

Ubiquitous Computing

Physical Computing

Date



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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

The INTERNET *of* THINGS



During 2008, the number of **things** connected to the Internet exceeded the number of **people** on earth.



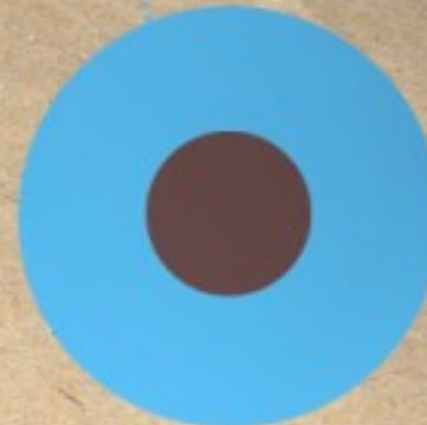
2003



2010



2015



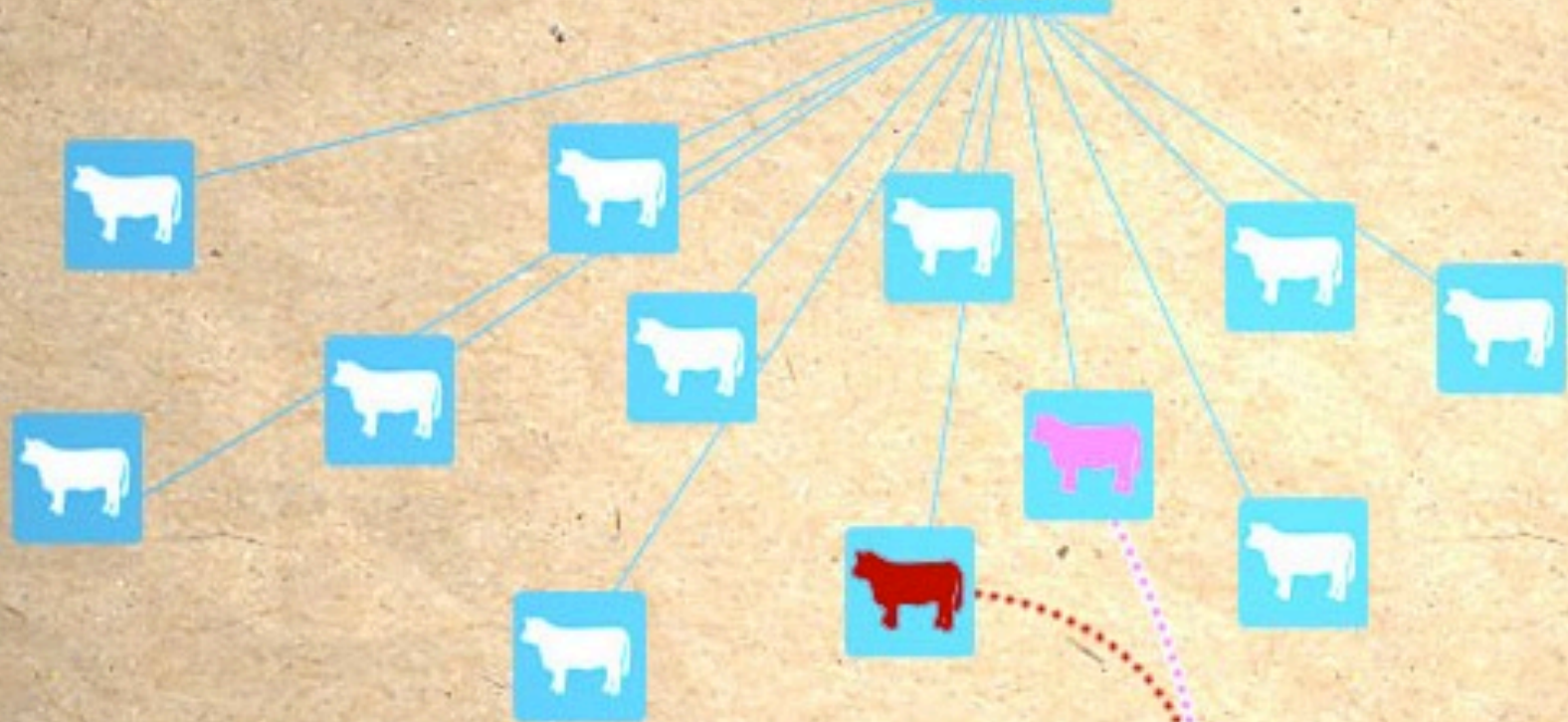
By 2020 there will be **50 billion**.

