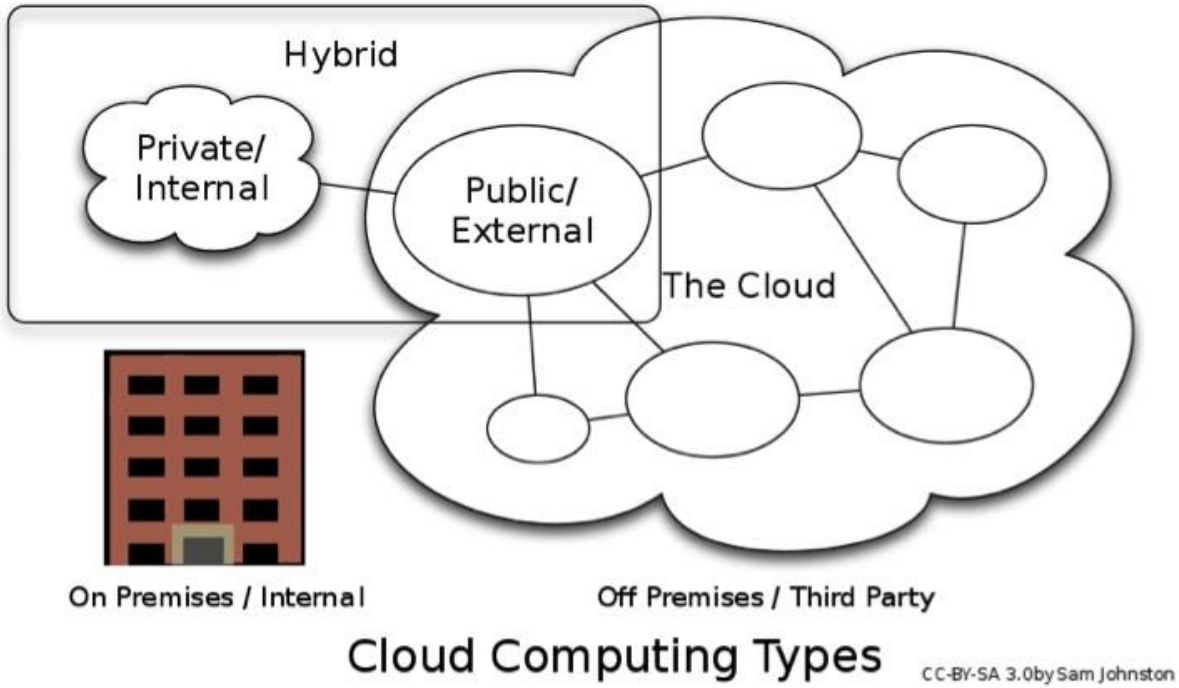
Example Clouds:

- Storage Clouds
  - Amazon Simple Storage Service (Amazon S3)
  - Dropbox
  - Google Drive
  - iCloud
  - CloudStor
- Computational Clouds
  - Amazon Elastic Compute Cloud (Amazon EC2)
- Platform/Application Clouds
  - Amazon Elastic Compute Cloud (Amazon EC2)
  - Google AppEngine
  - Microsoft Azure
  - Salesforce.com

Cloud and Utility Architectures

Types of Cloud:

- Public
- Private
- Hybrid
- Federated.

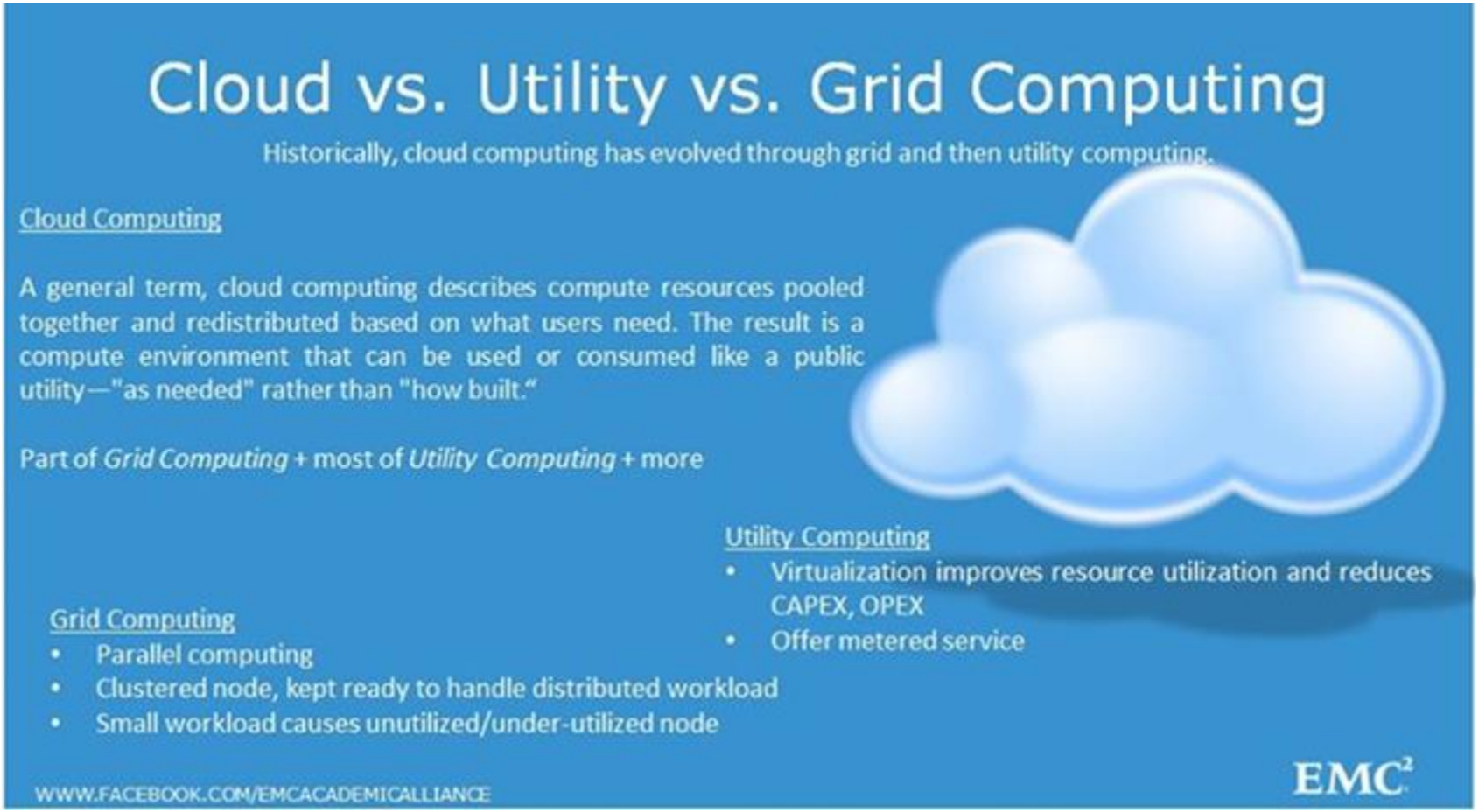


Video: 1: Cloud Computing Vision

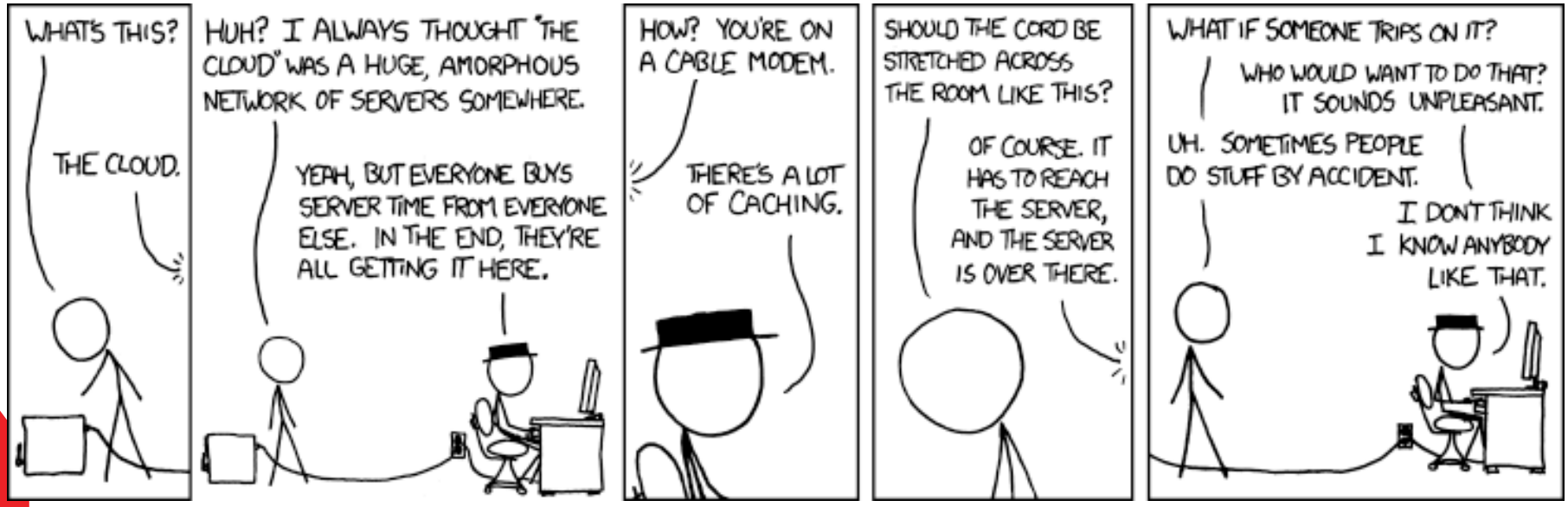
Steven Fry Explains Cloud Computing:

https://www.youtube.com/watch?v=J9LK6EtxzgM&spfreload=10%20Message%3A%20JSON%20Parse%20error%3A%20Unexpected%20EOF%20(url%3A%20https%3A%2F%2Fwww.youtube.com%2Fwatch%3Fv%3DJ9LK6EtxzgM)

