# Ubiquitous Computing
# Physical Computing

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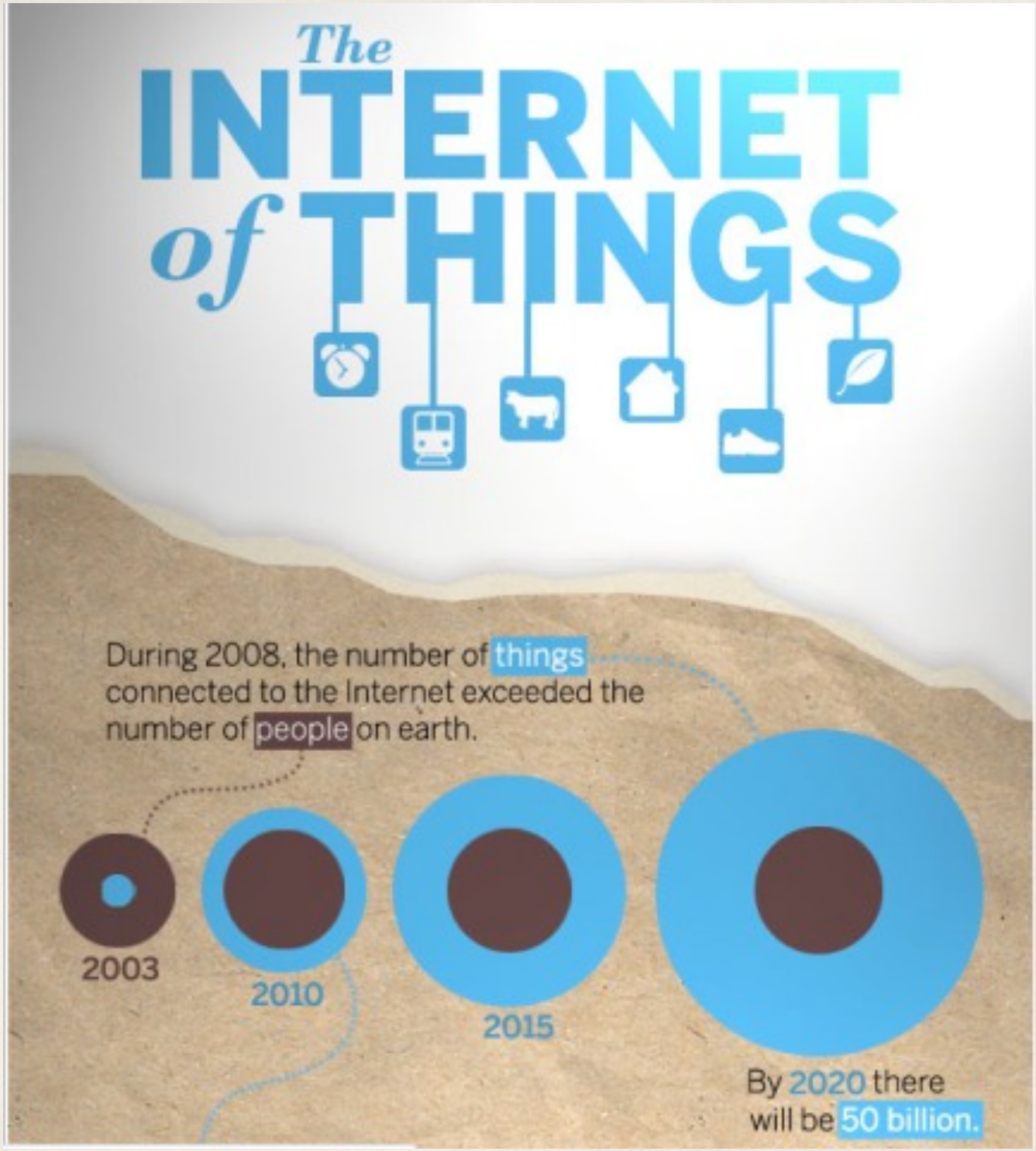
# Ubiquitous Computing

