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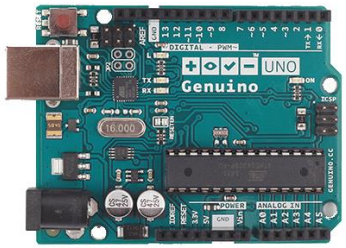
Prototyping the Internet Of Things

ARDUINO – GENUINO

ATMEL ATTINY

27th NOVEMBER 2015



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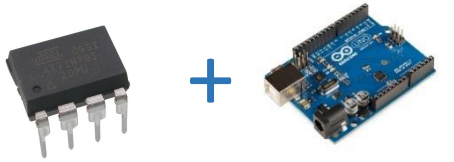
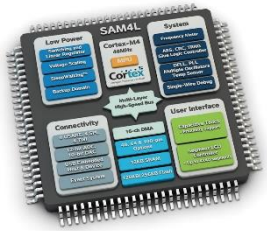
I work in the ICT industry for over 25 years. I'm a result-driven Information Security Consultant and Solution Architect with extensive experience in design, development and implementation of enterprise applications, infrastructure and security solutions to achieve organizational business objectives.

Vulnerability assessment, host hardening, computer forensic and security advisor of ICT infrastructure to industrial, financial companies, government agencies and the armed forces; Senior Architect for the Internet of Things (IoT) products, solutions and services.

Francesco Arruzzoli
Winitalia
CEO

OUR COURSE PATH





Scuola di Scienze e Tecnologie
Sezione di Informatica

Winitalia

Microsoft

Creaticity

Prototyping the Internet of Things

1 ARDUINO-GENUINO ATMEL ATTINY
27th November 2015

The first 7 hours of the course will provide some background about embedded systems and basic concepts about Arduino-Genuino and Atmel Attiny.

2 PIC
18th December 2015

7 hours will be devoted to the basic concept related to PIC microcontroller prototyping.

3 ARM CORTEX
15th January 2016
22nd January 2016

14 hours will be devoted to the basic concept related to ARM prototyping.

MICROSOFT
29th January 2016

7 hours will provide the main concepts characterizing the Microsoft Vision of the IoT.

4 PROJECT
5th February 2016

Full day working on an industrial case study.

Course information*

Embedded systems are increasingly being joined together into an "Internet of things" or sensor networks to enable several applications such as smart homes, manufacturing, energy distribution and transportation.

This course provides students with a knowledge and understanding of widely used boards and platforms for prototyping the Internet of Things.

The course is composed of 35 hours of lectures plus a final project. 6 CFU will be given to all students that attend the course and successfully complete the project and final test.

*For students of M.Sc. Degree Course of Computer Science

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OUR COURSE GOAL

MAKE A IoT STARTING FROM CONCEPT TO REALIZATION

OUR KEYWORDS

MAKING

SHORTCUT

HACKING

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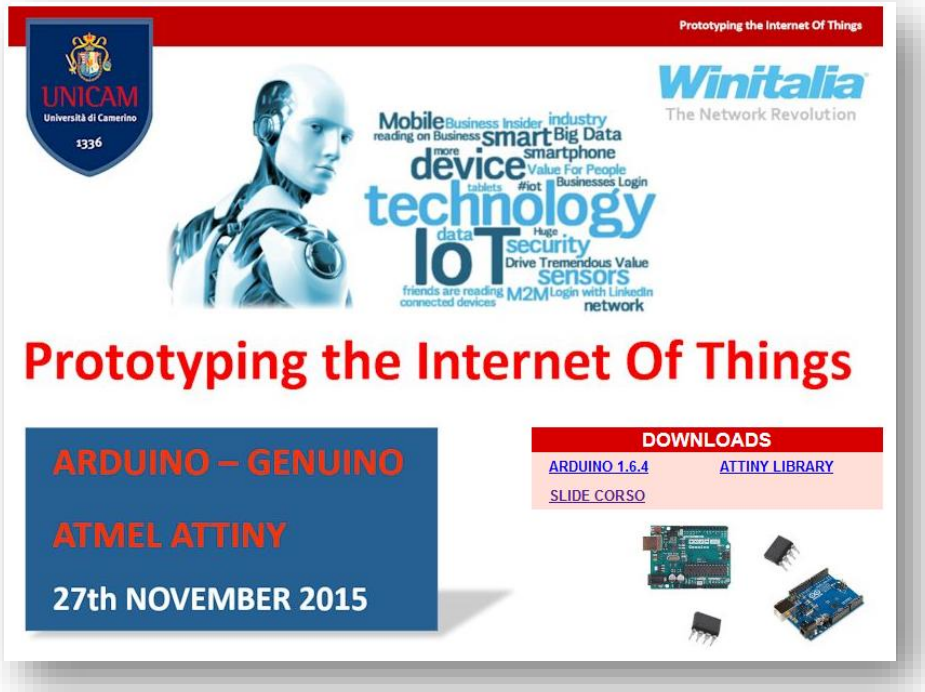
DOWNLOADS COURSE



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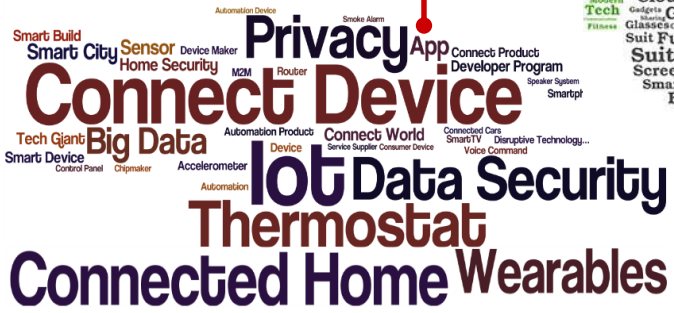
Ok but what is…



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More “Things” are being connected

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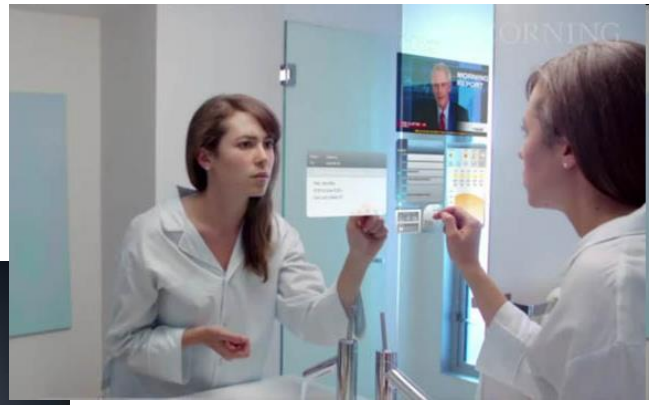
Home/daily-life devices
Business and
Public infrastructure
Health-care
…



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People Connecting to Things

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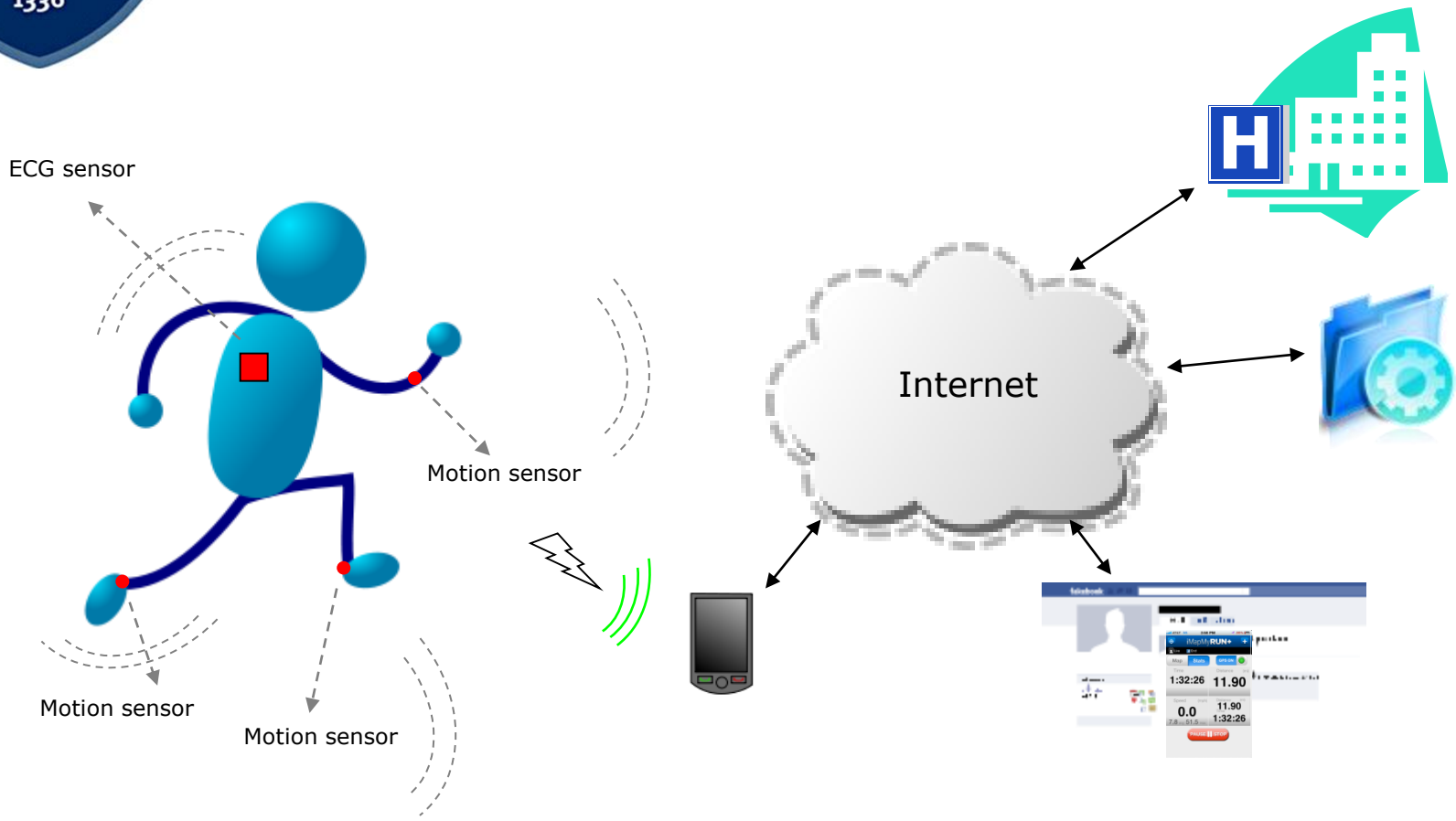
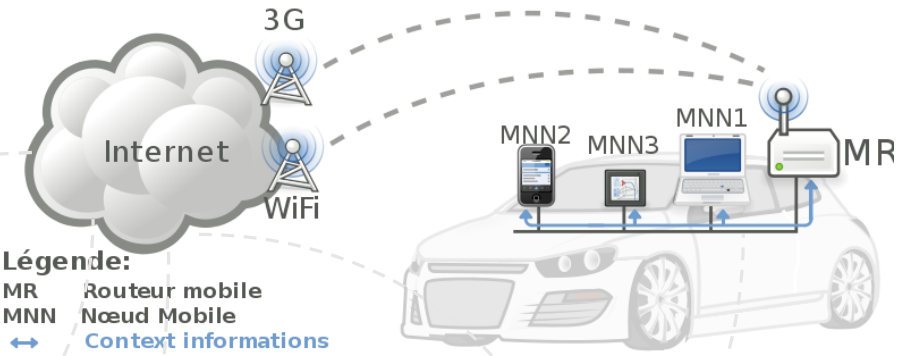
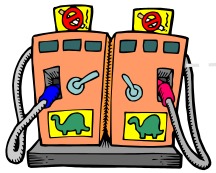