Cisco Systems Infographic

These **things** are not just smartphones and tablets.

They're every **thing**.

A Dutch startup, **Sparked**, is using wireless sensors on **cattle**.



So that when one is sick or pregnant, it sends a message to the farmer. Each **cow** transmits 200 mb of data per year.



We can monitor **ourselves** this way too.
Corventis makes a wireless cardiac monitor
that physicians can check for health risks.



And this is just the beginning.

These **things** are starting to talk to each
other and develop their own intelligence.
Imagine a scenario where.....

This is communicated
to your **alarm clock**,
which allows you 5 extra
minutes of sleep.



...your **meeting** was
pushed back 45 minutes.



...your **car** knows it will
need gas to make it to the
train station. Fill-ups
usually take 5 minutes.



...there was an accident on
your **driving route** causing
a 15 minute detour.



...your **train** is running 20
minutes behind schedule.



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 ...





...than the entire Internet...

...in 2008.



Cisco's Planetary Skin will use billions of networked sensors on land and in sea, air and space to detect and predict changes to the environment.




We already have cameras and computers that are one cubic millimeter. You could fit 150 of them in this icon.

With the IPv6 protocol, we will have

340,282,366,920,938,463,463,374,607,431,768,211,456

possible Internet addresses.

Cisco Systems Infographic



That's 100 for every atom
on the face of the earth.

Technological limitations are receding exponentially.
When billions of things are connected, talking and learning,
the only limitation left will be our own **imagination**s.



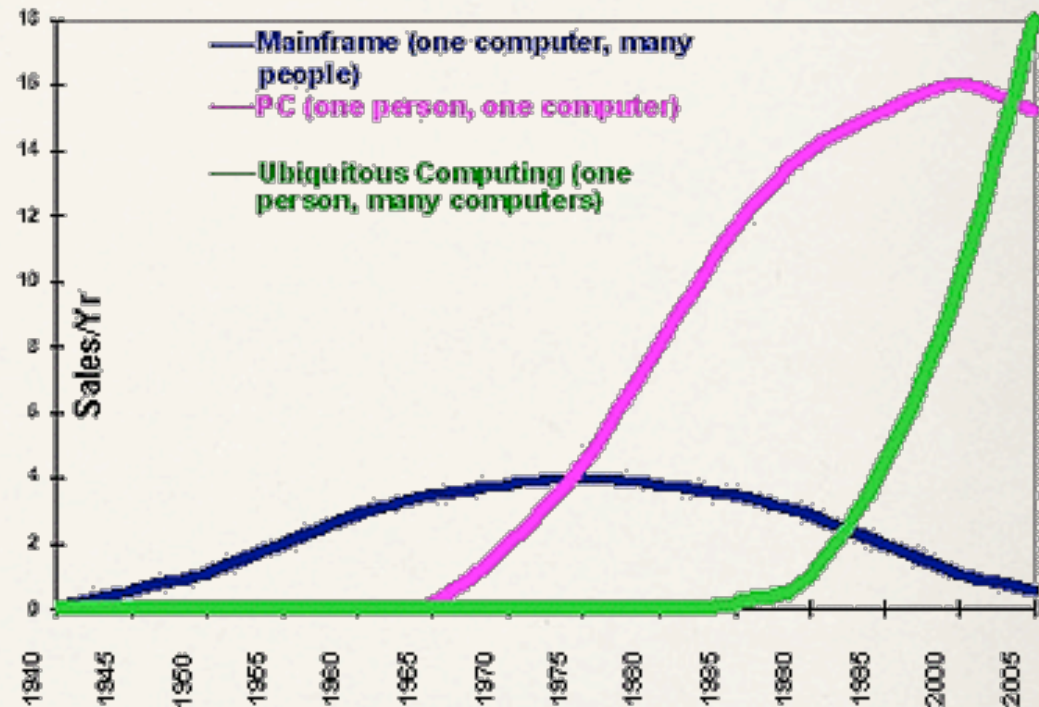
Sources: Cisco IBSG, Jim Cicconi, AT&T, Steve Leibson, Computer History Museum, CNN,
University of Michigan, Fraunhofer