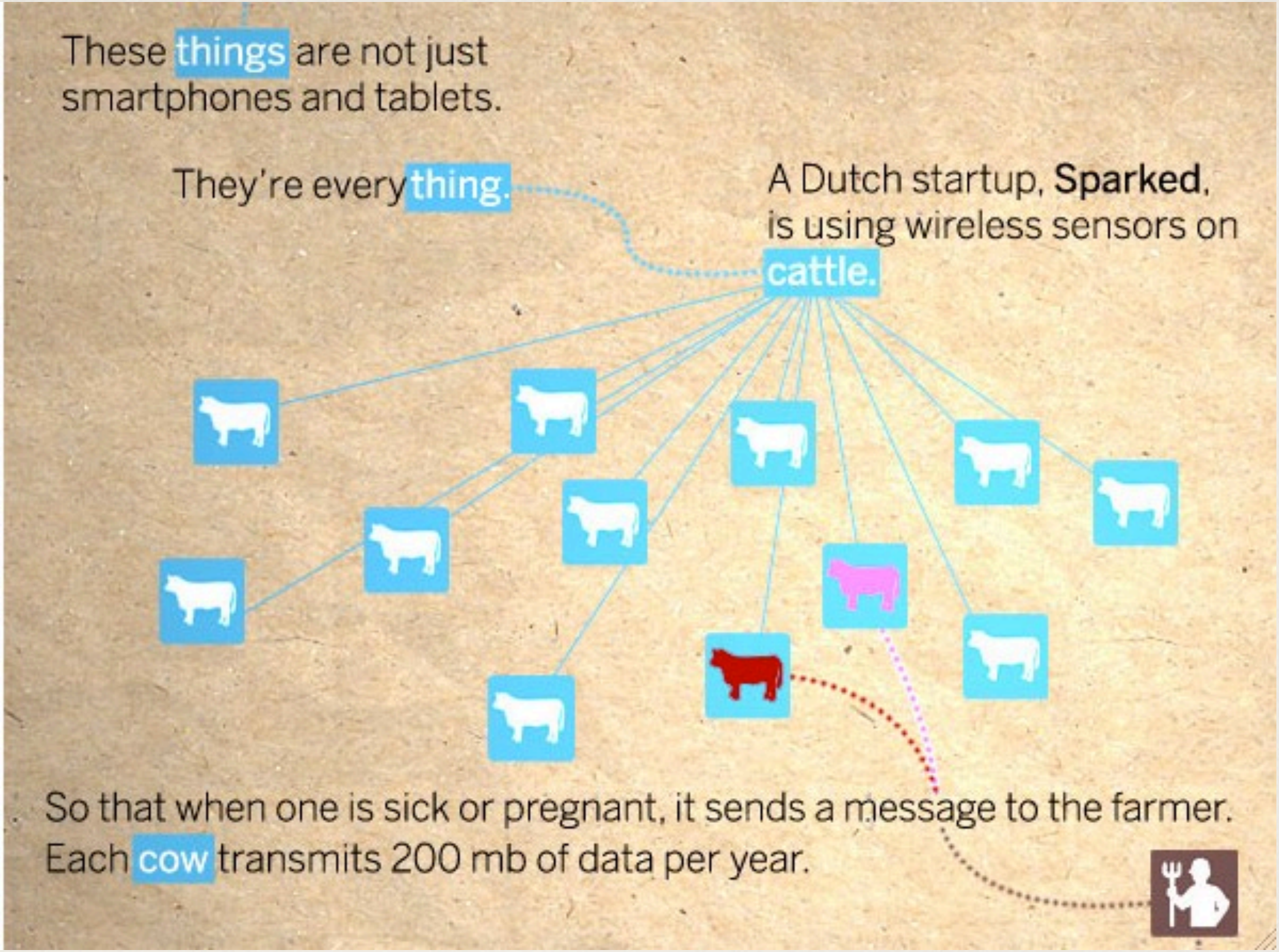
- "a post-desktop model of human-computer interaction in which information processing has been thoroughly integrated into everyday objects and activities" -- wikipedia
- "machines that fit the human environment instead of forcing humans to enter theirs" (York and Pendharkar, 2004)
- Also called:
  - Pervasive Computing
  - Ambient Intelligence
  - "The Internet of Things"
- Related: Wearable computing, physical computing

# Ubiquitous Computing

- 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 (ex-chief scientist, Xerox Parc)
- The next logical step in the technological revolution connecting people anytime, anywhere is to connect inanimate objects. This is the vision underlying the Internet of things: anytime, anywhere, by anyone and anything -- ITU, November 2005
- There are more devices tapping into the Internet than people on Earth to use them -- Dave Evans, Cisco