Cloud vs Utility vs Grid



Summary



- Cloud Computing is a heavily loaded term
- Has a meaning to the public
- Is part of the evolution of computing architectures
- It also has a solid technical definition
- To fully understand it, you need to understand the supporting technologies
- XKCD #908

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Internet of Things

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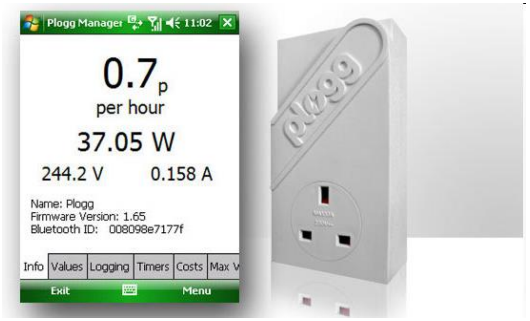
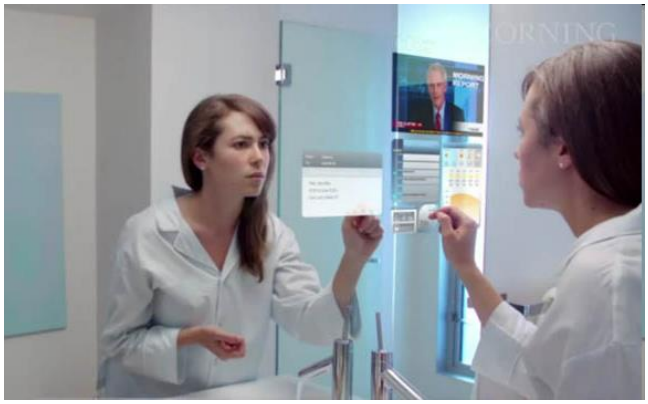
Sensor devices are becoming widely available



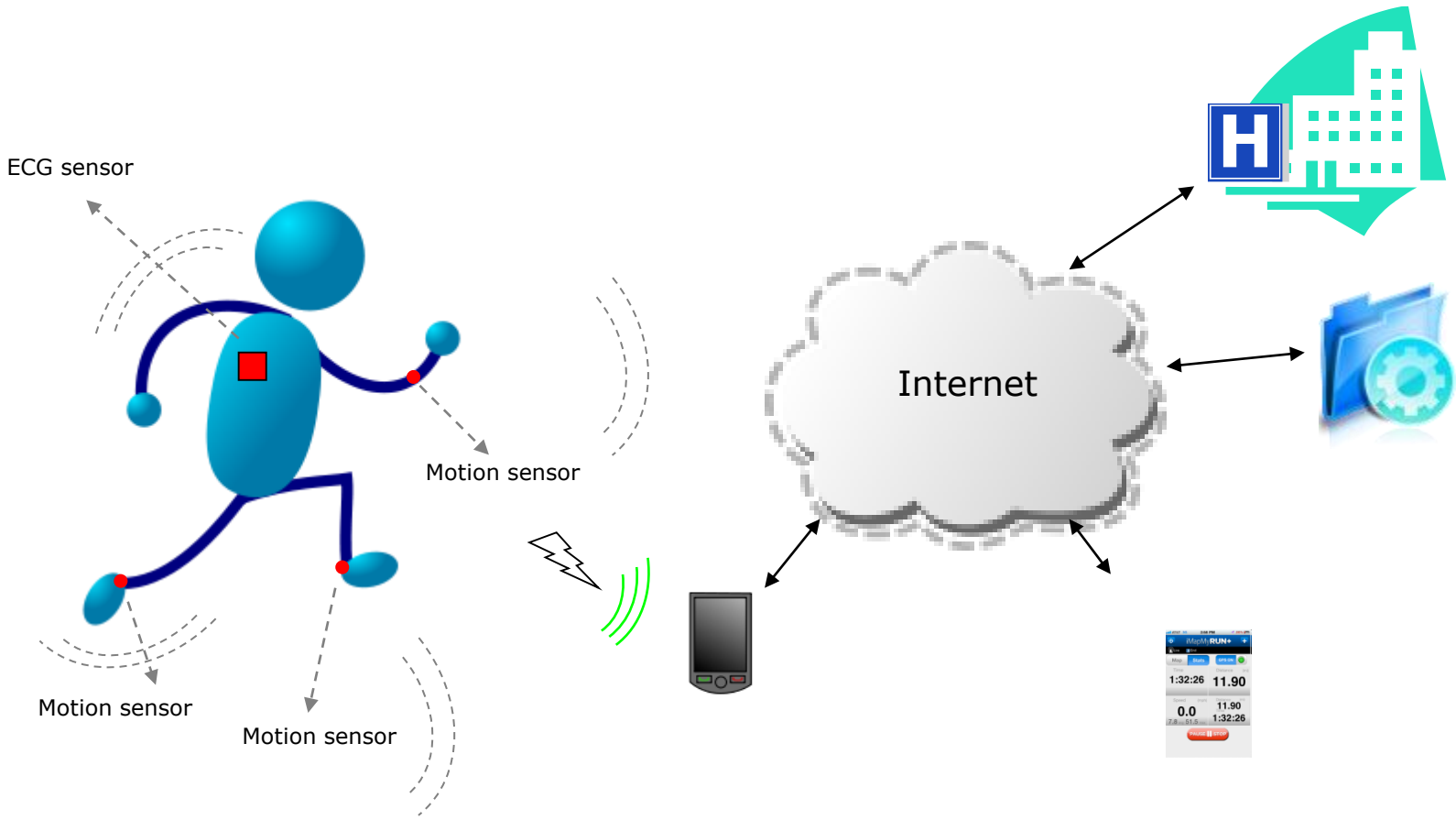
- Programmable devices
- Off-the-shelf gadgets/tools