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

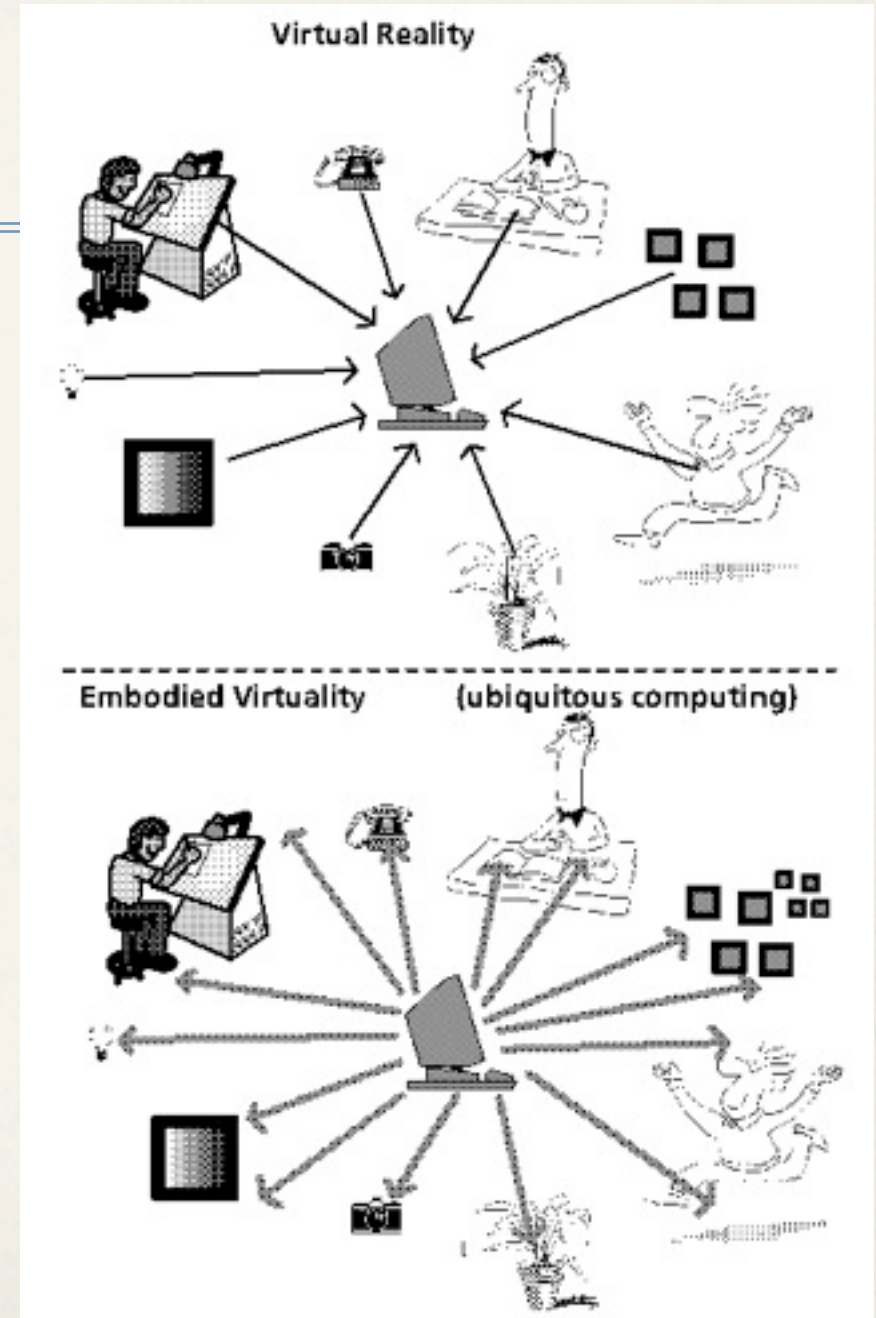


Principles of Ubiquitous Computing (Weiser)