Cisco Systems Infographic

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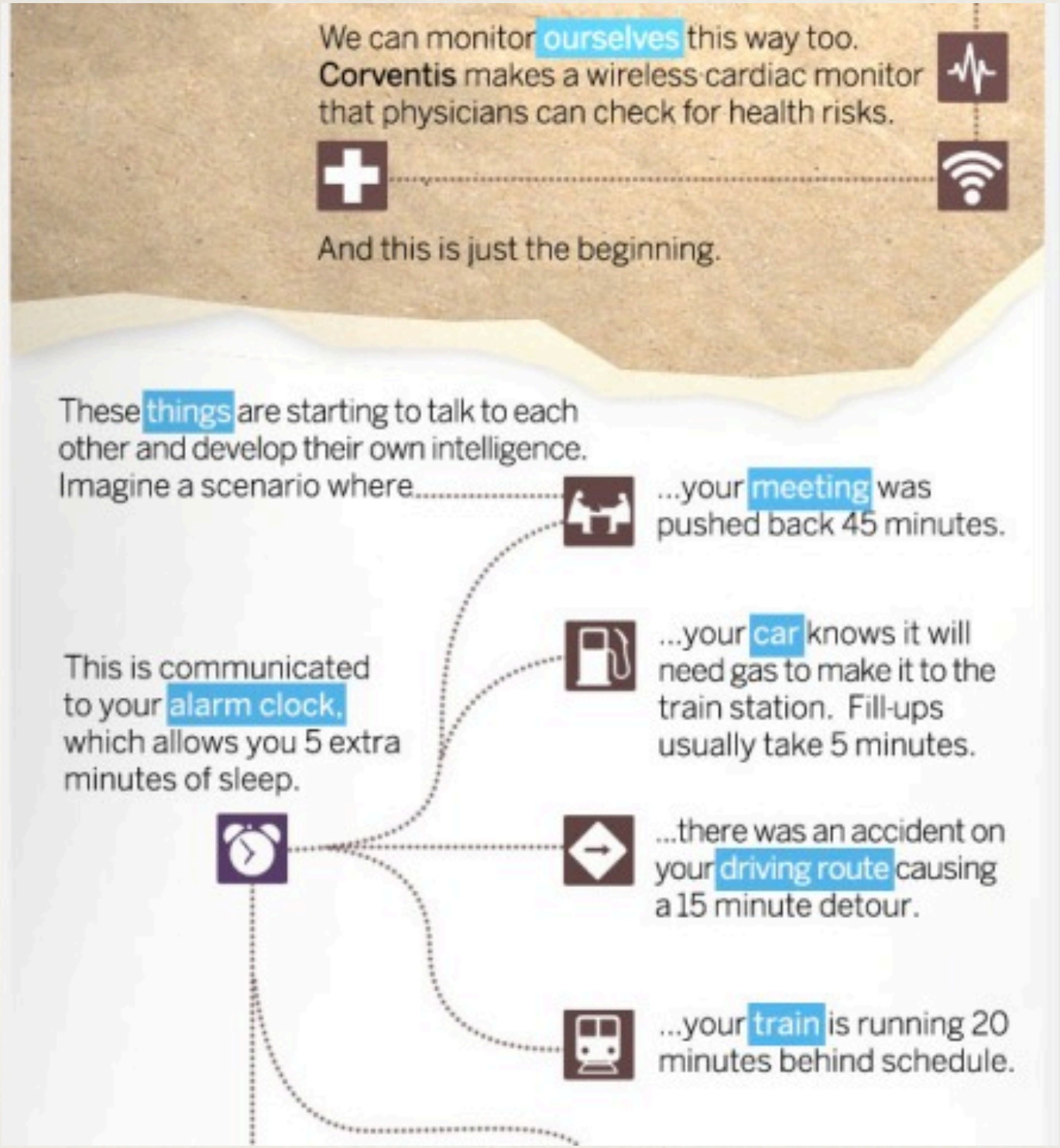



Cisco Systems Infographic

And signals your car to start in 5 minutes to melt the ice accumulated in overnight snow storms.

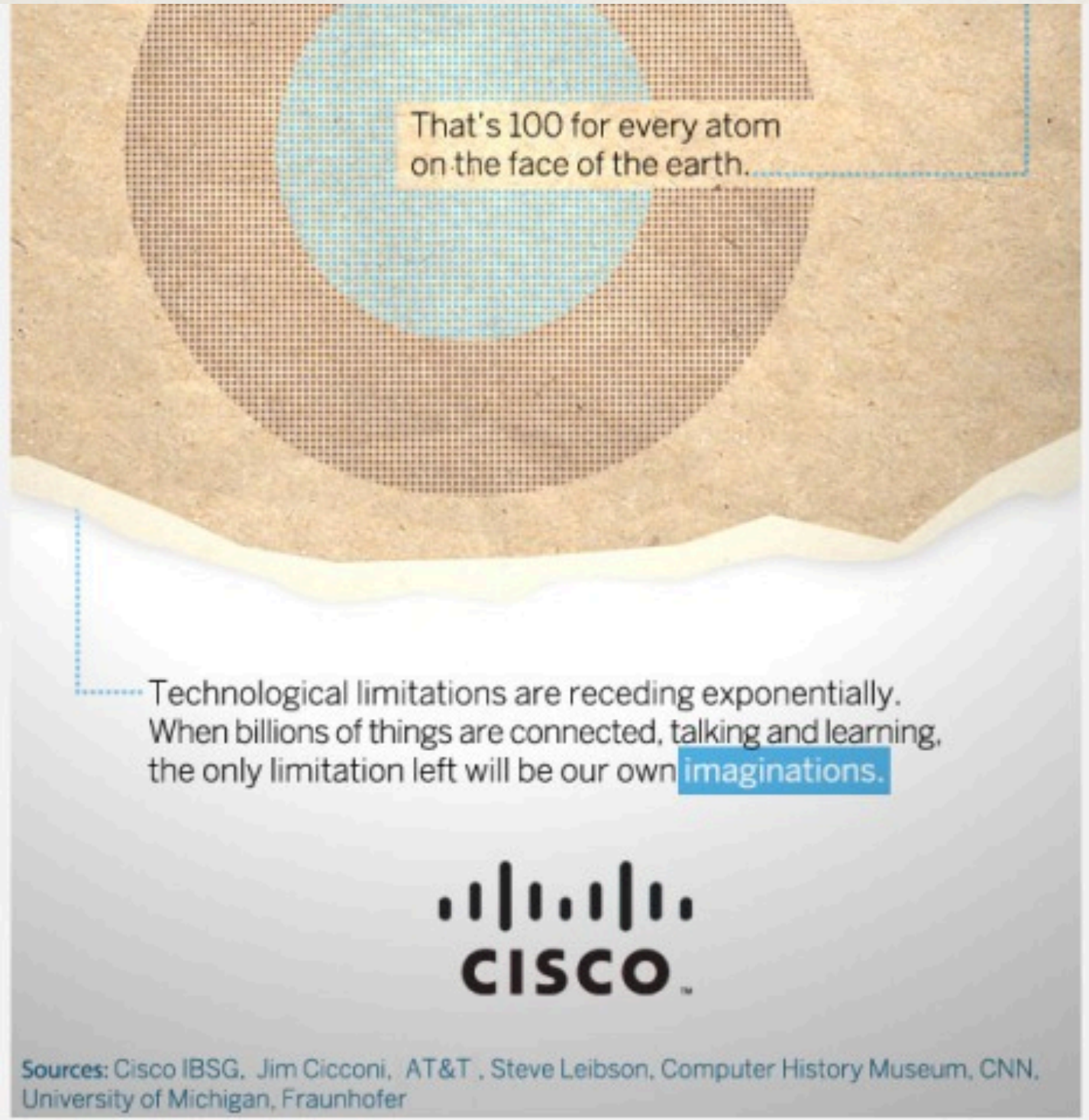
And signals your coffee maker to turn on 5 minutes late as well.