More "Things" are being connected

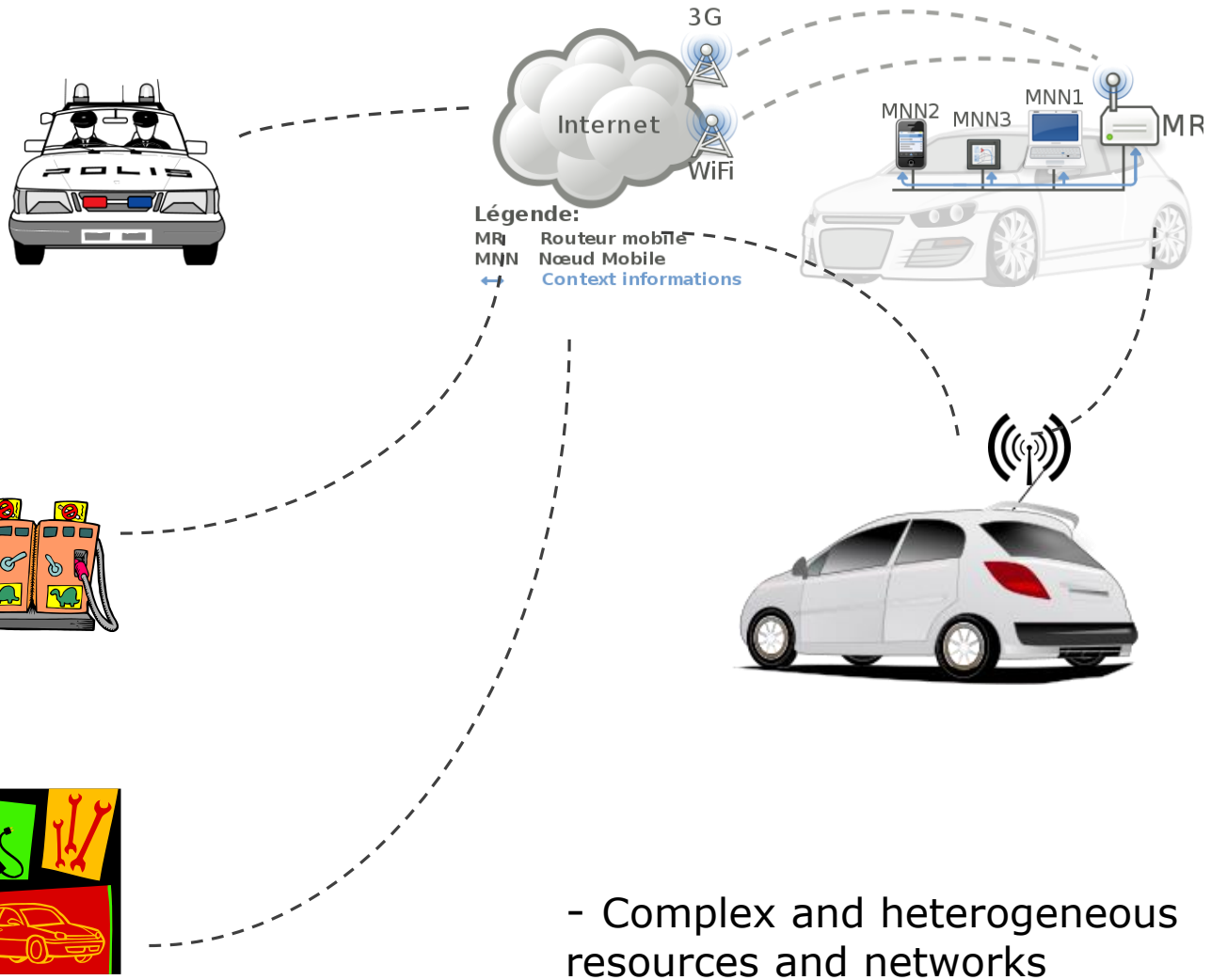


- Home/daily-life devices
- Business and
- Public infrastructure
- Health-care
- …

People Connecting to Things

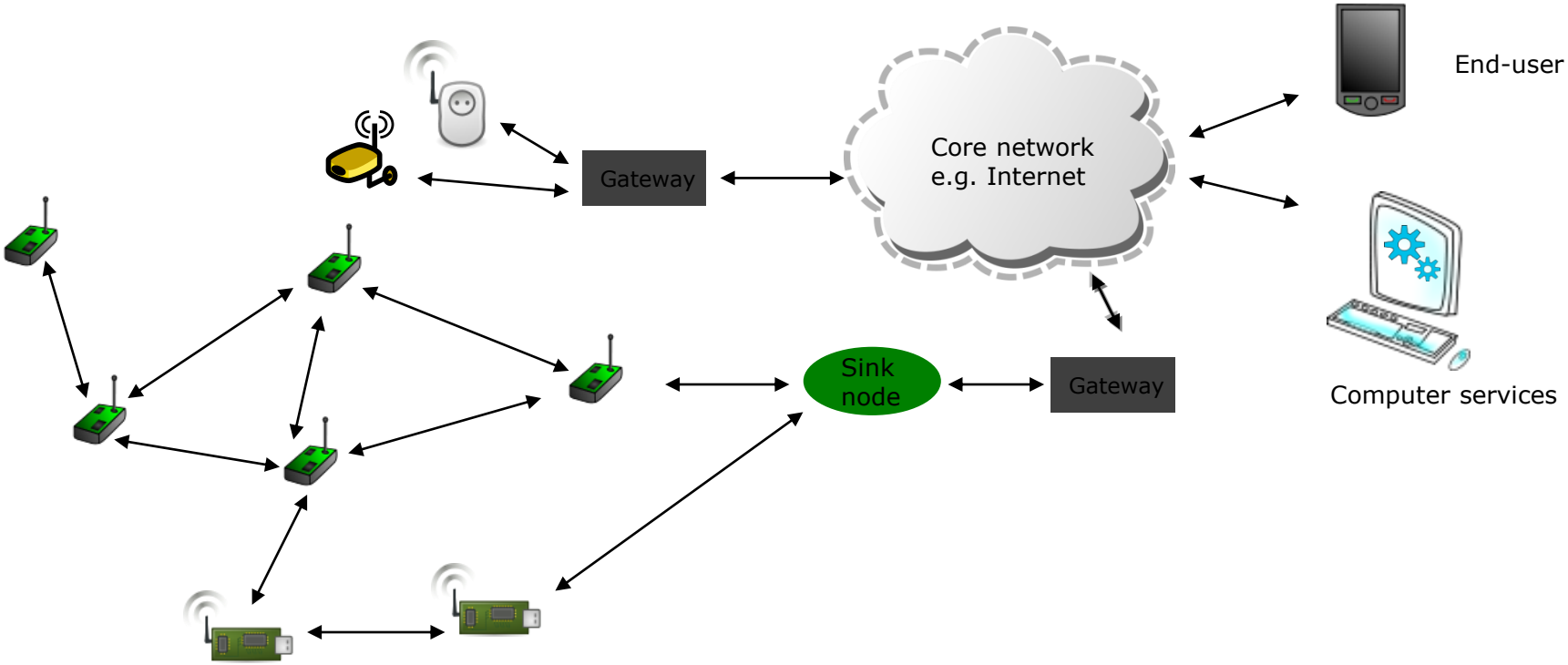


Things Connecting to Things



- Complex and heterogeneous resources and networks

Traditional Wireless Sensor Networks (WSN)

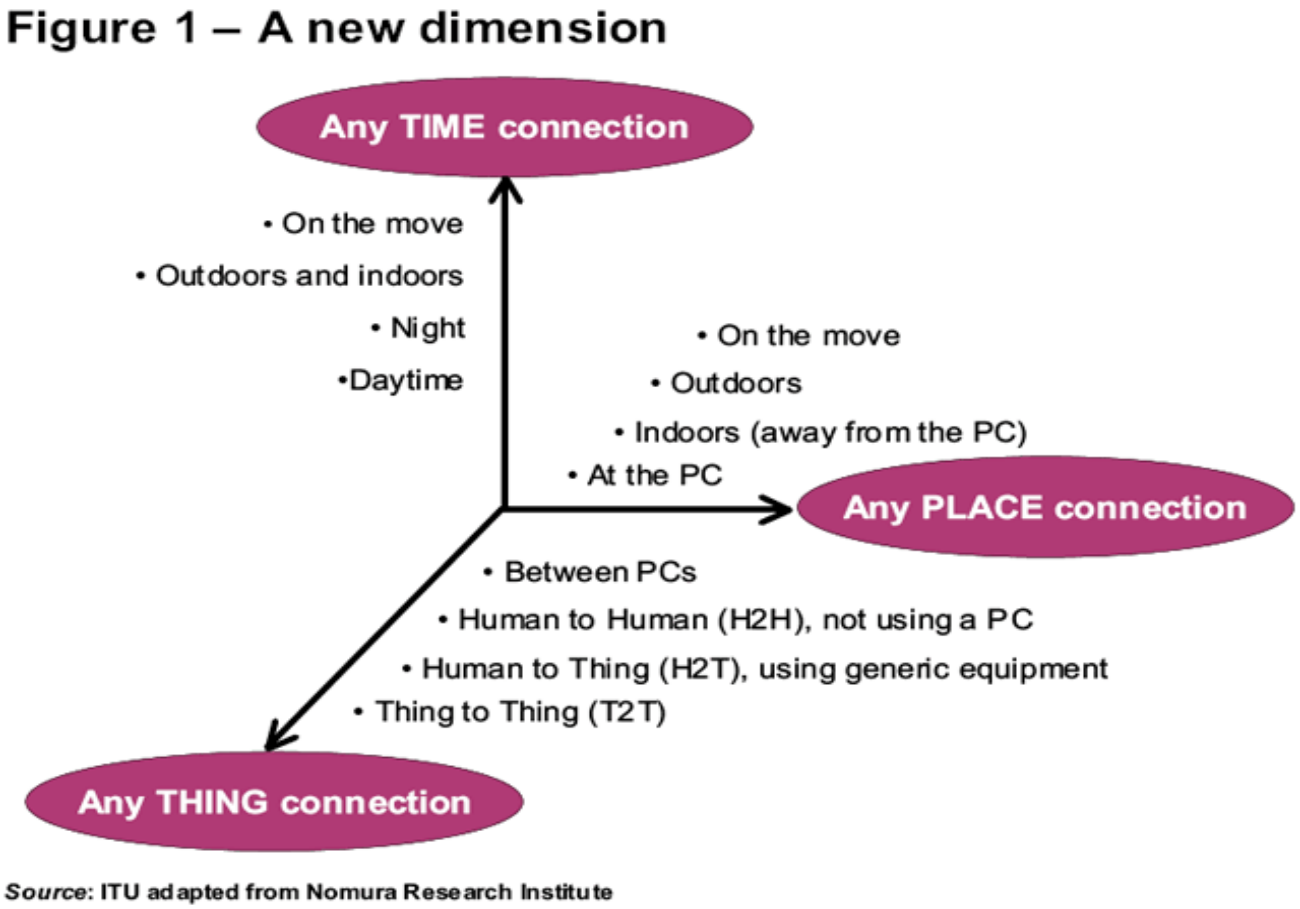


- The networks typically run Low Power Devices
- Consist of one or more sensors, could be different type of sensors (or actuators)