- ❖ 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

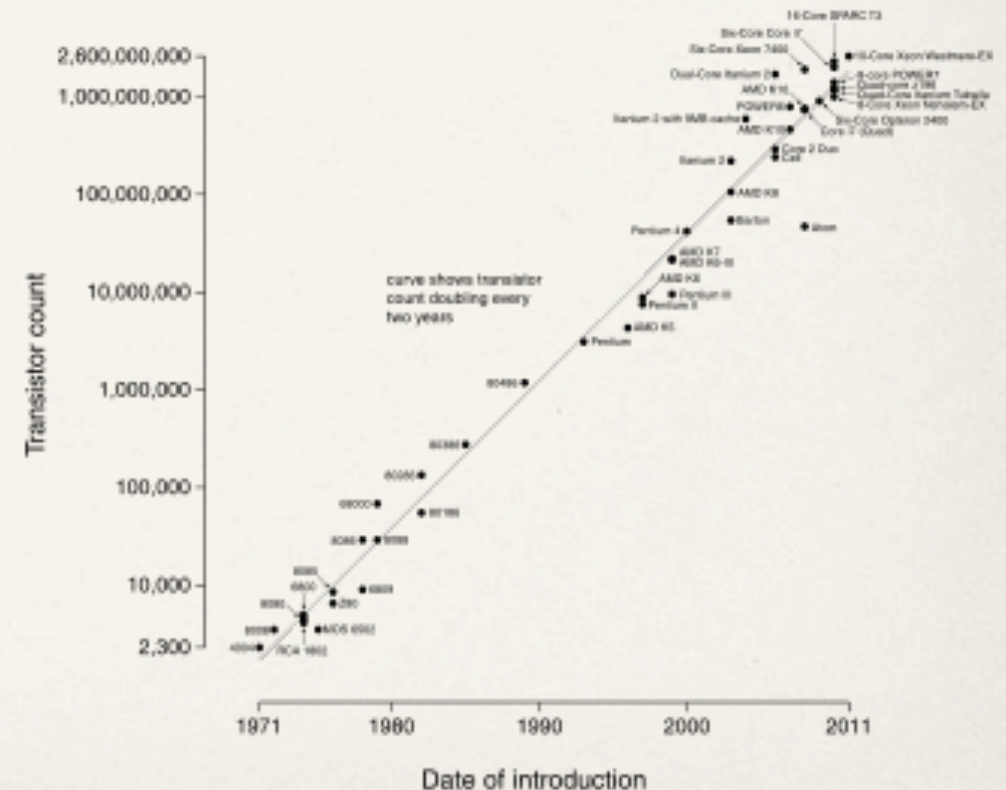
Smart Objects

- ❖ 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.

A small, fluffy, brown monkey-like creature is clinging to a black, rectangular object held by a hand. The creature has a pink nose and is looking towards the camera. The background is a plain, light-colored surface.

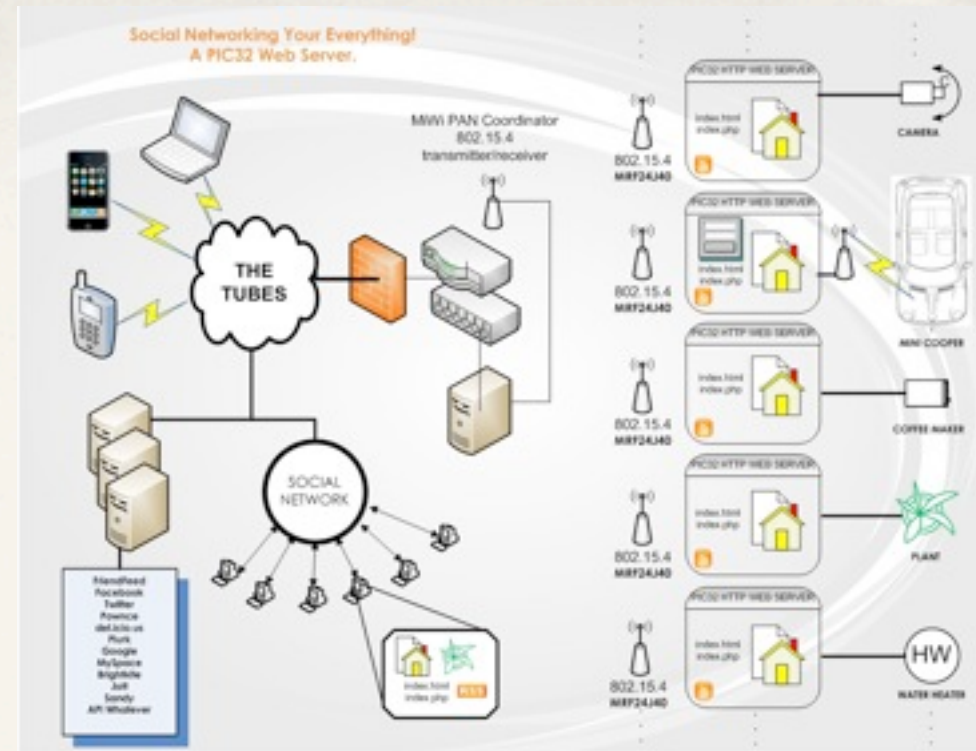
Microprocessor Transistor Counts 1971-2011 & Moore's Law