We are well on our way.

By the end of 2011, 20 typical households will generate more Internet traffic ...

Cisco Systems Infographic


Cisco Systems Infographic

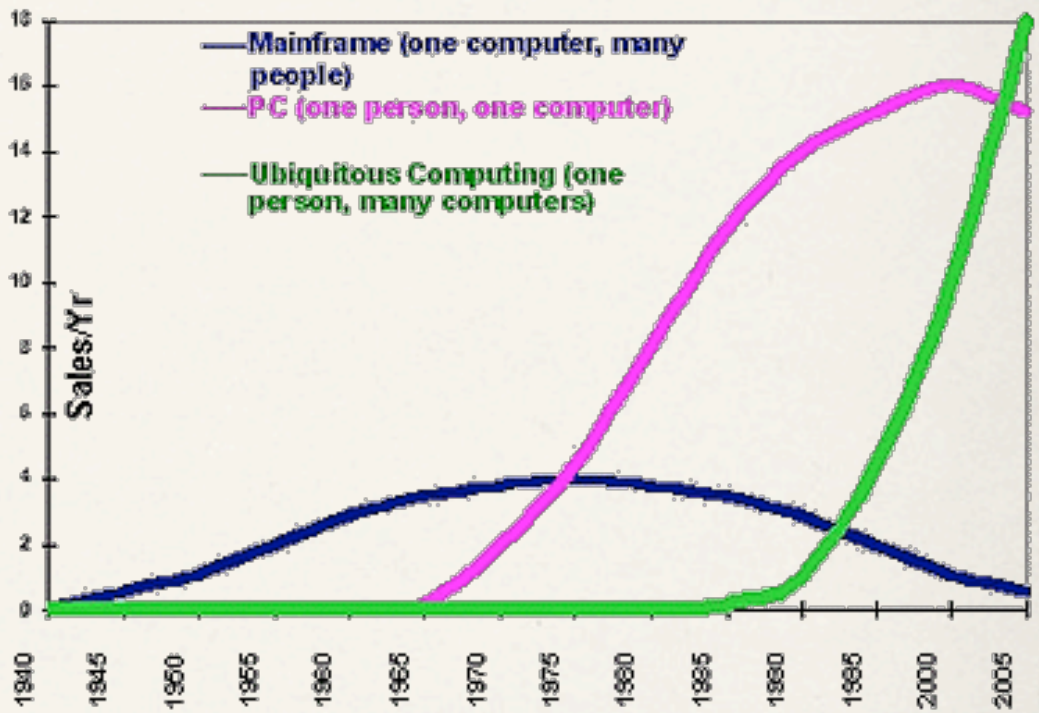



Cisco Systems Infographic

# Trends

Ubiquitous computing names the third wave in computing, just now beginning. First were mainframes, each shared by lots of people. Now we are in the personal computing era, person and machine staring uneasily at each other across the desktop. Next comes ubiquitous computing, or the age of calm technology, when technology recedes into the background of our lives.