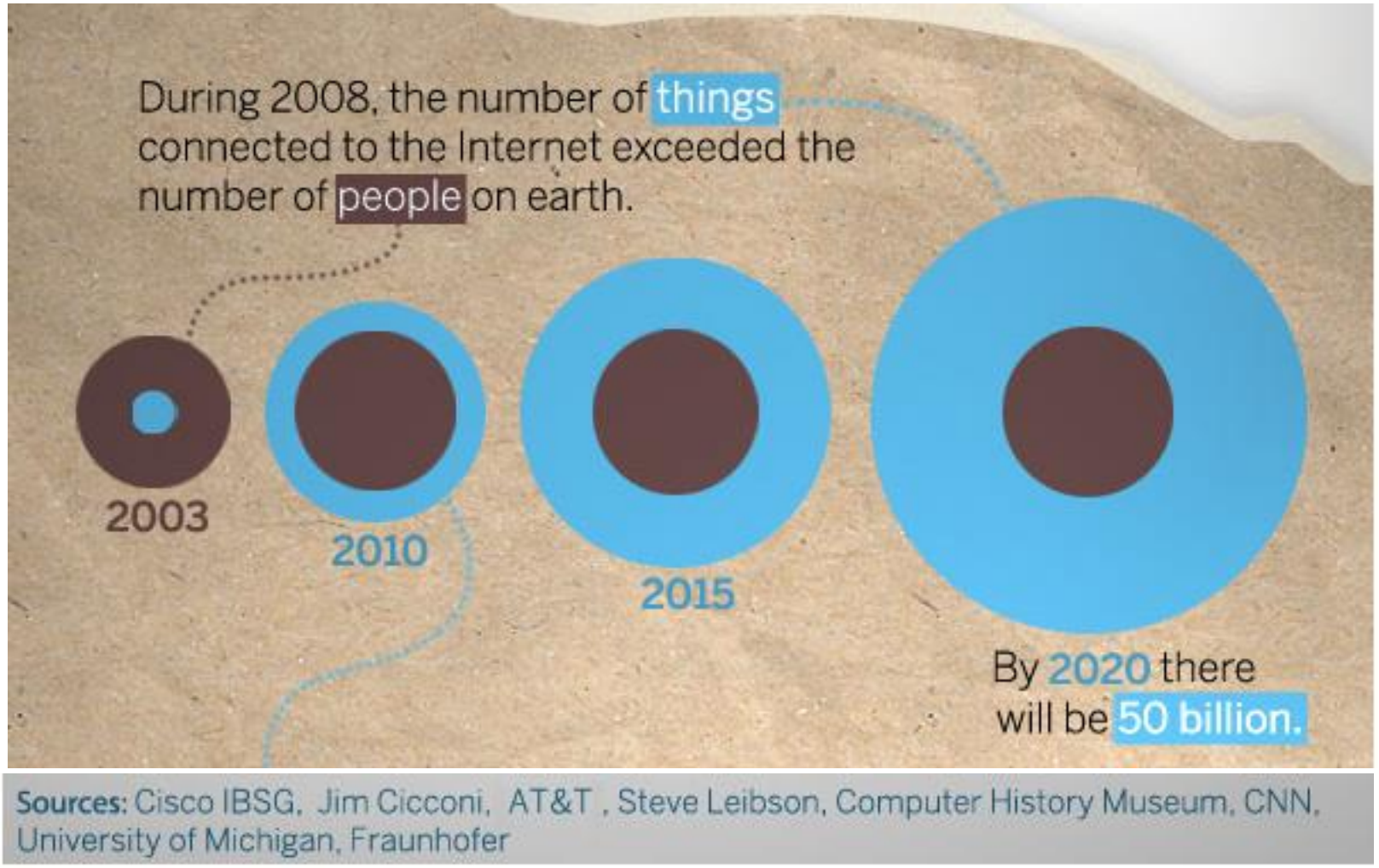
How are the networks changing?

- Extensions
  - More nodes, more connections, IPv6, 6LowPan,...
  - Any TIME, Any PLACE **+** Any THING
  - Machine 2 Machine, Internet of Things
    - Billions of interconnected devices,
    - Everybody connected.
- Expansions
  - Broadband
- Enhancements
  - Smart networks
  - Data-centric and content-oriented networking
  - Context-aware (autonomous) systems

Future Networks



“Things” connected to the internet



Define the Internet of Things (IoT)

(1) Wiki: The **Internet of Things** (**IoT**), also called The Internet of Objects, is the network of physical objects or "things" embedded with electronics, software, sensors, and network connectivity, which enables these objects to collect and exchange data.

(2) Wiki: **IoT** refers to a wireless network between objects, usually the network will be wireless and self-configuring, such as household appliances.

(3) 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

Define the Internet of Things (IoT)

(4) **T**he 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

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

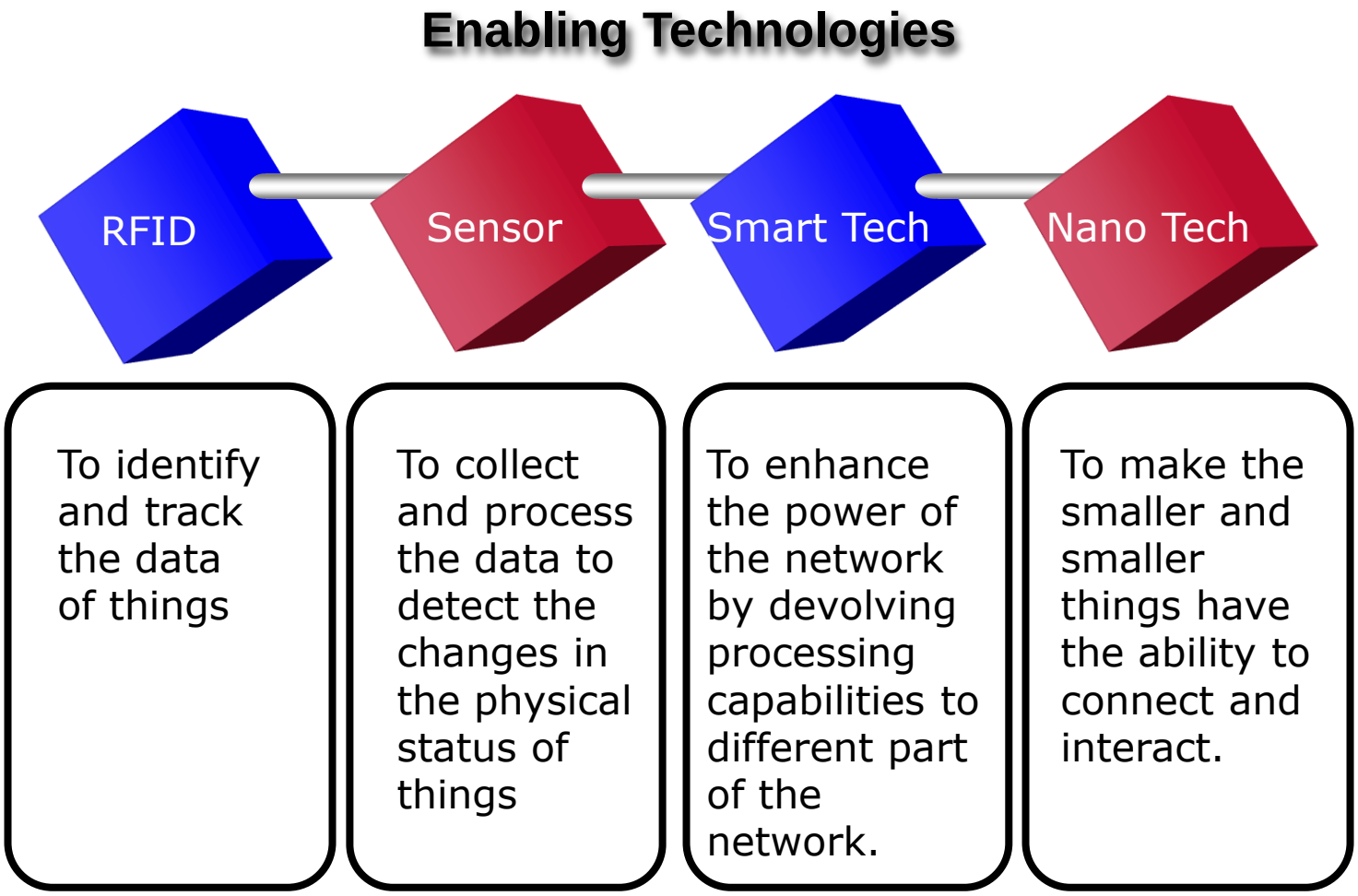
-------IoT in 2020

Define the Internet of Things (IoT)

- Extending the current Internet and providing connection, communication, and inter-networking between devices and physical objects, or "Things," is a growing trend that is often referred to as the *Internet of Things*.