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

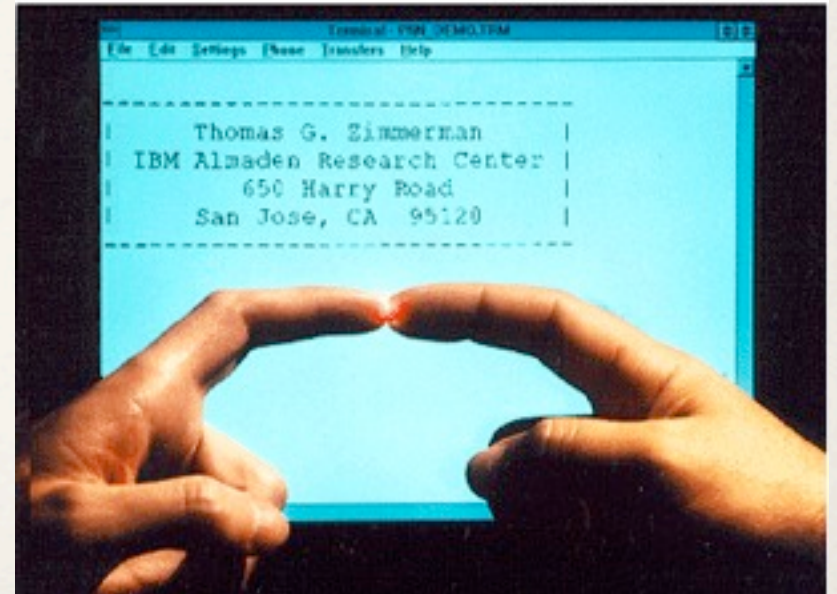


Enablers: Communications

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



From Computer Desktop Encyclopedia
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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

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Physical Computing is...

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



Physical Energy

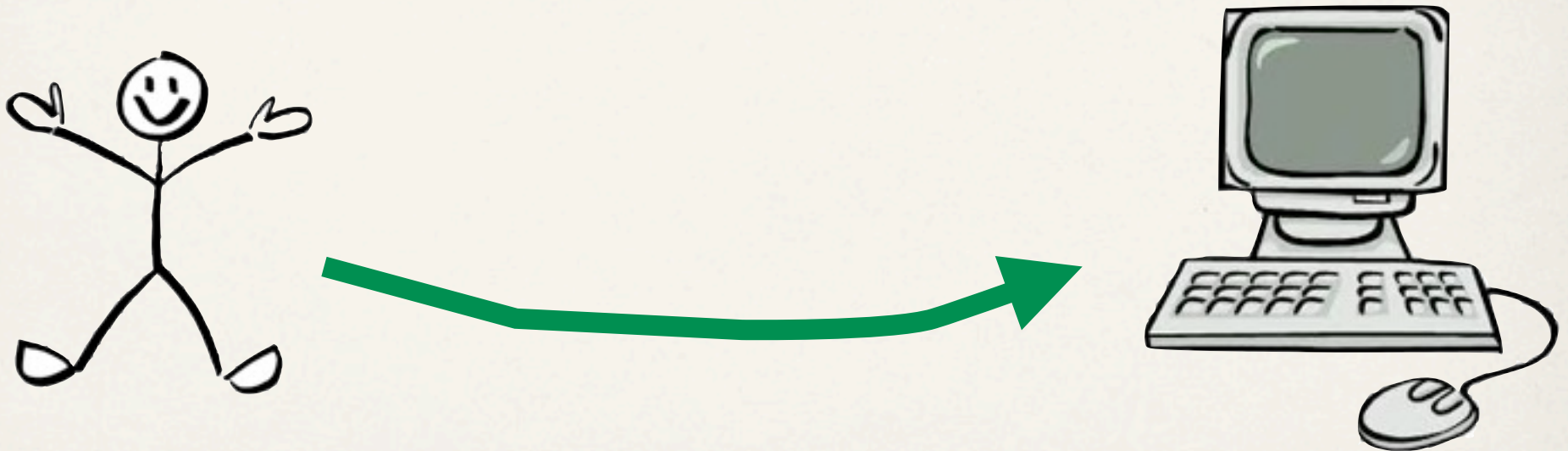
Transduction
The conversion of one form
of energy into another



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!