Mark Weiser

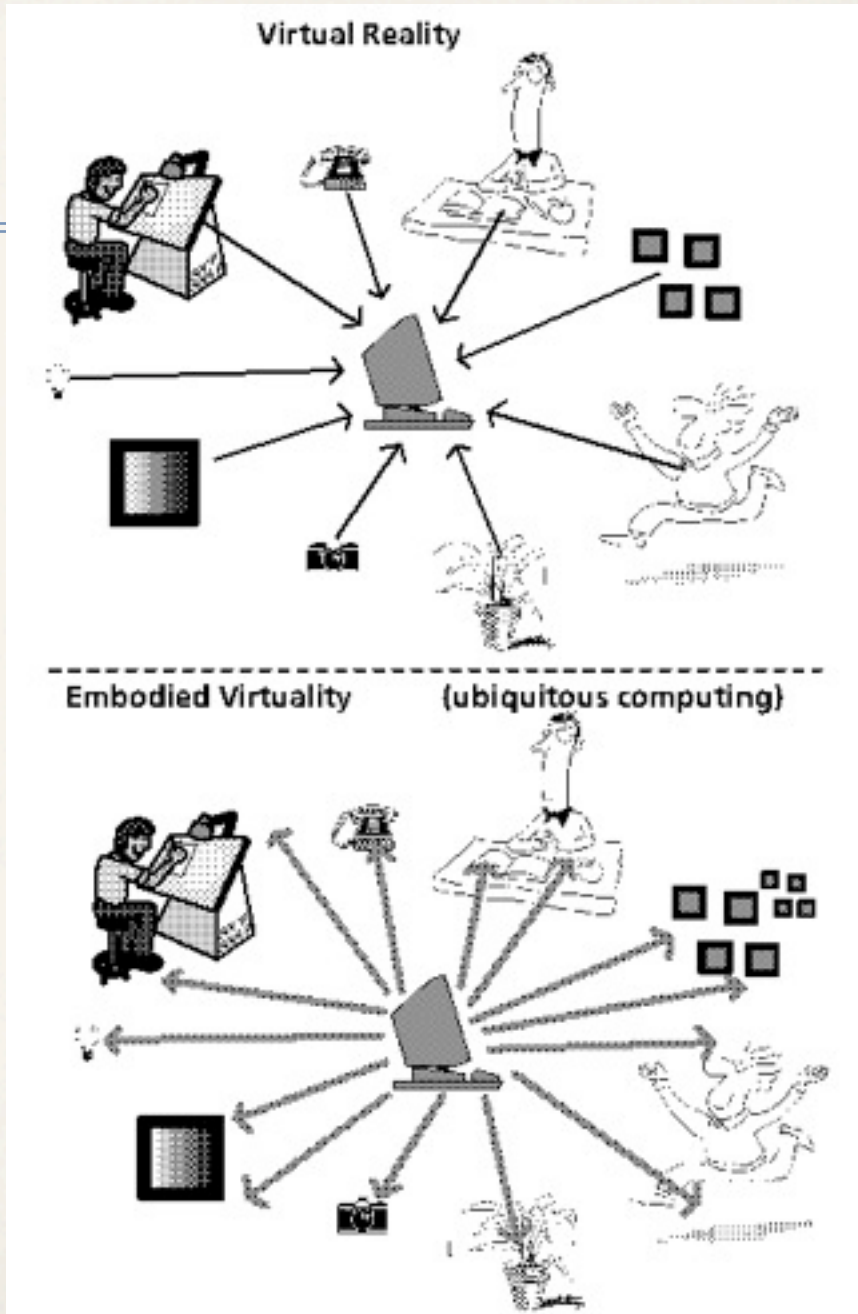


# Principles of Ubiquitous Computing (Weiser)

- 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: "that which informs but doesn't demand our focus or attention."

# Not Virtual Reality!

- Virtual Reality:
  - Immerses us in simulated world
- Ubiquitous Computing
  - Invisibly enhances real world



# Vision of Ubiquitous Computing

- Small, cheap, mobile processors and sensors
  - In almost all everyday objects
  - On your body (“wearable computing”)
  - Embedded in environment (“ambient intelligence”, “context-awareness”)
  - Interacting with users (“physical computing”)
  - Communicating with each other (“Internet of Things”, “Smart objects”)
- Hundreds of computers per person, but casual, low-intensity use (calm computing)