Things Connecting to Things

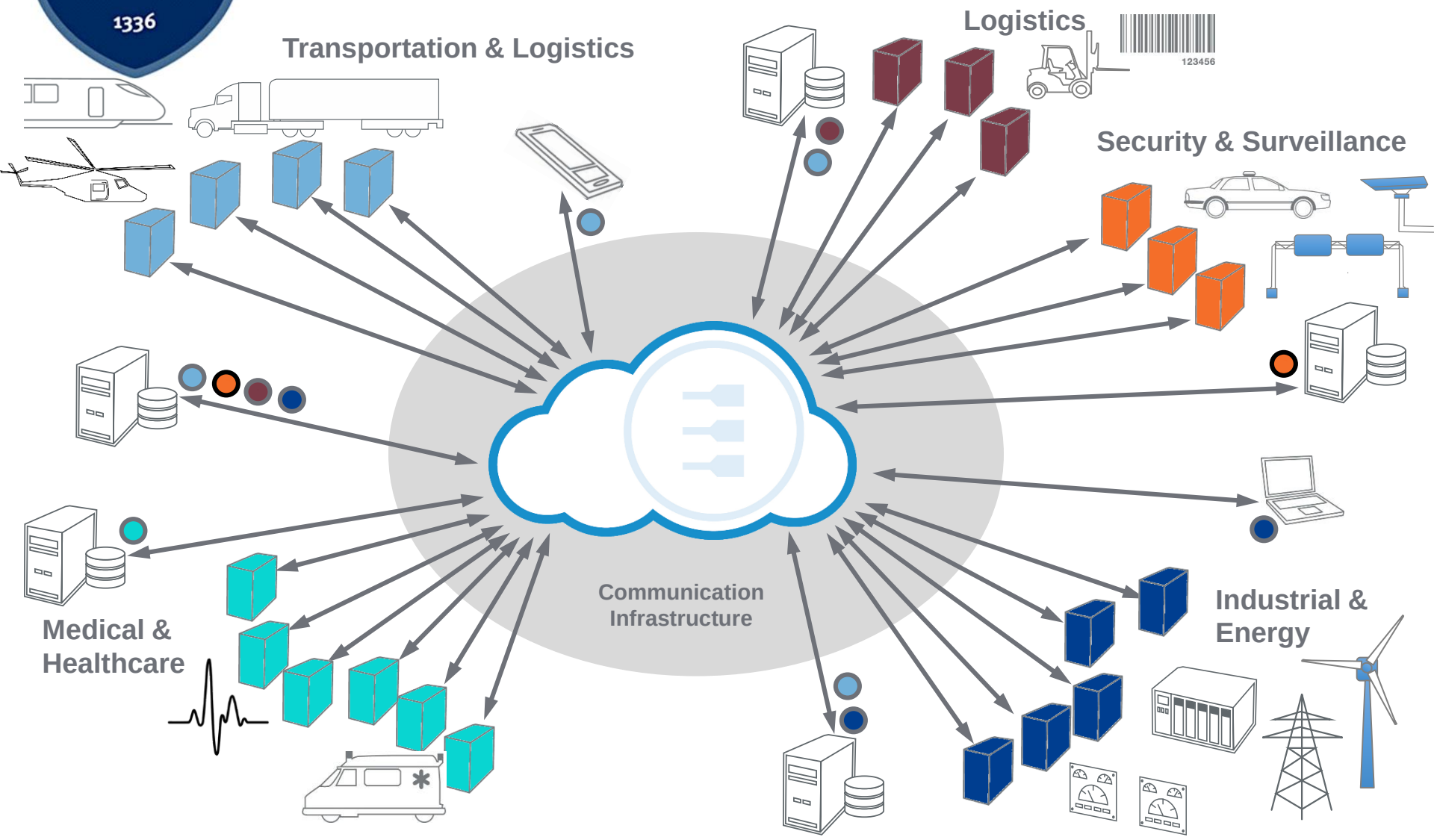




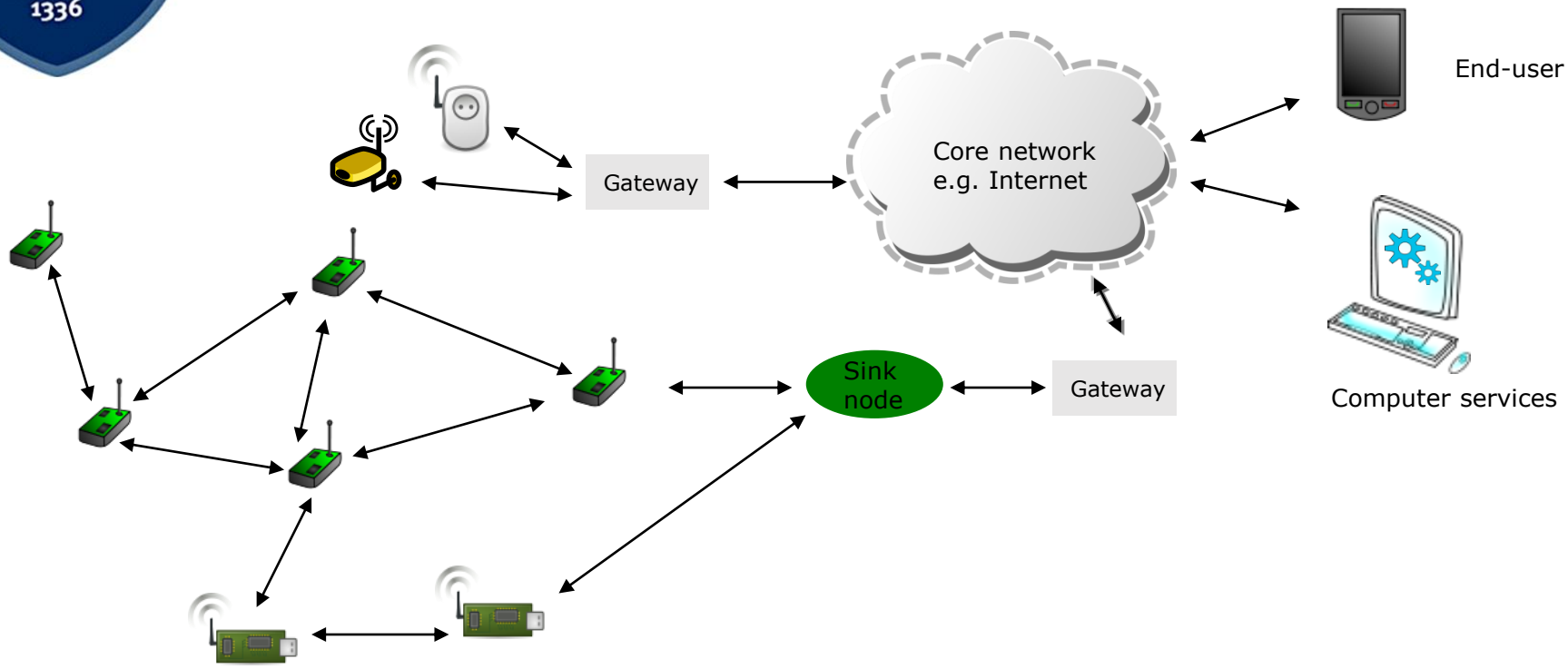
- Complex and heterogeneous resources and networks

The Internet of Things

Decoupling Producers & Consumers of M2M Device Data



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)

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How are the networks changing?

- Extensions
  - More nodes, more connections, IPv6, 6LowPan,...
  - Any TIME, Any PLACE + Any THING
  - M2M, IoT
    - Billions of interconnected devices,
    - Everybody connected.
- Expansions
  - Broadband
- Enhancements
  - Smart networks
  - Data-centric and content-oriented networking
  - Context-aware (autonomous) systems

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Future Networks

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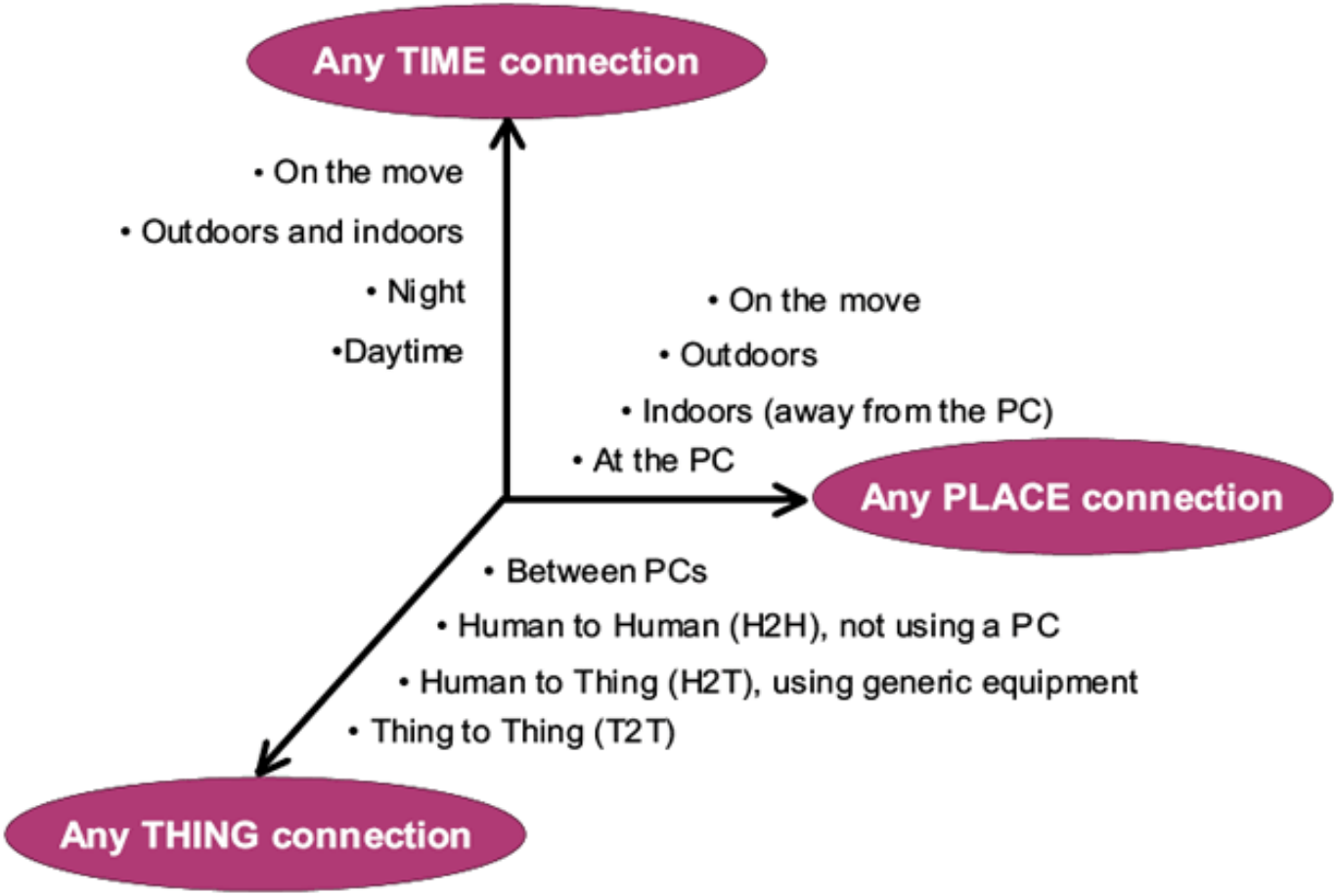