- The technologies and solutions that enable integration of real world data and services into the current information networking technologies are often described under the umbrella term of the Internet of Things (IoT)

State of the Art of IoT



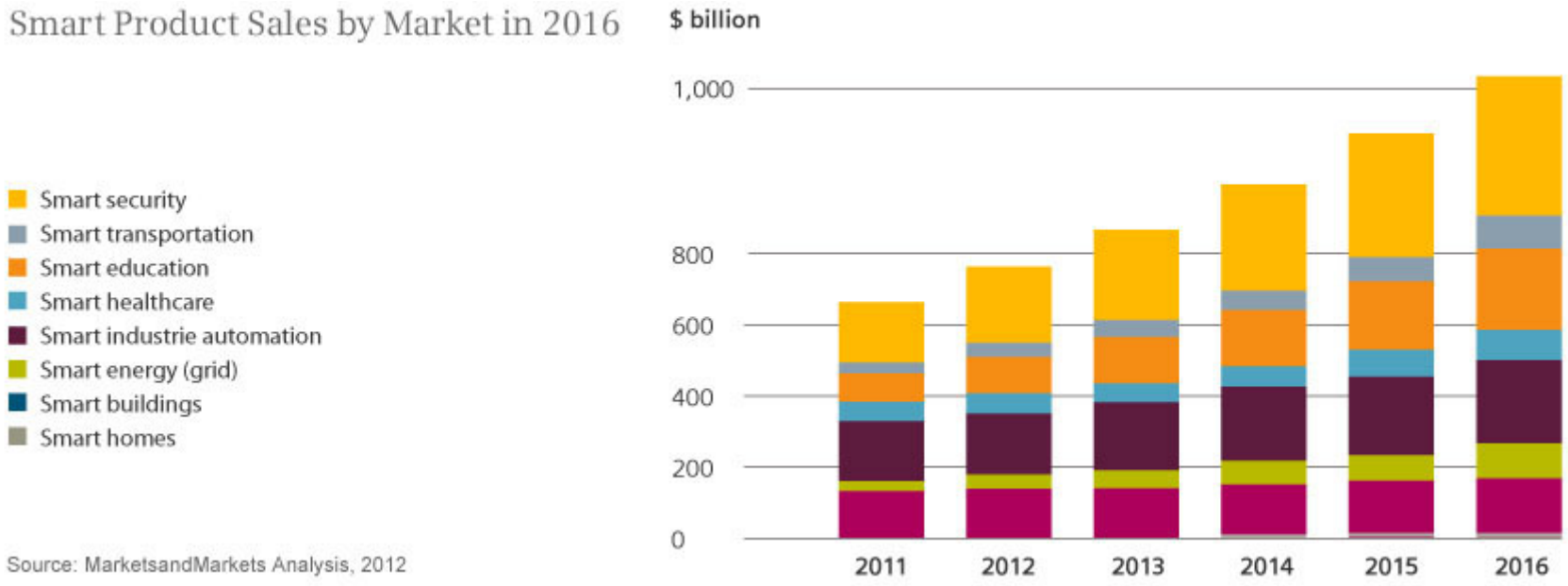
IoT growth (1/4)

- "According to a study conducted by Frost & Sullivan in 2011, the global RFID market of $3 billion to $4 billion (in 2009) will grow by twelve percent per year through 2016 and reach a volume of approximately $6.5 billion to almost $9 billion."
- 80 percent of all households in the European Union are expected to have intelligent power meters by 2020.
- A building's energy management can then be monitored and administered remotely via a smartphone or a PC. Market experts predict that this global market, which represented $5.3 billion in 2010.
- It is estimated that IoT product and service suppliers will generate incremental revenue exceeding $300 billion in 2020.
- ... that the worldwide market for IoT solutions will grow from $1.9 trillion in 2013 to $7.1 trillion in 2020.

Source: Siemens, http://www.siemens.com/innovation/apps/pof_microsite/_pof-fall-2012/_html_en/facts-and-forecasts-growth-market-of-the-future.html
http://www.forbes.com/sites/gilpress/2014/08/22/internet-of-things-by-the-numbers-market-estimates-and-forecasts/#5071b472dc99

IoT growth (2/4)

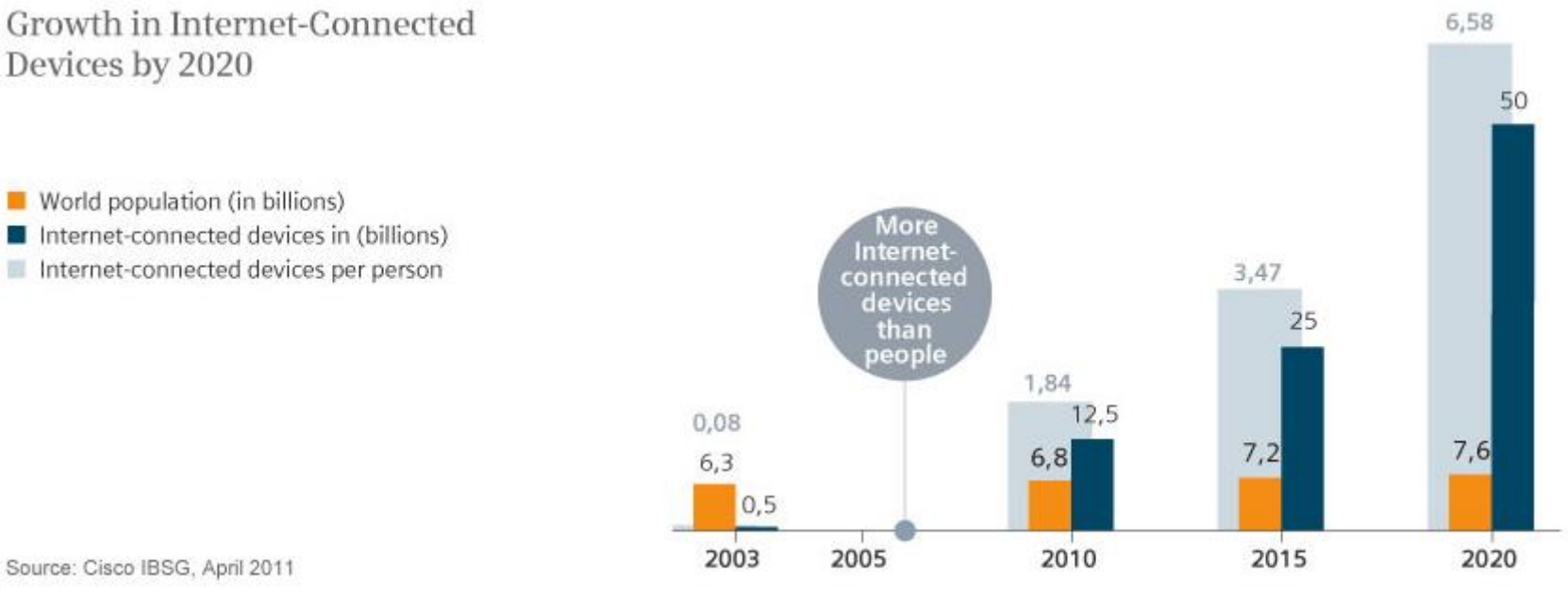
Smart product sales



Source: Siemens, http://www.siemens.com/innovation/apps/pof_microsite/_pof-fall-2012/_html_en/facts-and-forecasts-growth-market-of-the-future.html

IoT growth (3/4)

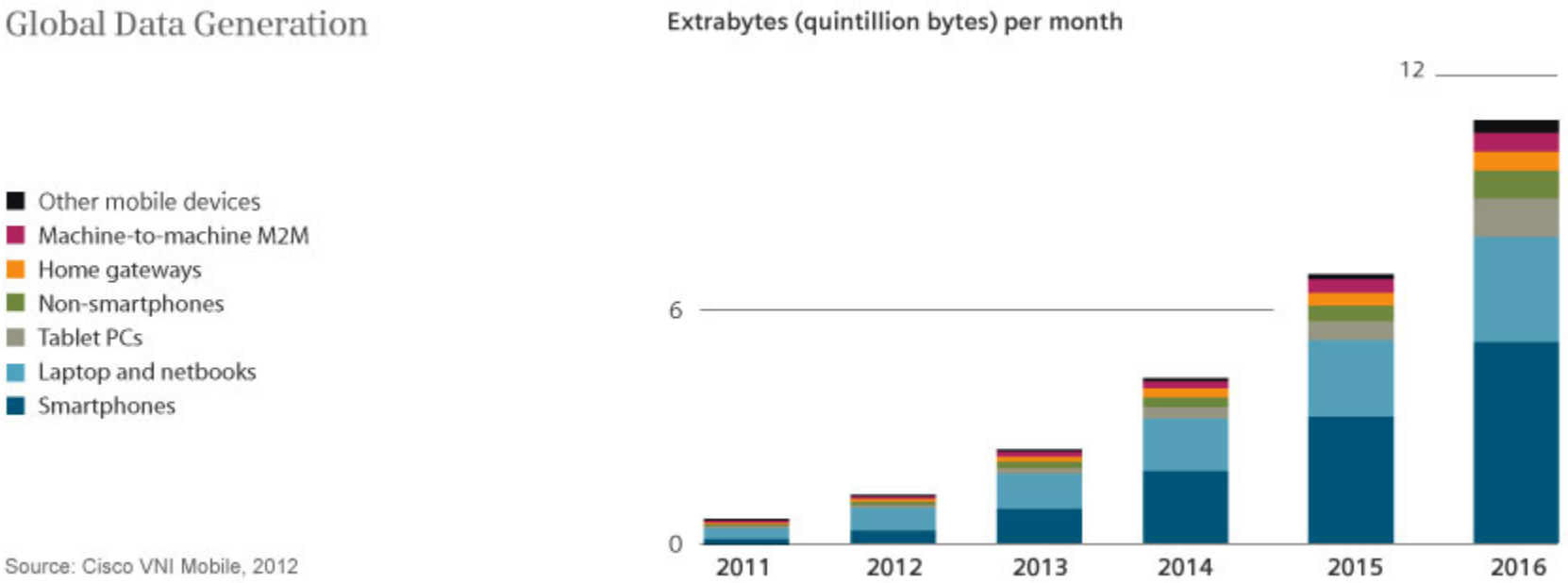
Internet Connected devices



Source: Siemens, http://www.siemens.com/innovation/apps/pof_microsite/_pof-fall-2012/_html_en/facts-and-forecasts-growth-market-of-the-future.html