# Ubiquitous System Devices

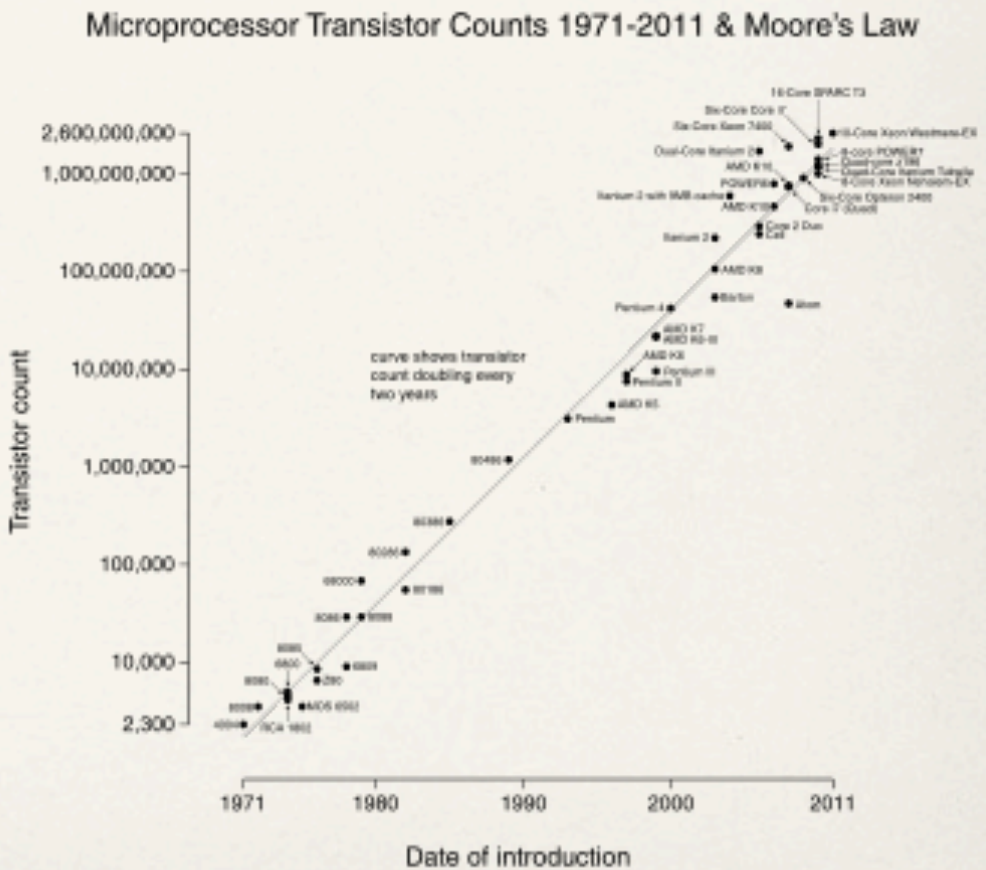
- Basic Forms (Weiser 1991):
  - Tabs -- cm-sized; smartphones, smart cards
  - Pads -- decimeter-sized; laptops, tablets
  - Boards -- meter-sized; smart surfaces, smart boards
- Take away need for visual display (Posad 2009):
  - Dust -- nm - mm; MEMS
  - Skin -- fabrics, polymers; flexible, non-planar; OLEDs
  - Clay -- 3D, arbitrary; ensembles of MEMs; tangible

# Smart Objects

- Real world objects, enriched with information processing capabilities
- Embedded processors in everyday objects
- Communications capability between objects
- Memory within objects for pertinent events
- Context-sensitive behavior through sensors, location/situational/context awareness
- Responsive/proactive through actuators, or communication with environment or other smart objects.