Source: ITU adapted from Nomura Research Institute

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"Thing" connected to the internet

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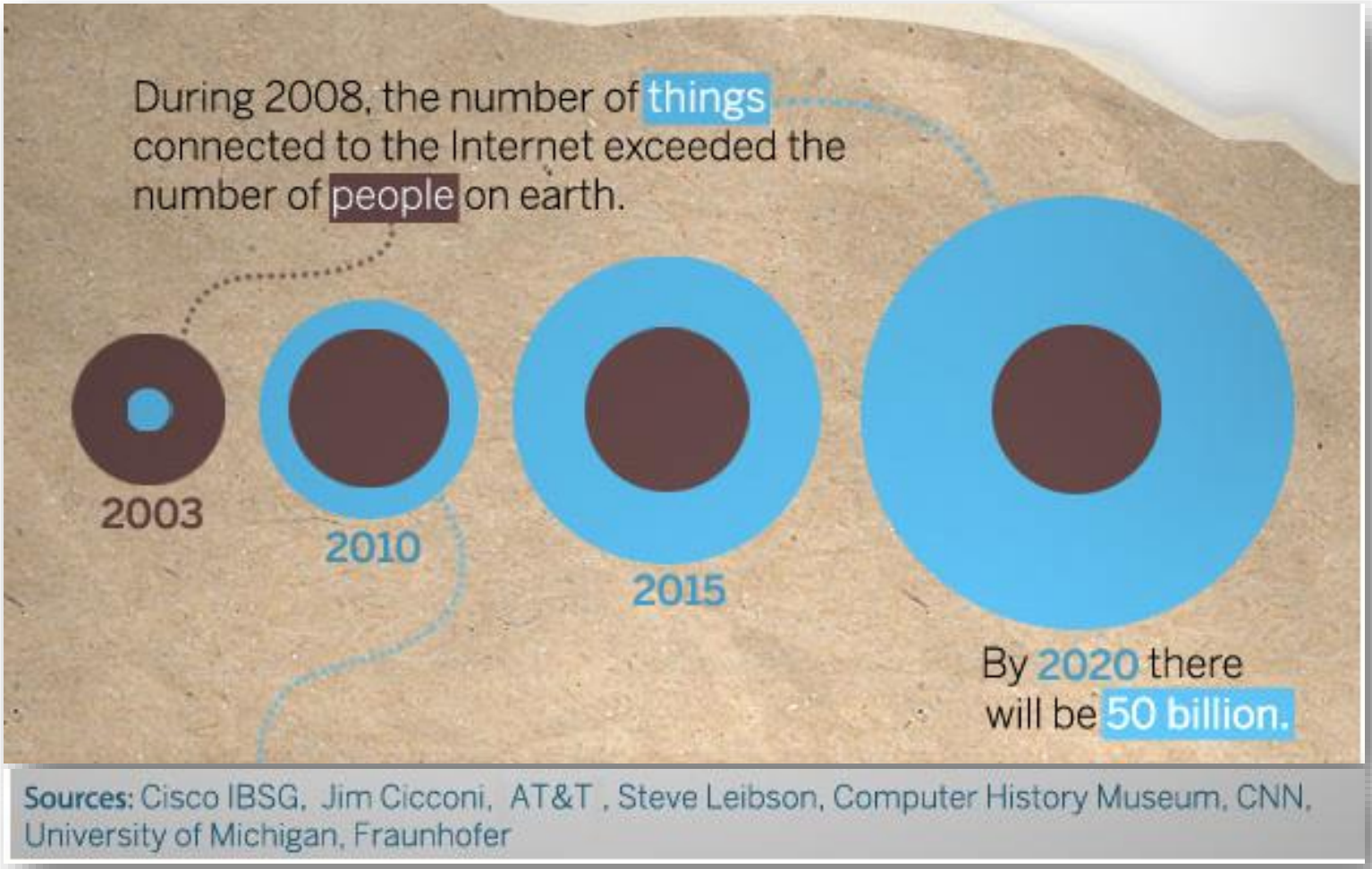

Image Courtesy: : CISCO

Market growth

- "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.
- In February 2012 the Chinese government therefore decided to set up a fund of approximately $775 million to support this field in the next five years. It will grow to $11 billion by 2015.
    - This sector is expected to grow to $116 billion by 2015, according to a report published by the Xinhua News Agency in late 2010.

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

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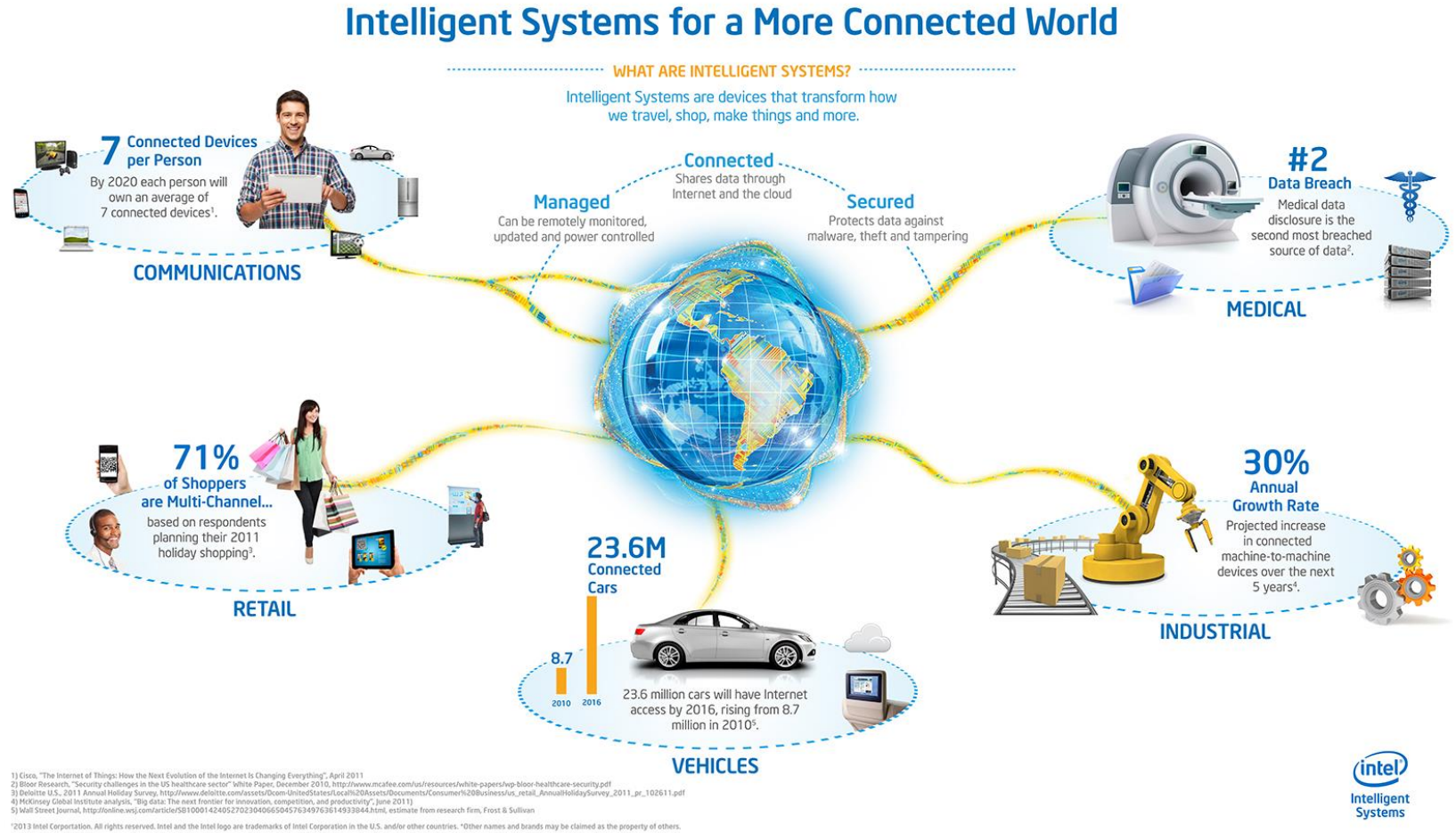
Internet of Things (IoT)

- 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*.