IoT growth (4/4)

Data Generation



The application of the IoT

Scenario: shopping

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

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

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

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

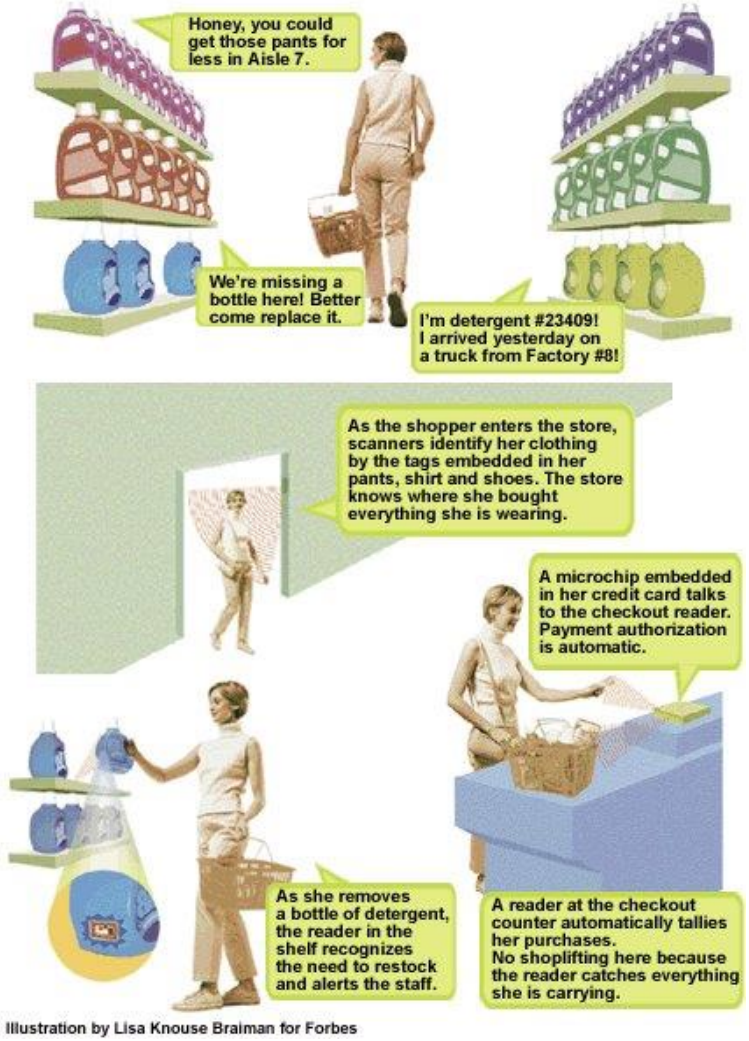
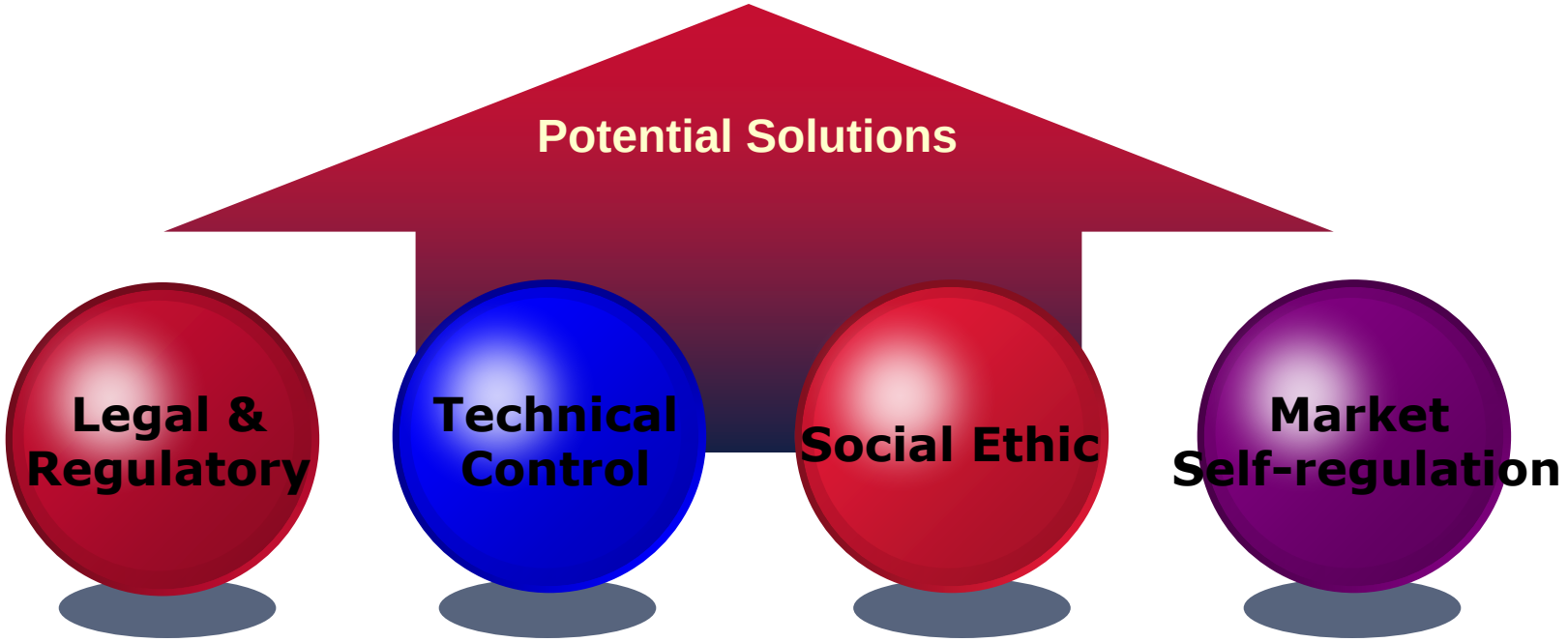


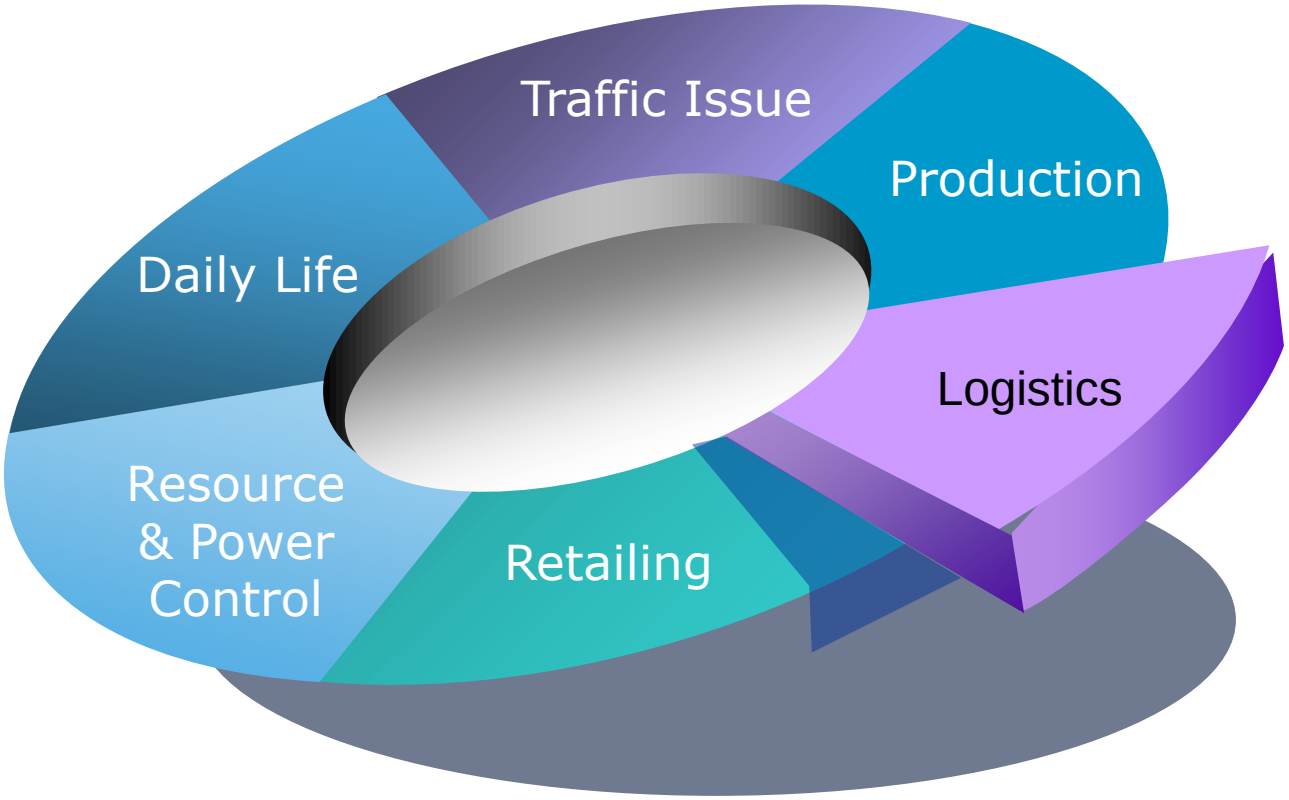
Illustration by Lisa Knouse Braiman for Forbes