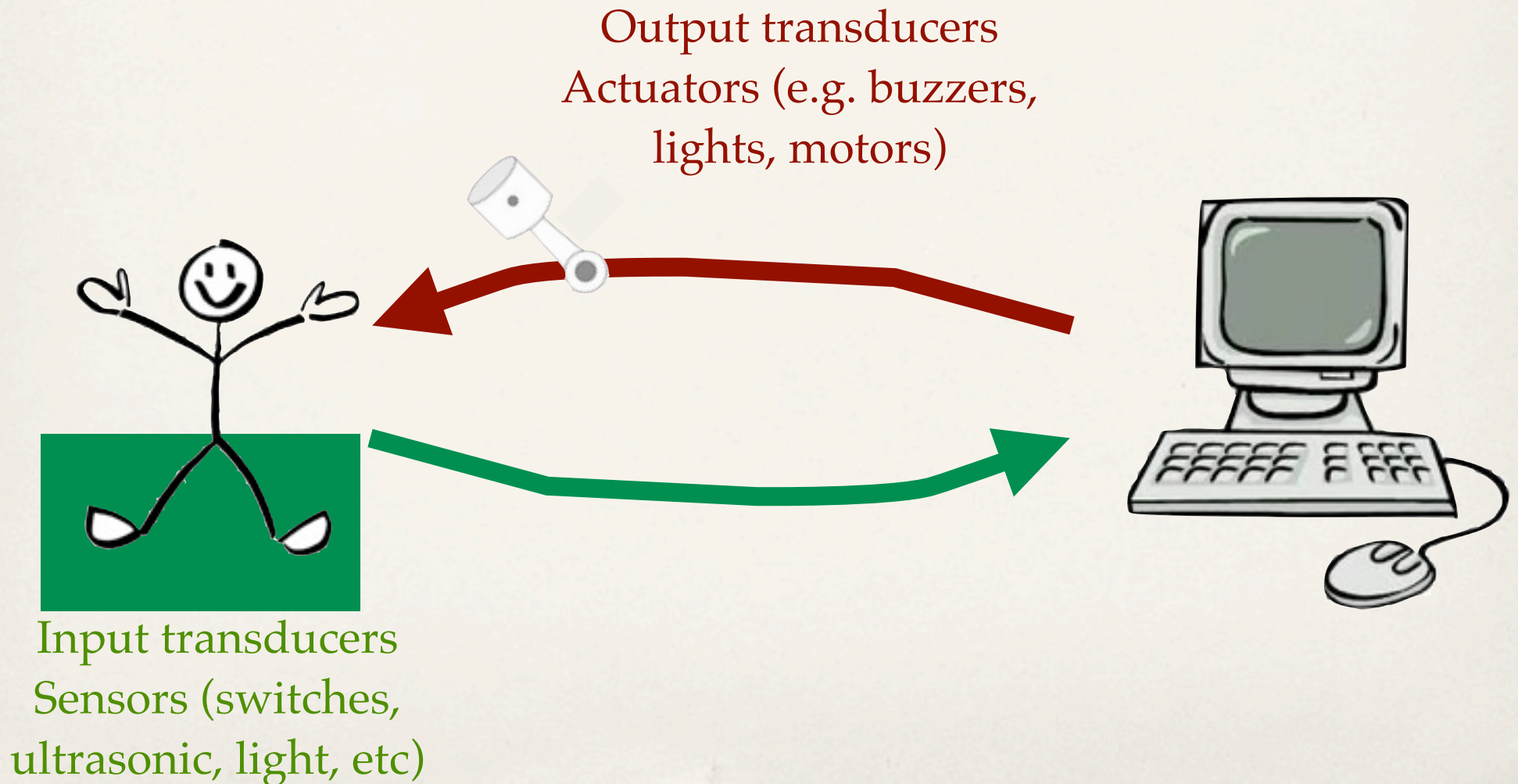


Output

- ❖ 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



Microcontroller

Gateway between the physical and virtual

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