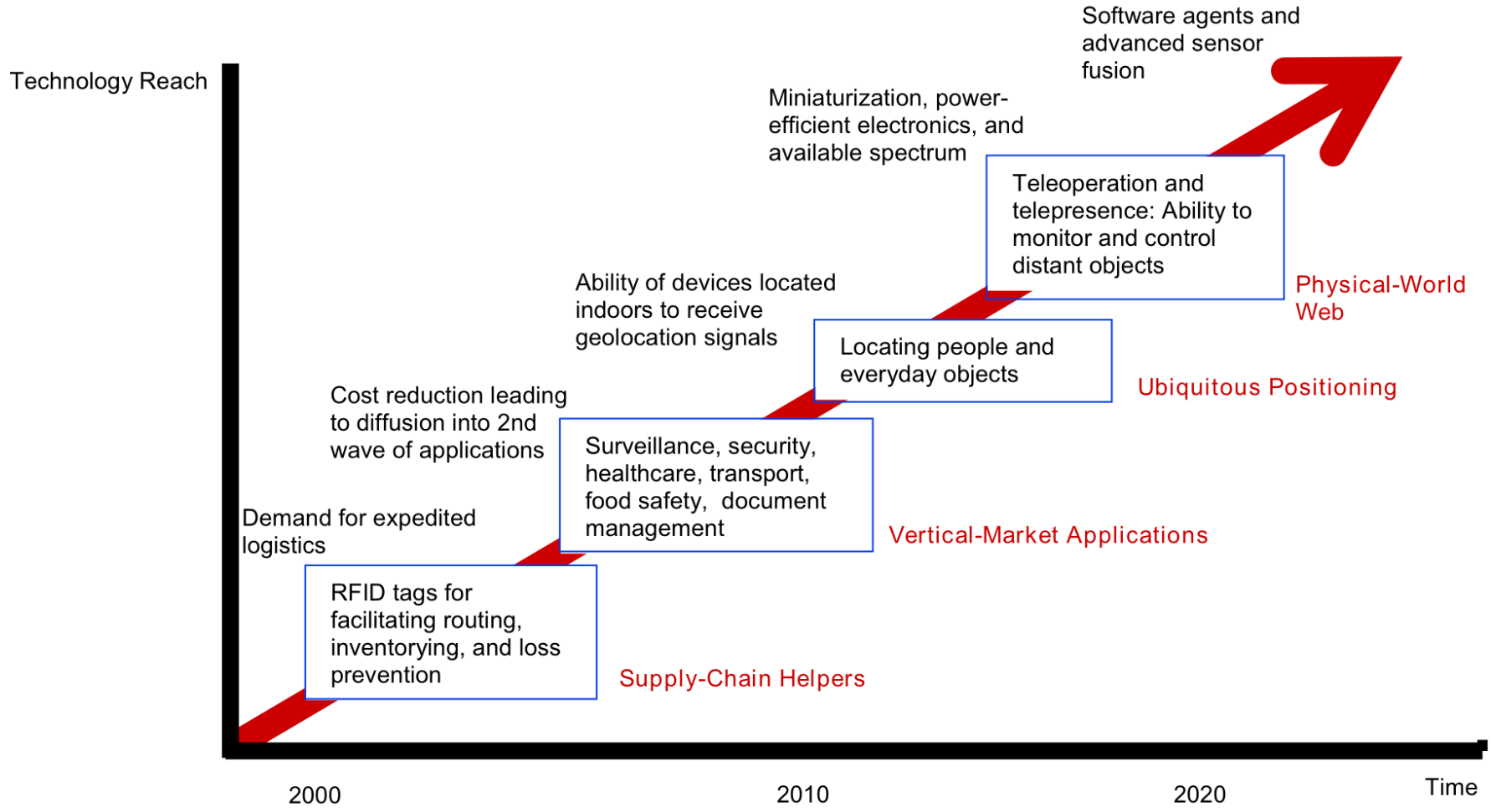
- "The technologies and solutions that enable integration of real world data and services into the current information networking technologies are often described under the umbrella term of the Internet of Things (IoT)"

Opportunities



Source: http://blog.trentonsystems.com/internet-of-things-crosses-business-personal-boundaries/

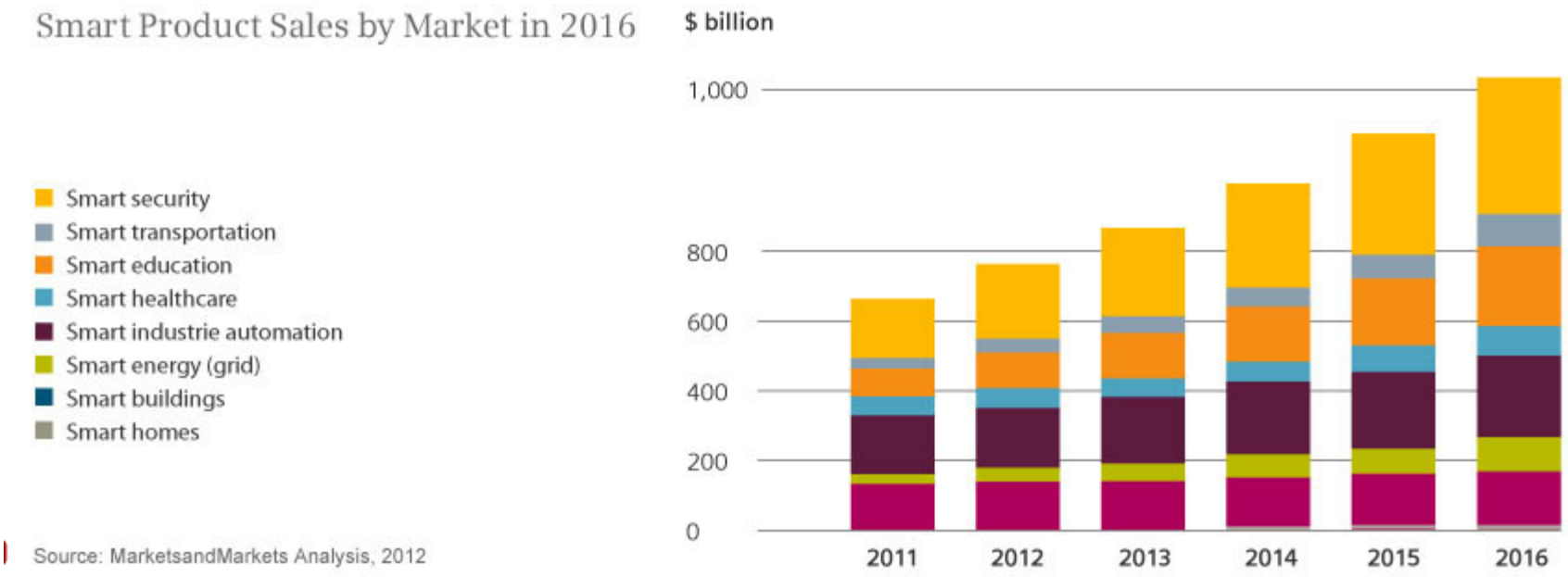
Technology trend



Source: SRI Consulting Business Intelligence

Smart product sales

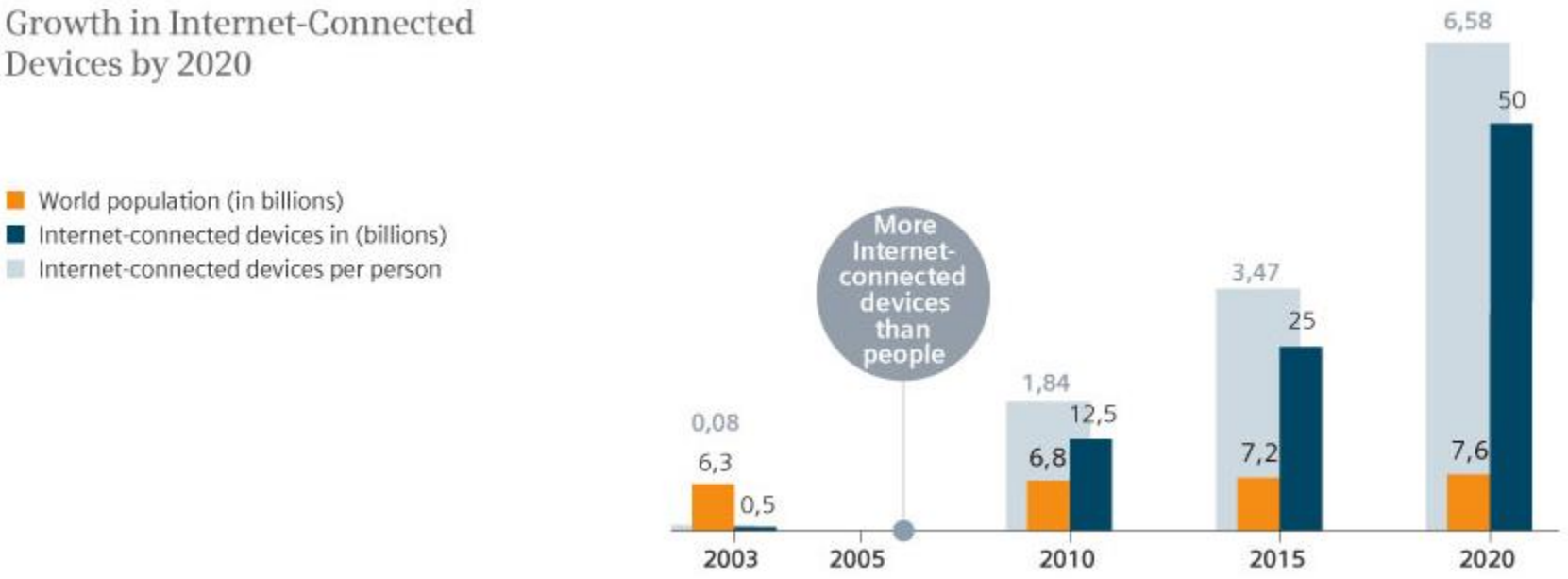
Smart Product Sales by Market in 2016



Source: MarketsandMarkets Analysis, 2012

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

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

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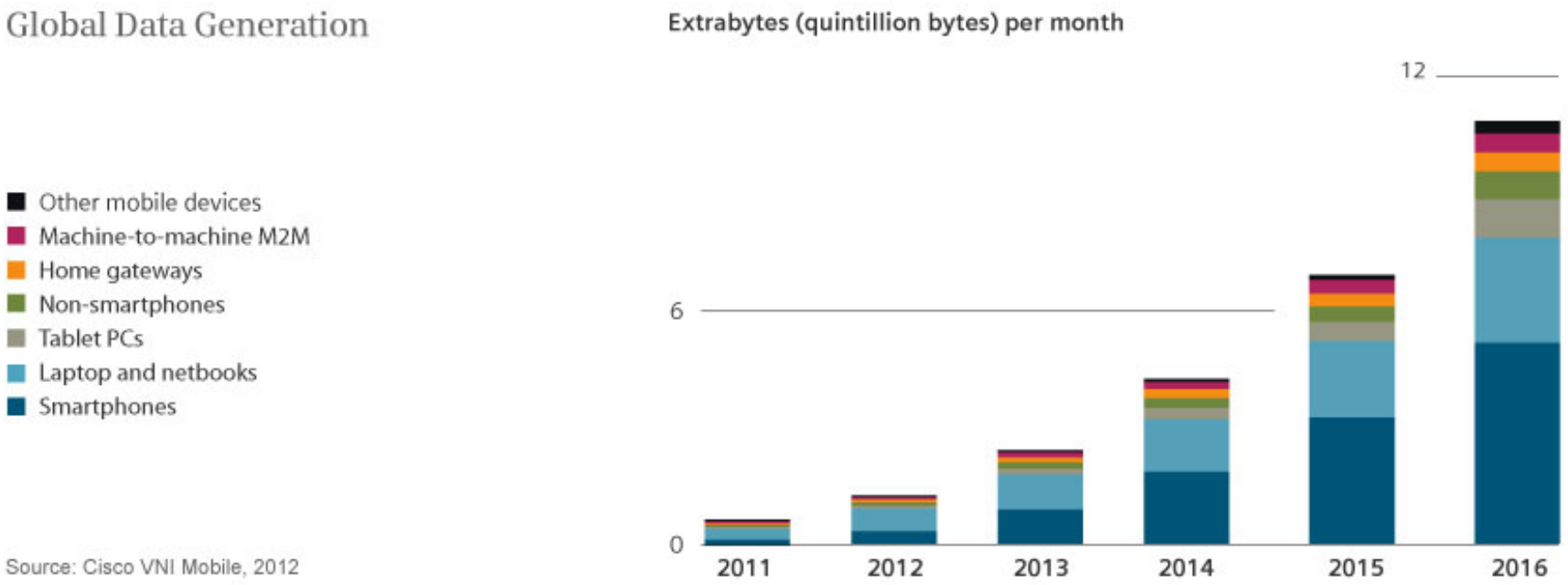
Global Data Generation

- Everyday around 20 quintillion (10^18) bytes of data are produced.
  (Source: http://www-01.ibm.com/software/data/bigdata/).