The Challenge of IoT

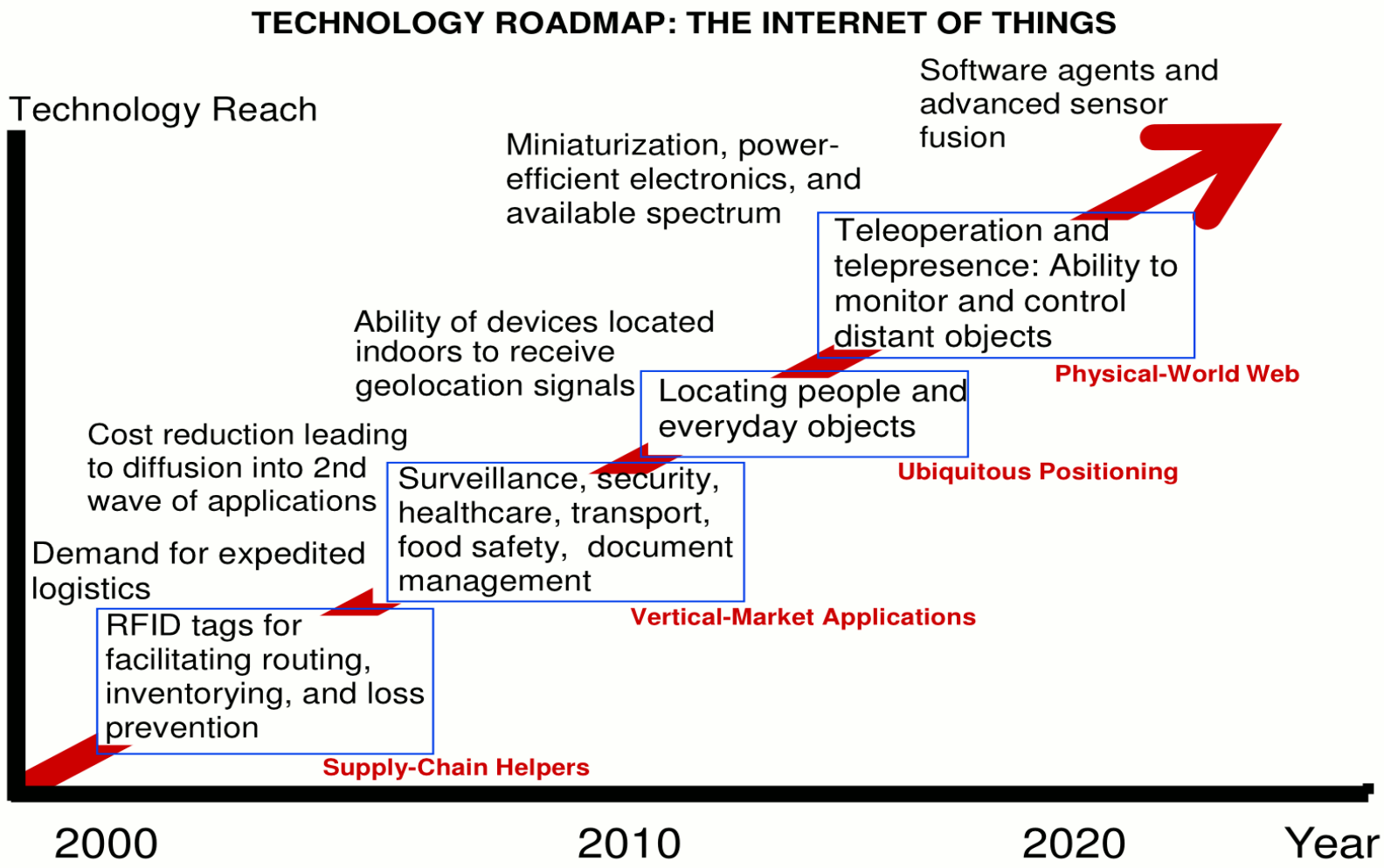
How to convince users that the IoT technology will protect their data and privacy when tracking



The Future of IoT



Technology Road Map: IoT



Video 2: Internet of Things Vision

Intel's View

https://www.youtube.com/watch?v=uEsKZGOxNKw&spfreload=10%20Message%3A%20JSON%20Parse%20error%3A%20Unexpected%20EOF%20(url%3A%20https%3A%2F%2Fwww.youtube.com%2Fwatch%3Fv%3DuEsKZGOxNKw)

Video 3: Internet of Things Vision

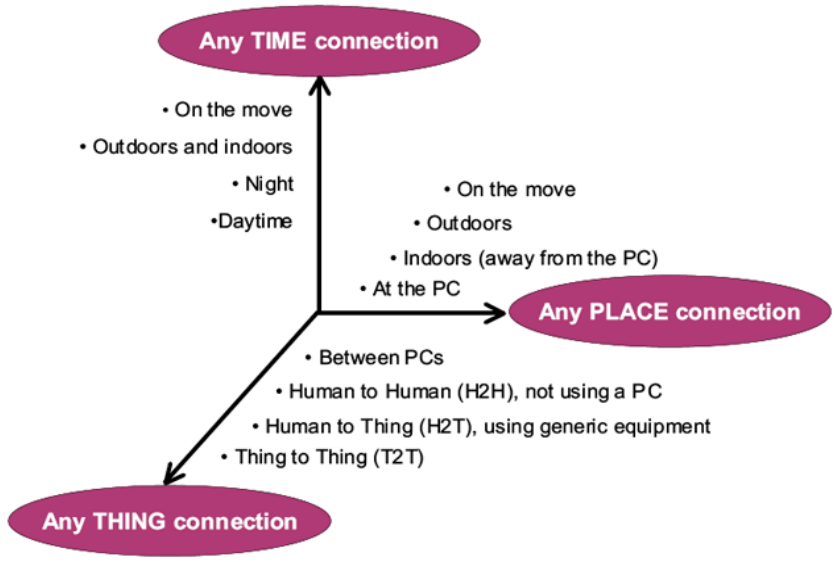
IBM experts opinions

https://www.youtube.com/watch?v=sfEbMV295Kk&spfreload=10%20Message%3A%20JSON%20Parse%20error%3A%20Unexpected%20EOF%20(url%3A%20https%3A%2F%2Fwww.youtube.com%2Fwatch%3Fv%3DsfEbMV295Kk)

Summary

- The Internet of Things is about extending the Internet to the physical world
- Is already here
- Promises massive growth
- Will impact all areas:
  - Health
  - Transport
  - Retail
  - Industry

Figure 1 – A new dimension



Source: ITU adapted from Nomura Research Institute

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Ubiquitous Computing (AKA hiding technology)

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"Any technology sufficiently advanced is indistinguishable from magic."

Arthur C. Clarke

The Essence of Understanding Computers

- Computer – a job title!
- Computer science is the only major branch of science that is named after a gadget.
- What matters is not technology itself,
  but its impact on us and vice versa.