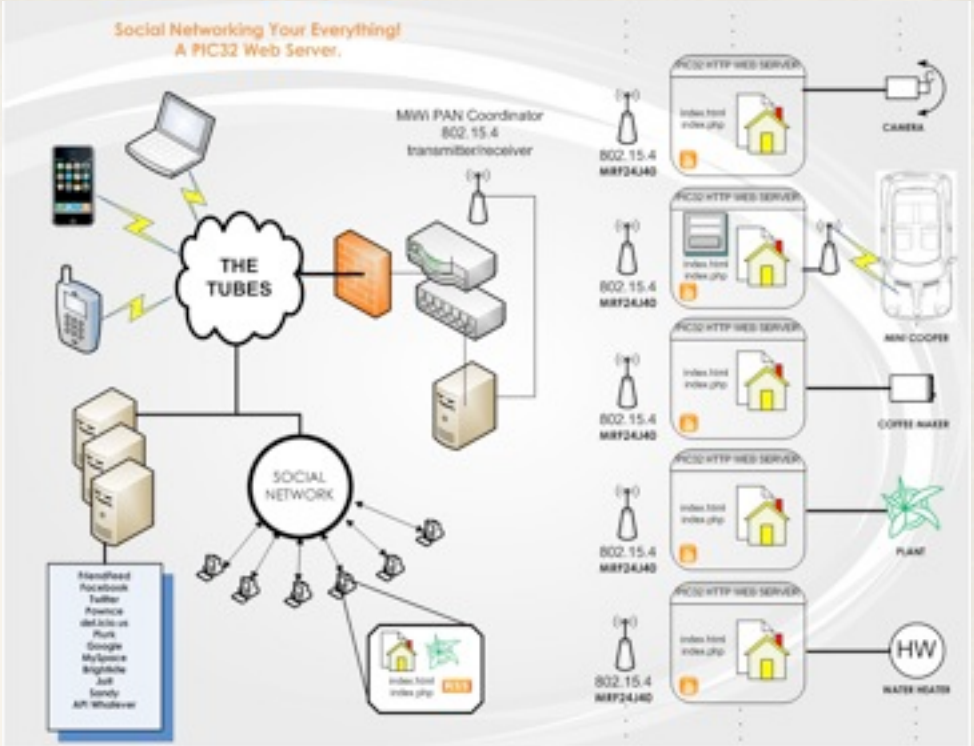
# Enablers: IC Technologies

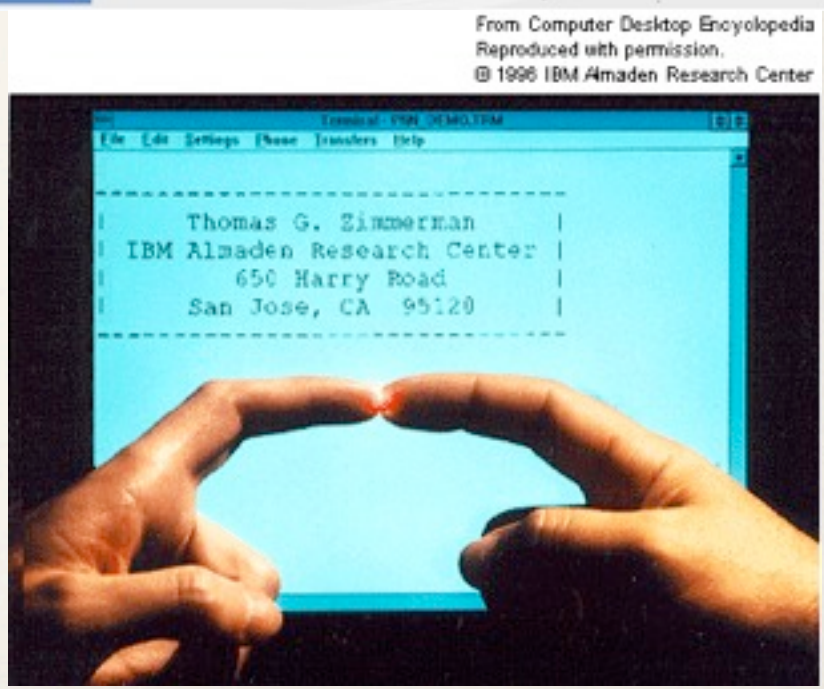
- Moore's Law
  - # transistors on a chip doubles every 18 months
- Extension: Most important technology parameters double every 1-3 years:
  - Computation cycles
  - Bandwidth
  - Memory, Storage capacity



# Enablers: Communications

- Ethernet
- Powerline
  - Coffee maker automatically connects to the Internet
- Wireless
  - Mobile phone: GSM, GPRS, 3G, 4G
  - Wireless LAN (> 10Mb/s)
  - PAN (Bluetooth), BAN
  - Ad-hoc networks




IBM Almaden Research Center: Transfer of business card information by touching fingers

# Enabler: New Materials

- Semiconductors, fibers: Silicon-based computing
- Moving on to???
  - Polymers? (Flexible displays)
  - Textiles?
  - Optical Computing
  - DNA Computing
  - ...

# Enabler: Sensors and Actuators

- Cameras, microphones...
- Radio Sensors
- RFID / NFC
- Fingerprint sensors
- Location Sensors
- ...

# UbiComp Scenarios

Sal looks out her windows at their neighborhood. She sees cars, buildings, sunlight, etc through most of her windows. But through one special window, she sees electronic trails that have been kept for her of her neighbors coming and going.

- Transparent, cheap large display
- Location sensing of people
- Network to communicate location information
- Privacy Policies

Adapted from Kevin Regan's notes

# UbiComp Scenarios

On her way driving to work, Sal sees that the traffic is very heavy. On her heads-up display, she notices an indicator on a side street informing her about a new food shop that just opened. She decides to turn down that street and get a cup of coffee while avoiding the traffic jam.

- Unobstrusive, natural behavior.
- Information moves smoothly from the peripheral to the center and back again.
- Location-dependent and context-sensitive.

Adapted from Kevin Regan's notes

How the computer sees us,
(From O'Sullivan and Igoe)

# Physical Computing

*Date*

# Physical Computing is...

- A conversation between the physical world and the virtual world of the computer