- This data includes textual content (unstructured, semi-structured, structured) to multimedia content (images, video and audio), on a variety of platforms (enterprise, social media, and sensors).

Data Generation



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Innovation fostered by interoperability

- Interoperability is a crucial building block
  - increasing variety of applications
  - enabling emergence of niche-markets (long-tail)
  - articulating standard technical interfaces and P2P
  - allowing convergence of distinct systems in the open ecosystem of IoT,
- Interoperability reduces access barriers
  - to digital content
  - to a great variety of innovative services of any kind
- Interoperability enhances user autonomy
  - increases creativity and freedom of stakeholders and actors in the field
  - widen the range of choice for consumer

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Sensor devices are becoming widely available

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

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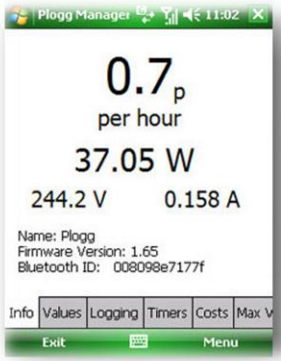

The technical side

- Competing technical solutions
  - Different types of RFID
  - Alternatives solutions to RFID
- The main technological needs
  - Guaranteeing the performance of solutions in use contexts
  - Ensuring the durability of solutions
  - Conceiving an efficient data management system
  - Some specific bottlenecks (memory, privacy…)
- The standardization and interoperability = a key dimension
  - Dependence on existing standards.
  - A standard of standards.
  - Standards “granularity” and interoperability

The business perspective

- What performance?
  - Local contexts (quality, prices…)
  - Macro effects
- Who should invest and why?
  - Traditional firms vs new entrants
  - ROI
- New Business Models
  - Redefinition of the value chains
  - New services for consumers
  - New resources for efficiency
- The supply side
  - Which market ?
  - Which suppliers ?

Diffusion uncertainties : privacy, the mostly mentionned risk

- Multifaceted risk
  - Traditional + emerging
  - Personal + industrial
  - Technical + process questions
- Efficiciency vs. Privacy
- Multiple identities, regulation
- A market for security and Privacy Enhancing Technologies

M2M risks and liability
- Environment
- Falsification
- Logarithmic conflicts
- Trust in informations

Ethical concerns
- From things to animal and individual tagging
- awareness and education
- Freedom of silence, withdrawing and forgetfulness

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The usability viewpoint

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How to Define the Iot?

- *Formally :* a network of networks which enables to identify digital entities and physical objects
  - *whether they are inanimate (including plants) or animate (animals and human beings) – directly and without ambiguity, via standardized electronic identification systems and wireless mobile devices, and thus make it possible to retrieve, store, transfer and process data relating to them, without discontinuity between the physical and virtual worlds"* (Benghozi, Bureau, Massit-Folléa, 2008)
- *Conceptually* : new identities for objects
  - "*Things having identities and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental, and user contexts*" (working group Eposs)
- *Technically* : an extension of the Internet
  - naming system and reveals a convergence of digital identifiers in the sense that it is possible to identify digital information (URL website addresses for instance) and physical elements (like a pallet in a warehouse, or a sheep in a herd) in a standardized way
- *From the user point*: a new space for innovative services

IoT hardware

Any Internet-connected computer with an **interface to the real world** (sensors, actuators)

Small => can be **embedded into things**

Small computer = **microcontroller** (or **board**), e.g. Arduino, Netduino Plus, BeagleBone, …

Note: connecting your board to the Internet via a desktop PC and USB is also fine, just a bit overkill

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Meet Arduino Board

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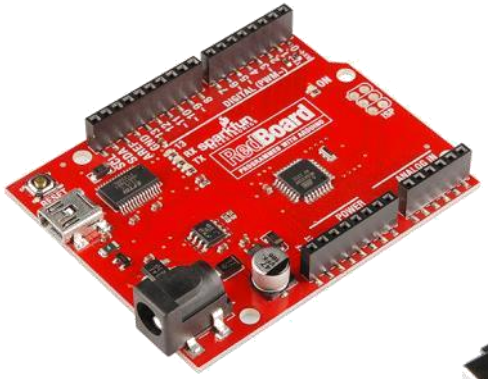
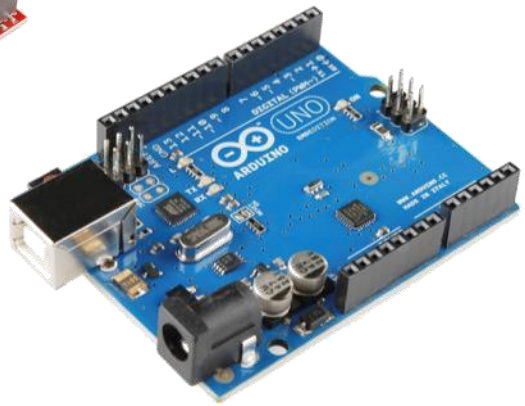
- "Strong Friend" Created in Ivrea, Italy
- in 2005 by Massimo Banzi & David Cuartielles
- Open Source Hardware
- ATMEL Processor
- Coding is accessible & transferrable → (C++, Processing, java)



open source hardware



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Meet Arduino Uno

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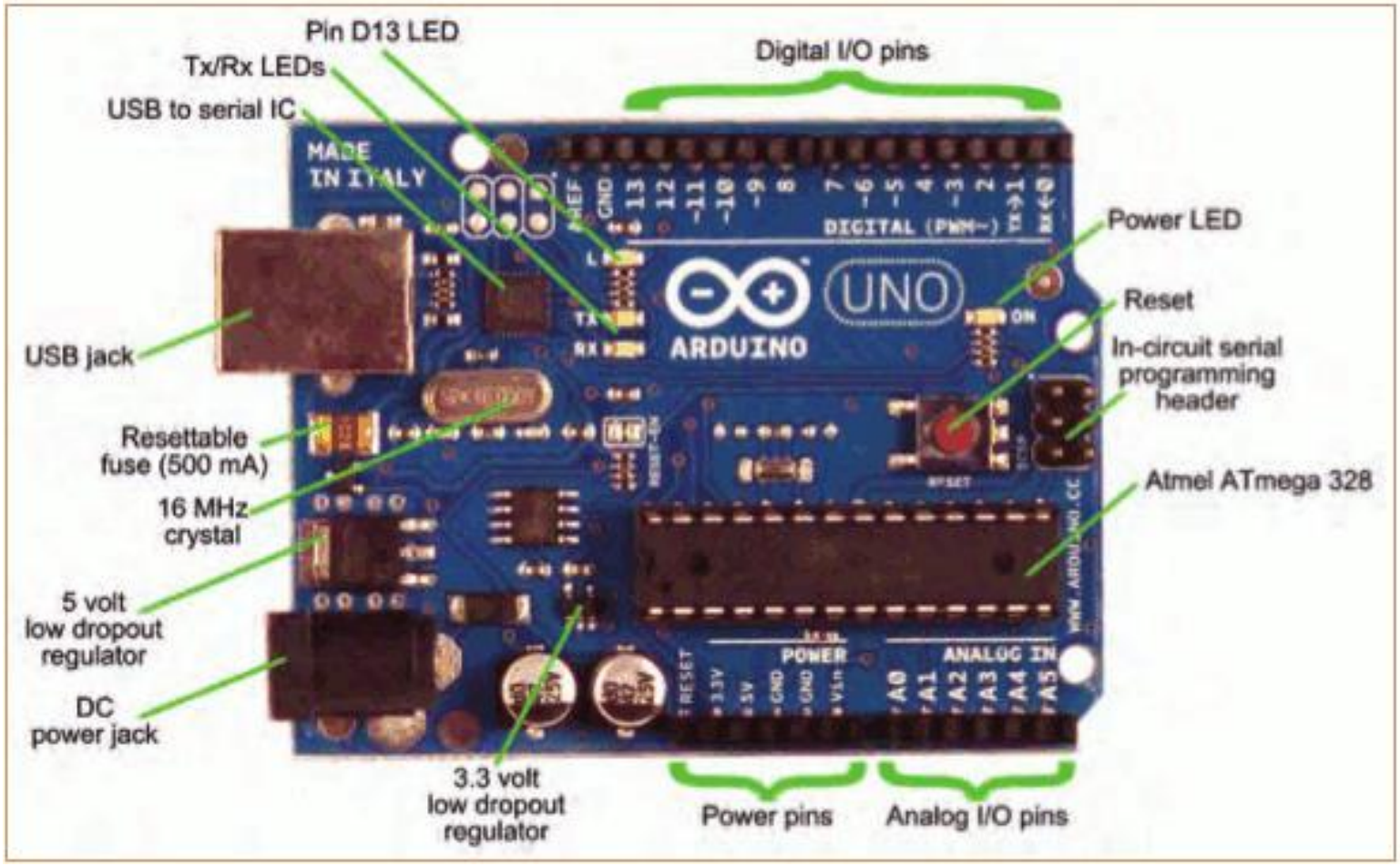

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One Step Beyond

Arduino M0 Pro

core ARM Cortex® M0+ a 32 bit

Professional Debug without JTAG Emulator

32 bit Application, ATMEL DEBUG INTEGRATED OpenOCD

Microcontrollore - ATSAMD21G18, 48pin LQFP
Tensione di funzionamento - 3.3V
Pin Digitali I/O - 14, con 12 PWM e UART
Pin di ingresso analogico - 6, canali ADC 12 bit
Pin di output analogico - 1, DAC 10 bit
Corrente DC per Pin I/O - 7 mA
Memoria Flash - 256 KB
SRAM - 32 KB
EEPROM - fino a 16KB
Frequenza di clock - 48 MHz

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two Step Beyond

Genuino (outside USA) / Arduino 101 (USA only)

Coming soon (february 2016 ?)

Microcontroller	Intel Curie
Operating Voltage	3.3V (5V tolerant I/O)
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 4 provide PWM output)
PWM Digital I/O Pins	4
Analog Input Pins	6
DC Current per I/O Pin	4 mA
Flash Memory	196 kB
SRAM	24 kB
Clock Speed	32MHz

Arduino 101 & Genuino 101 are the ideal successor of the UNO, updated with the latest technologies. It recognises gestures, and features a six-axis accelerometer and gyroscope.