The major Trends in Computing

Mainframe *(Past)* **1:N**
one computer shared by many people

↓

Personal Computer *(Present)* **1:1**
one computer, one person

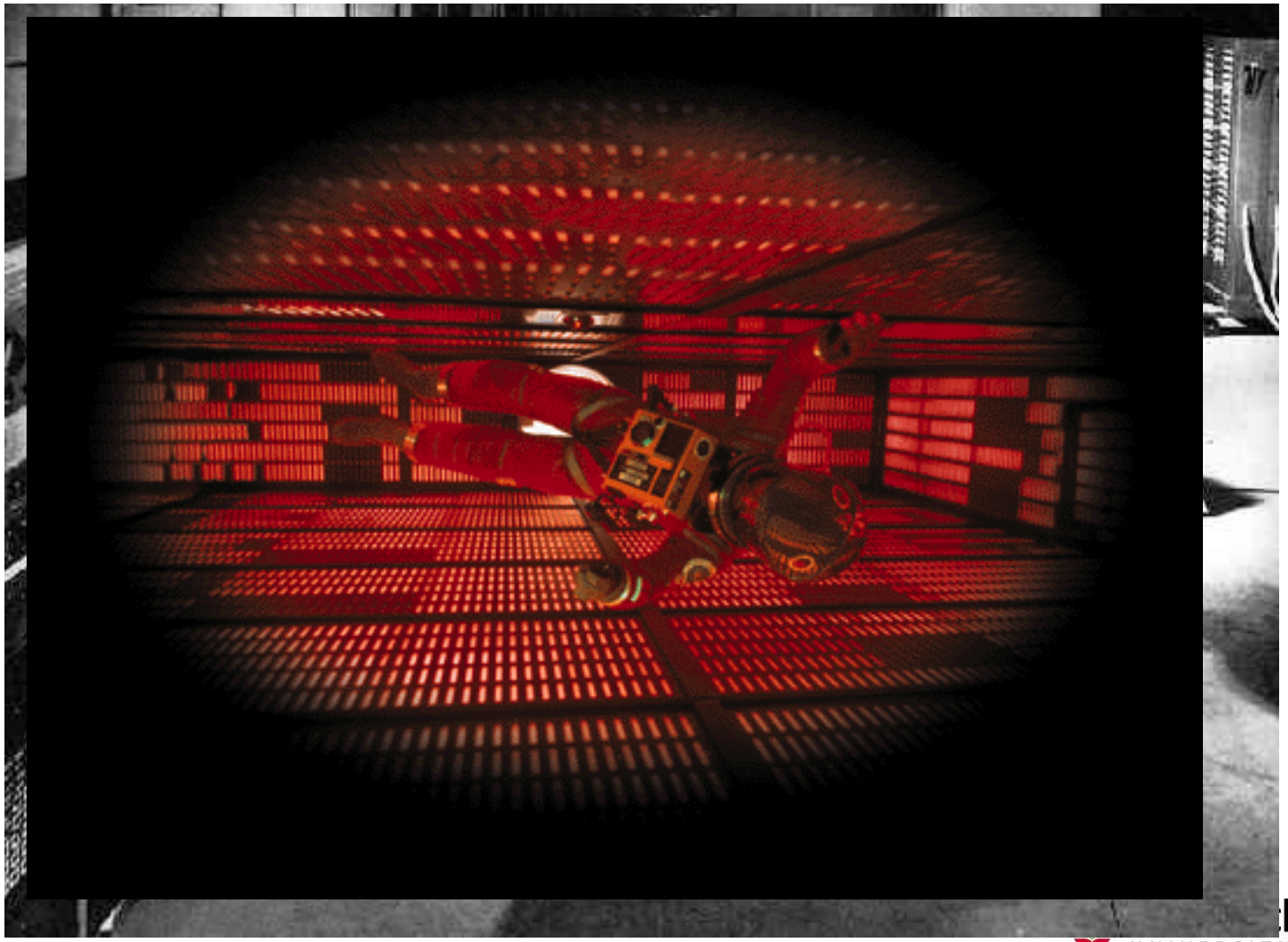
↙ ↘

N:1 **Internet - Widespread Distributed Computing**

Ubiquitous Computing **N^k:1**

many computers shared by each one of us

Phase I - The Mainframe Era



Phase II - The PC Era

Transition Phase - The Internet

The Internet brings together elements of the mainframe era and the PC era.

⇓

Client = PC

Server = Mainframe

Phase III - The Ubiquitous Computing Era

UC - Definition

Elements that define ubiquitous computing:

1. *Ubiquity/Pervasiveness* – lots of devices
2. *Connectedness* – the devices are networked
3. *Context-awareness* – the system is aware of the context of users
4. *Invisibility* – device effectively becomes invisible

Ubiquitous Computing – How To Understand It

- Ubiquitous Computing goal: enhancing computer use by making many computers available throughout the physical environment, but making them effectively invisible to the user.
- Ubiquity
  - Everywhere
  - Adaptation to environment
  - Intuitive, transparent, natural interfaces

What Ubiquitous Computing is NOT

- It is not science fiction (SF), though it relies a great deal on it.
- It is not impossible.
- It is not Virtual Reality (VR).
- It is not a Personal Digital Assistant (PDA).
- It is not a personal agent (PA).

Early work in Ubiquitous Computing

A vision of a future form of computing set forth by Mark Weiser (1991)

- The computer has ceased to exist as a distinct entity and merged with the normal everyday objects that people use in their daily tasks.
- The normal physical environment will become equipped with extremely cheap but powerful devices for computing and networking.

Ubiquitous Computing – Here And Now

- Most work now is concentrating on the mobile infrastructure for wireless networking
- TCP/IP and OSI are unprepared for handling mobility (machine's name, and its network address are variant)
- "Calm Technology" : Calmness is a new challenge that Ubiquitous Computing brings to computing
- "The Periphery" : Calm technology will move easily from the periphery of our attention, to the center, and back.

Ubiquitous Computing – Here And Now

Ubiquitous Computing – Technology point of view

- The most powerful things are those that are effectively invisible to the user.
- Make a computer so embedded and so natural, that we use it without even thinking about it.
- Important issues: location and size:
  - Ubiquitous Computing must know where they are (Context-awareness, Legal issues);
  - Hundreds of wireless UCs per person;
  - Size: 1mm to wall size.

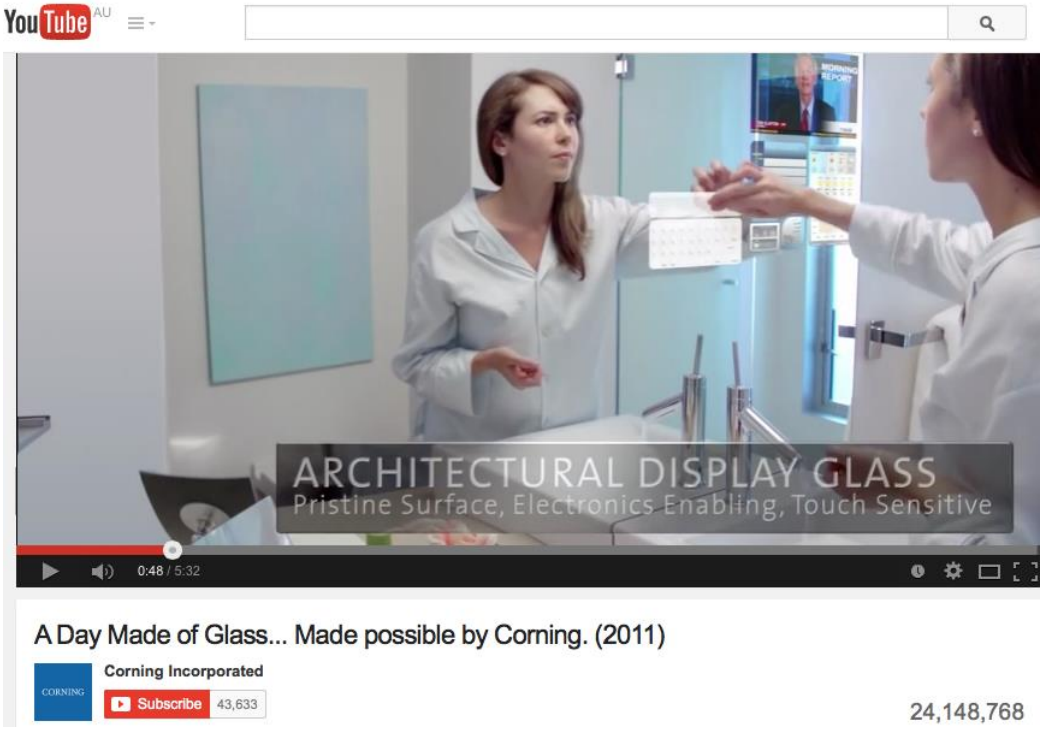
Ubiquitous Computing – Hardware Demands

- Technology required for Ubiquitous Computing :
  - Cheap, highly advanced VLSI technology (nanotech),
  - Very low-power computers with convenient displays,
  - Low-power, ultra-fast network for interconnection:
    - wireless end-points
    - cellular topology
    - wide-bandwidth range
- Software systems for UC applications and support.

Ubiquitous Computing – The Prophecy

- Whenever people learn how to use something sufficiently well, they stop being aware of it.
- Pushing computers into the background will make people more aware of those on the other end of link.
- UC will help resolve the problem of info overload.

Video 4: Ubiquitous Computing Vision



- Materials and Computing- Corning Glass Marketing Video:
- Think about the innovation required to achieve this goal…

https://www.youtube.com/watch?v=6Cf7IL_eZ38&spfreload=10%20Message%3A%20JSON%20Parse%20error%3A%20Unexpected%20EOF%20(url%3A%20https%3A%2F%2Fwww.youtube.com%2Fwatch%3Fv%3D6Cf7IL_eZ38)

Ubiquitous Computing – Privacy and Security

- Who will have the control: "the owner" or the central authority?
- How private can one be?
  - Preserving privacy of location.
  - Morris's rule: "Build computer systems to have the same privacy safeguards as the real world."
  - Legal issues: "Burglar Problem"
    - Steganography
    - "fingerprinting"
  - Social issues: "Problem of Restricted Individuality".
- Secure and reliable services

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Summary

Subtitle if required

Summary

- It is an exciting time for Computer Systems
- Cloud Computing
- Internet of Things
- Ubiquitous computing
- Be aware of what is going on!

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