Transduction

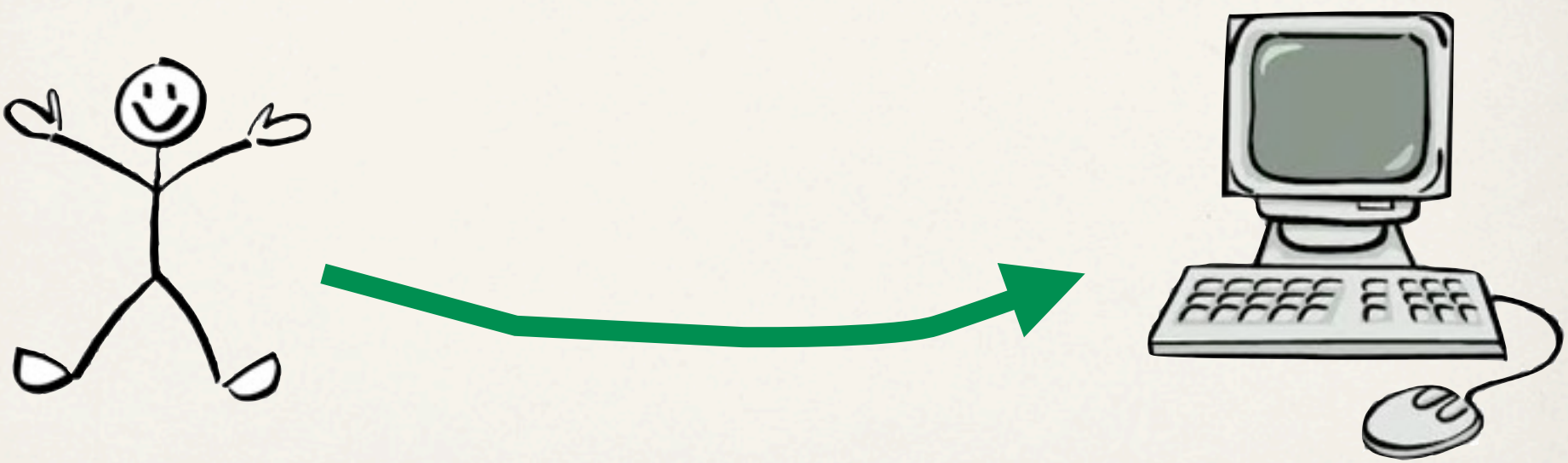
The conversion of one form of energy into another

Physical Energy

Electrical Signals

# Input

- Input is about sensing the world, or your physical energy/expressions.
- Usually is easier than output because it takes less energy to sense things than to change things!

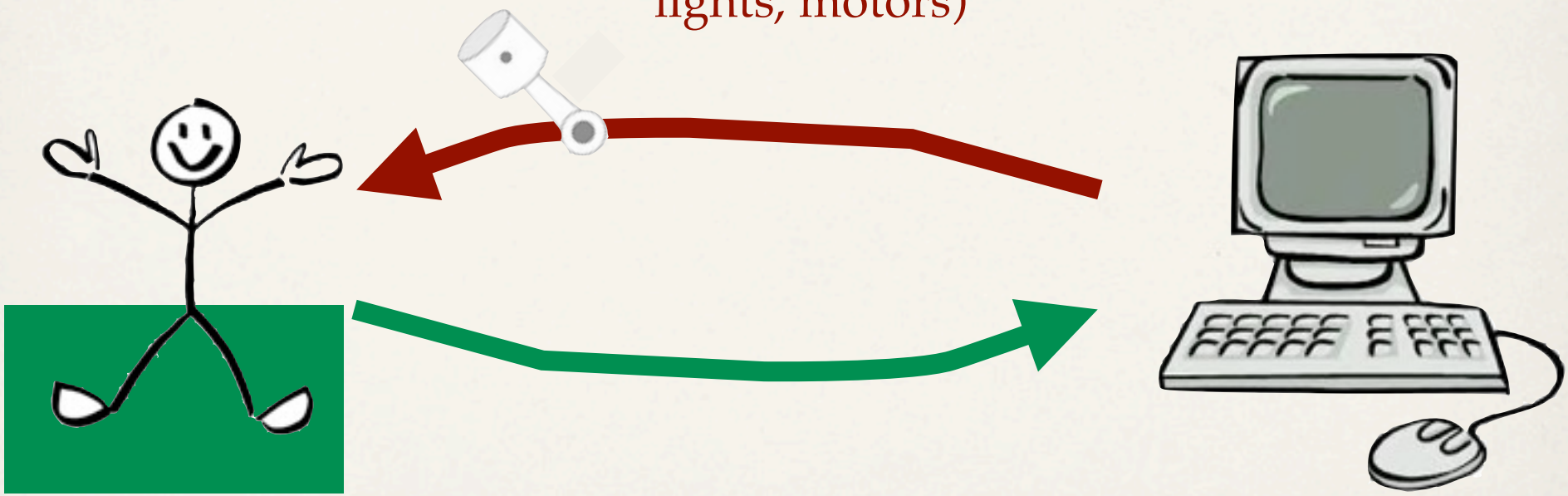


# Output

- The most exciting thing about physical computing is changing the environment.
- But also most difficult to do, because it involves moving things (electrical and mechanical skills)

# Transducers

Output transducers
Actuators (e.g. buzzers, lights, motors)



Input transducers
Sensors (switches, ultrasonic, light, etc)

# Microcontroller

Gateway between the physical and virtual

1. Receive information from sensors
2. Control actuators.
3. Send information to computer and other devices.