KEEP
CALM
AND
HANDS
ON

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Serial Communication

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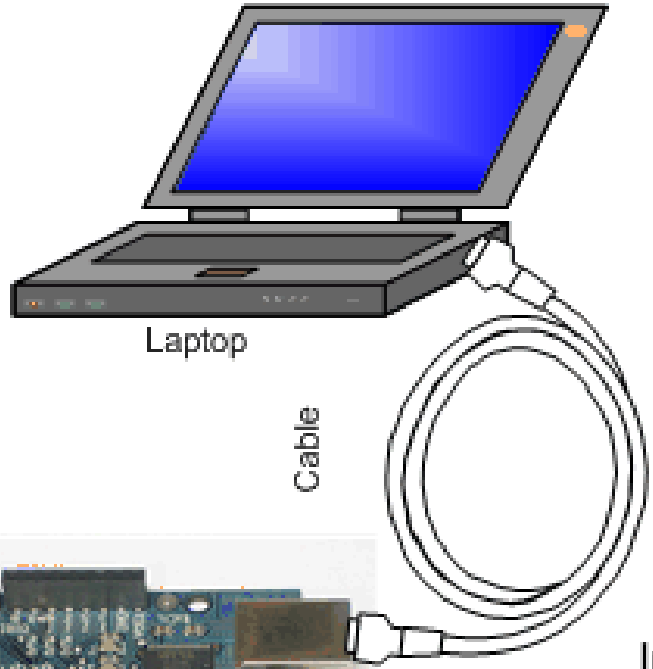
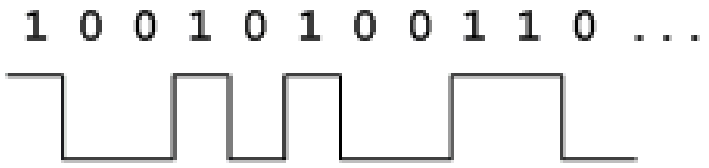
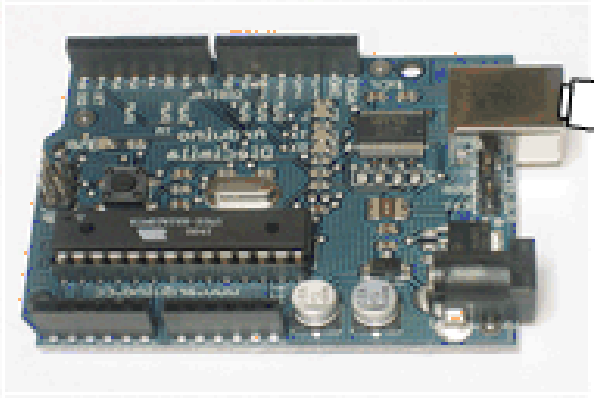


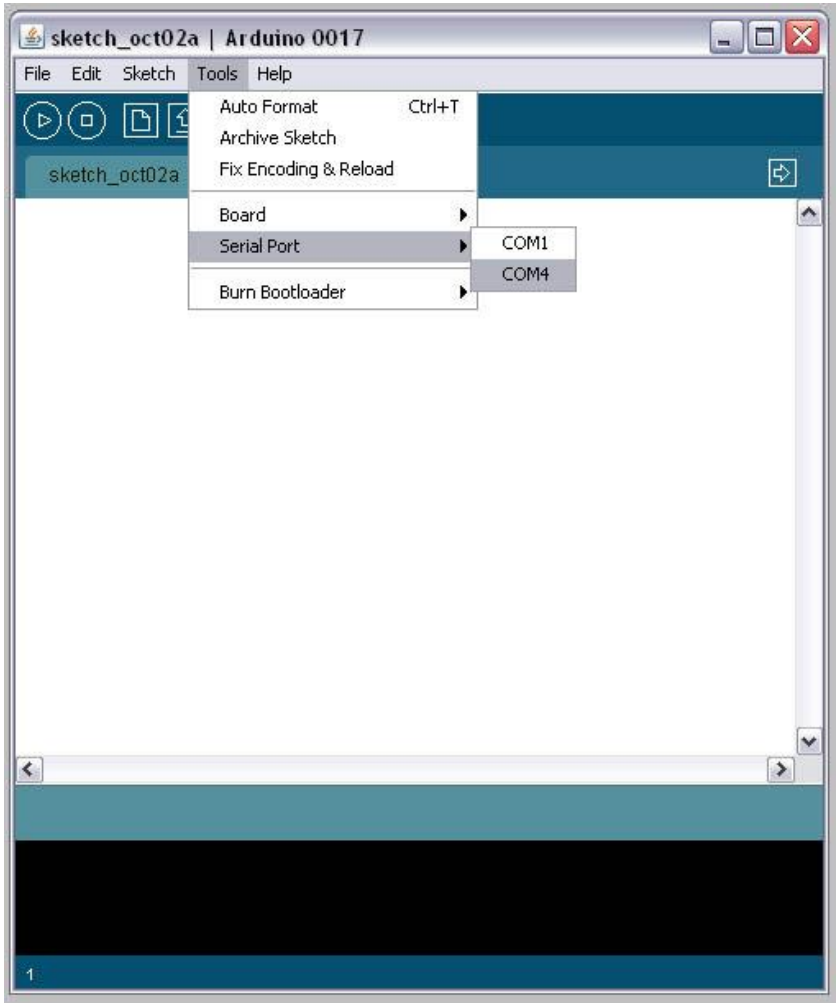




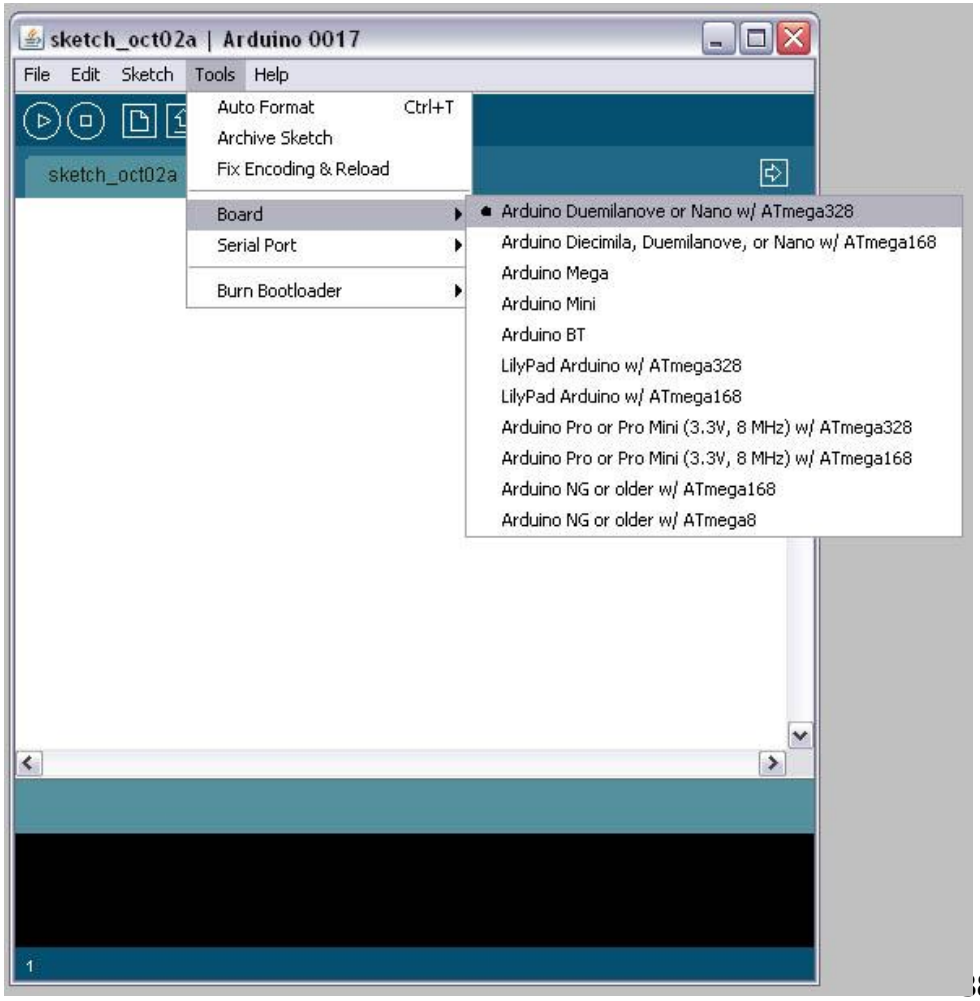
Information passes between the computer and Arduino through the USB cable. Information is transmitted as zeros (‘0’) and ones (‘1’)… also known as **bits**!

Arduino software

Select your port



Select microcontroller type



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Arduino “Language”

- Language is standard C/C++ (but made easy)
- Lots of useful functions

  pinMode() – set a pin as input or output

  digitalWrite() – set a digital pin high/low

  digitalRead() – read a digital pin’s state

  analogRead() – read an analog pin

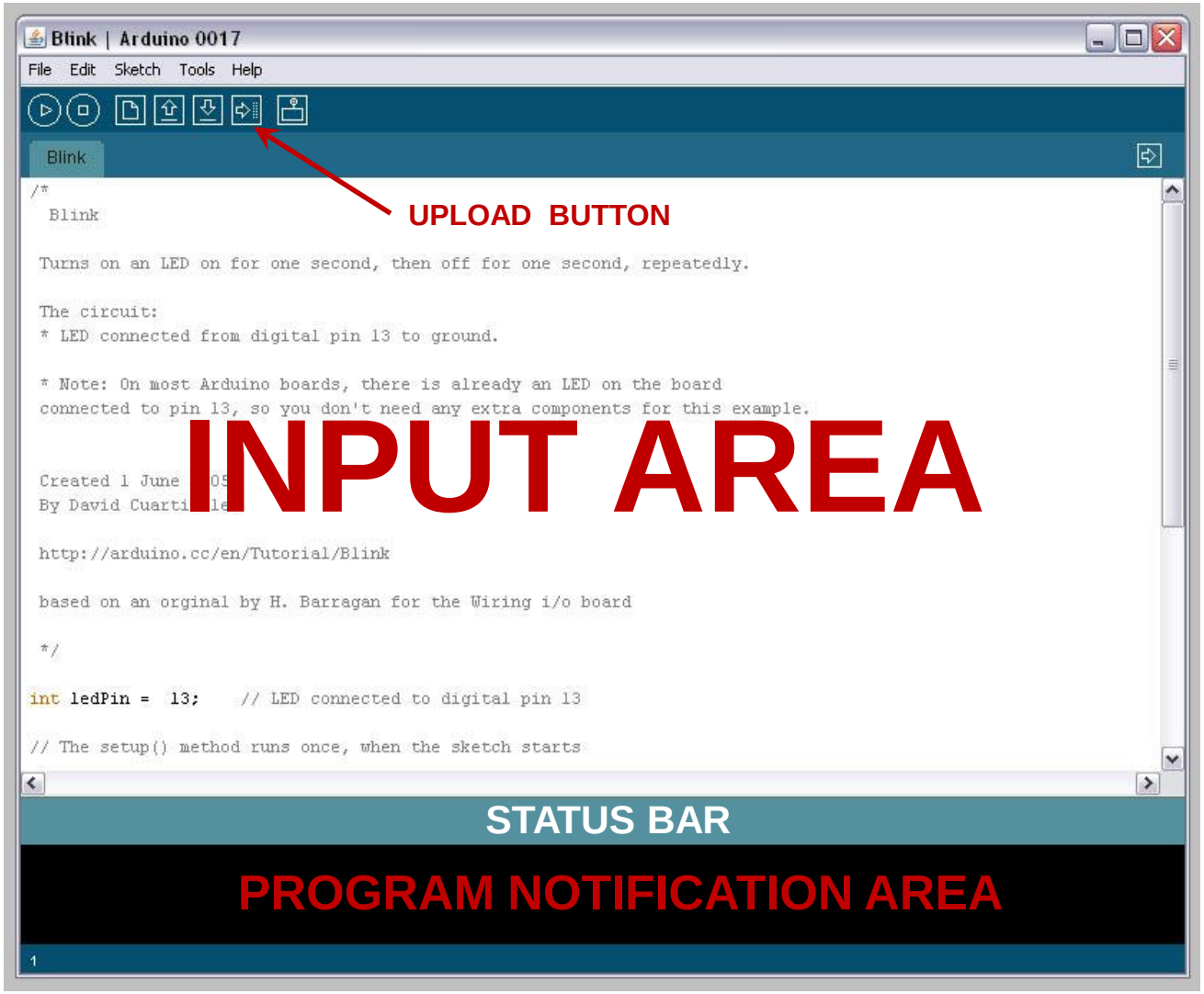
  analogWrite() – write an “analog” PWM value

  delay() – wait an amount of time (ms)

  millis() – get the current time

- And many others.

Arduino software



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Serial Communication

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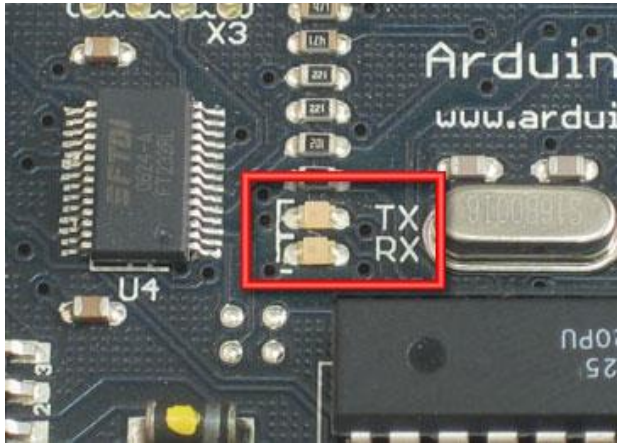

- ***Compiling*** turns your program into binary data (ones and zeros)
- ***Uploading*** sends the bits through USB cable to the Arduino
- The two LEDs near the USB connector blink when data is transmitted
  - **RX** blinks when the Arduino is receiving data
  - **TX** blinks when the Arduino is transmitting data

IO Pins

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Two states (binary signal) vs. multiple states (continuous signal)

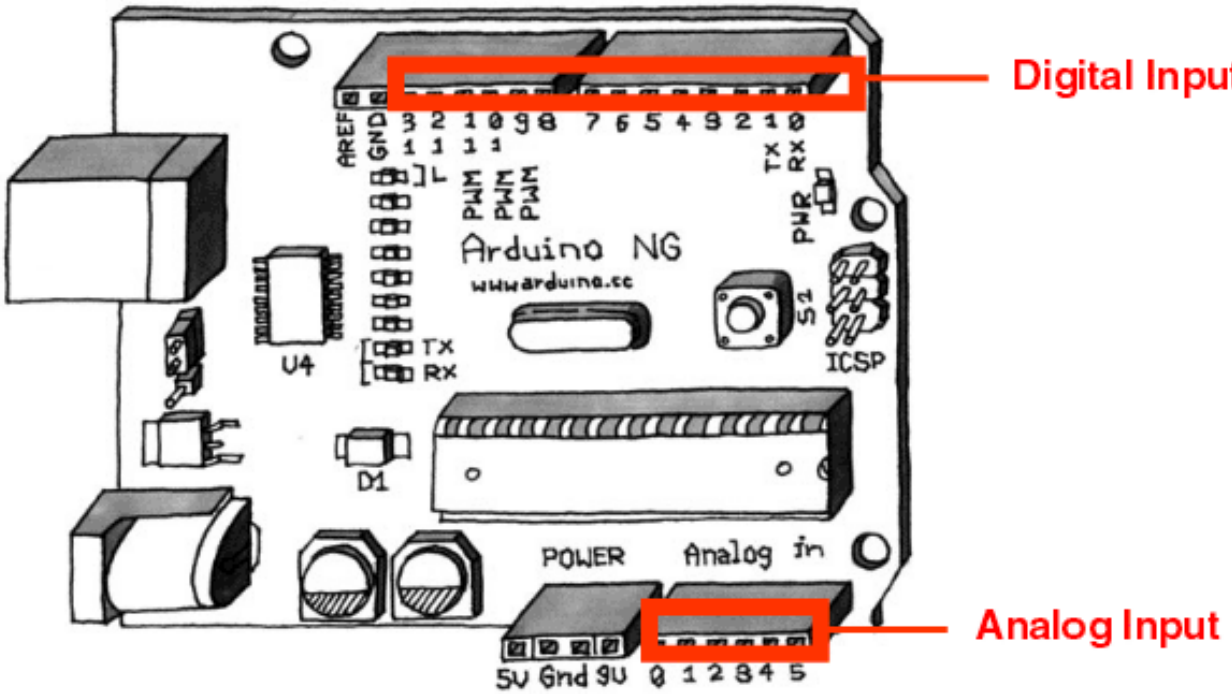

Image from *Theory and Practice of Tangible User Interfaces* at UC Berkley

Let's get to coding…

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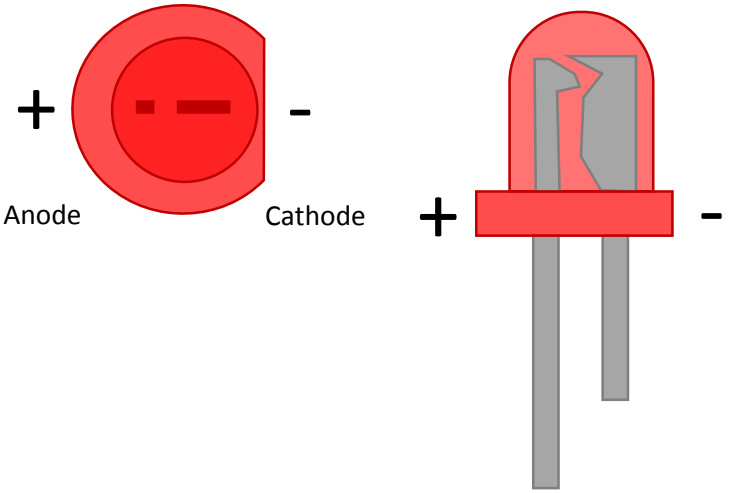
- Project #1 – Blink
  - "Hello World" of Physical Computing

- *Psuedo-code – how should this work?*

The LED



The **LED** (**L**ight **E**mitting **D**iode)

is a simple, digital **actuator**

LEDs have a **short leg** (**-**) and a **long leg** (**+**)

and it matters how they are oriented in a circuit

To prevent damage, LEDs are used together with a 1KΩ **resistor** (or anything from 300Ω to 2KΩ)

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Wiring a LED with Arduino

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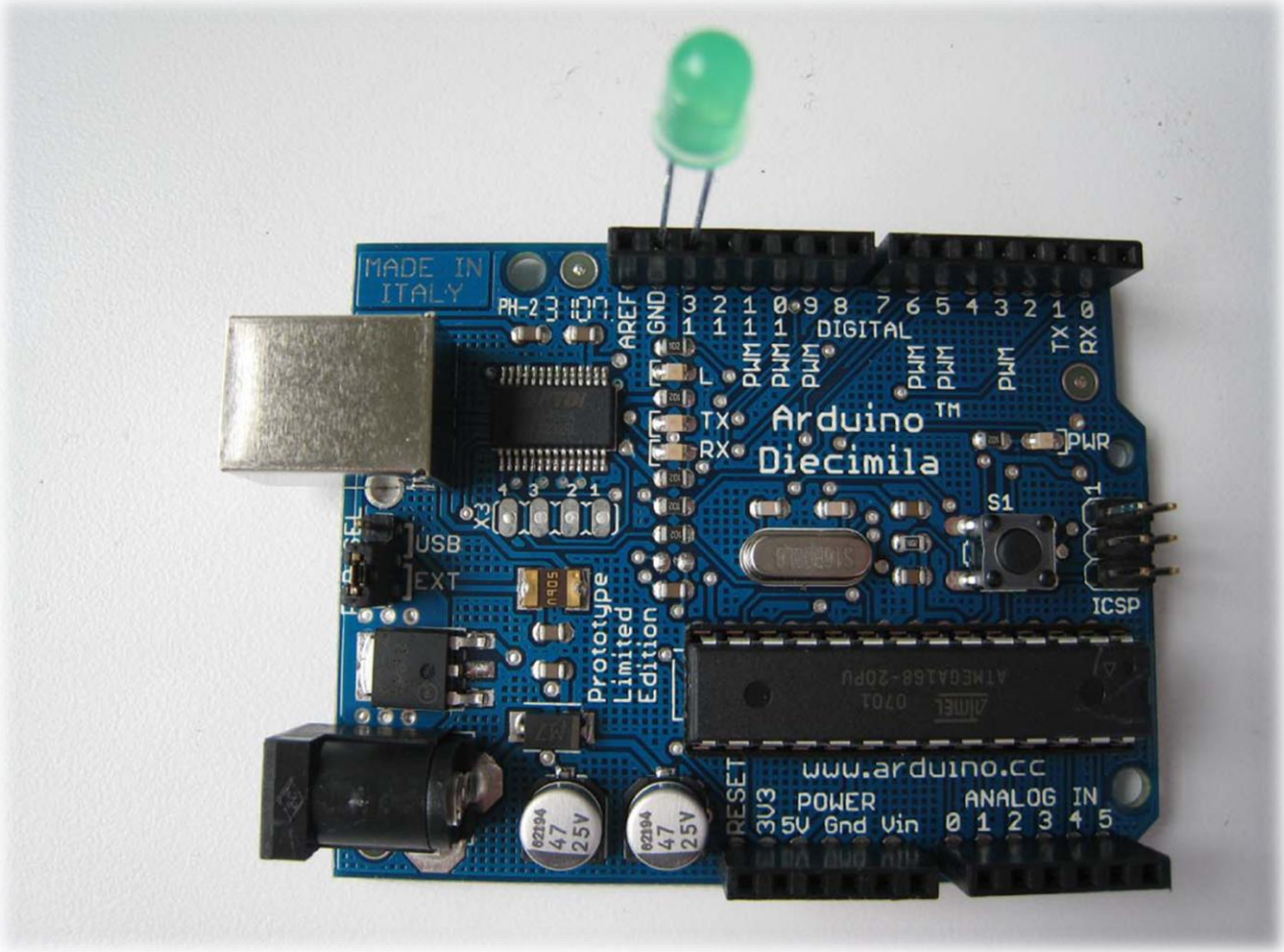
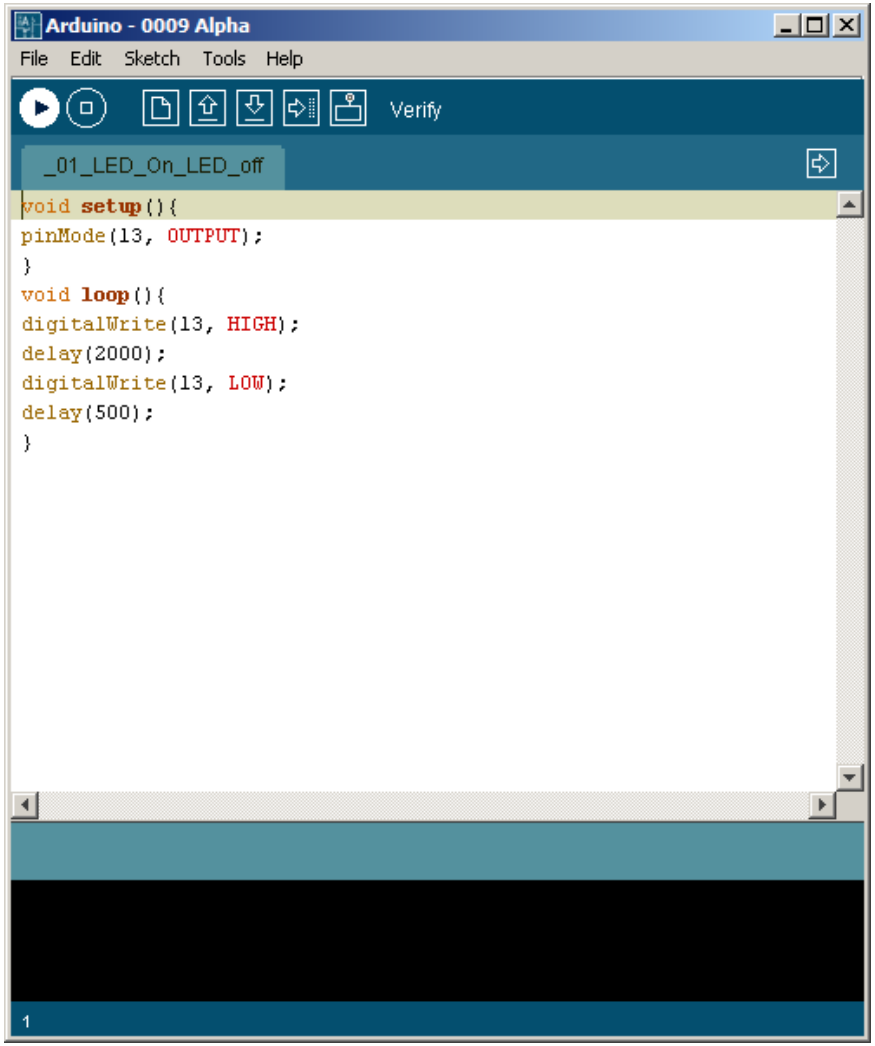


Arduino-Digital Output-LED




```
void setup(){
pinMode(13, OUTPUT);
}
void loop(){
digitalWrite(13, HIGH);
delay(1000);
digitalWrite(13, LOW);
delay(1000);
}
```

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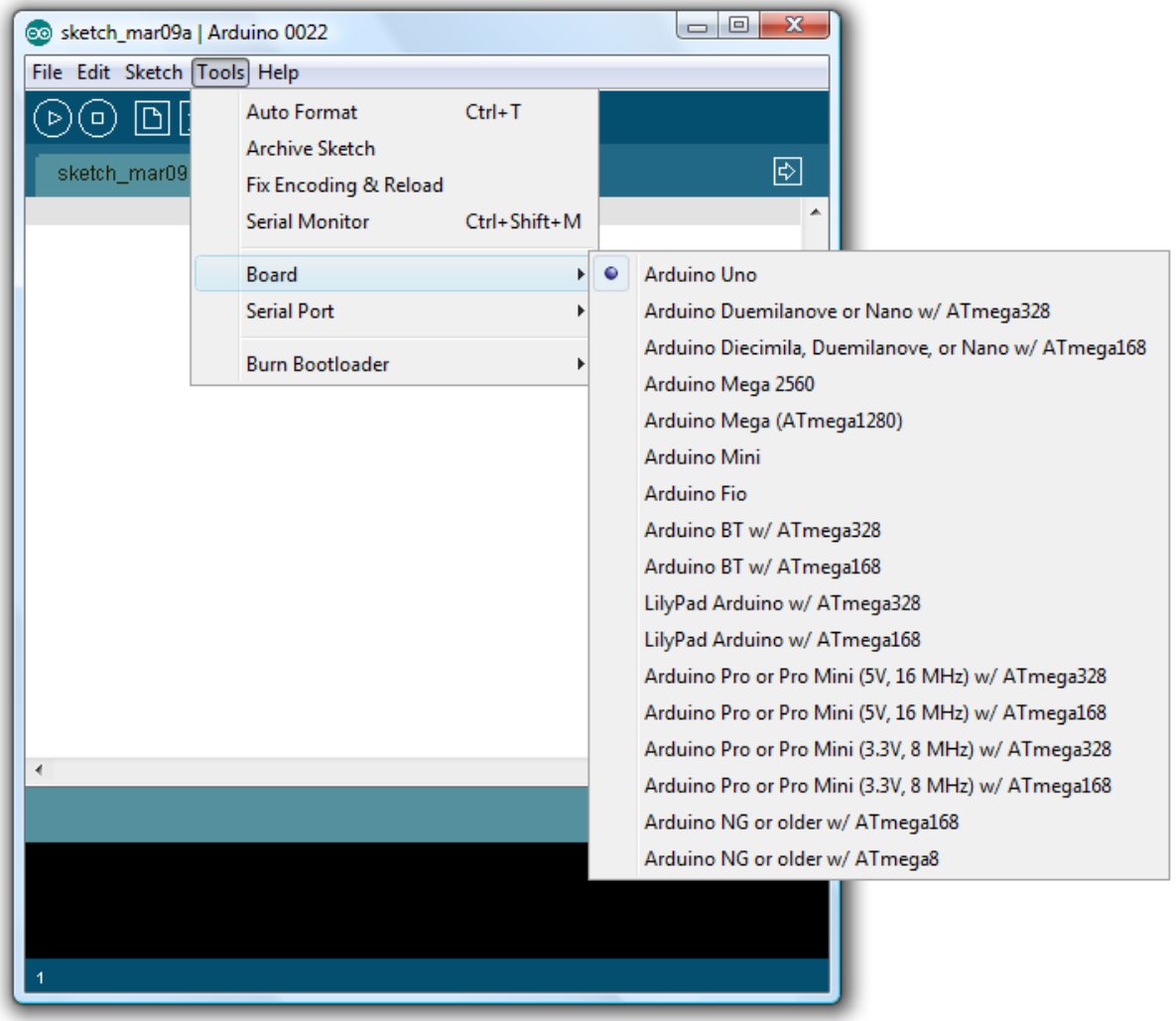
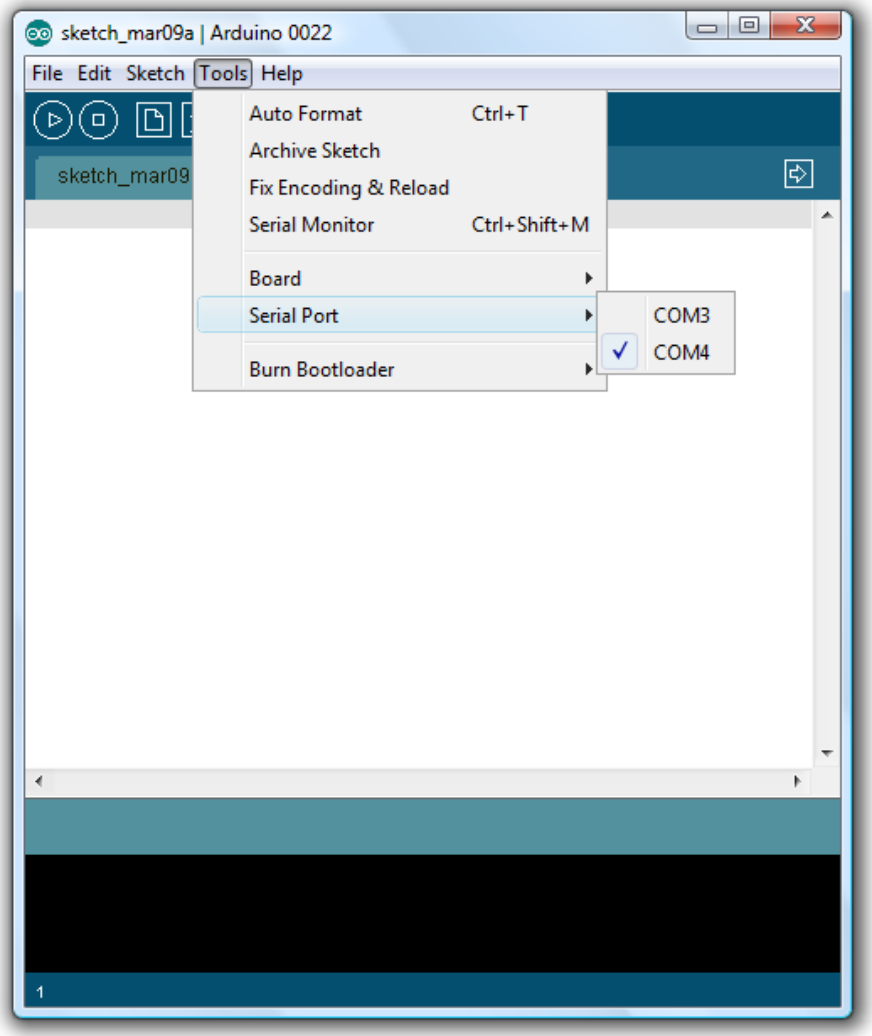
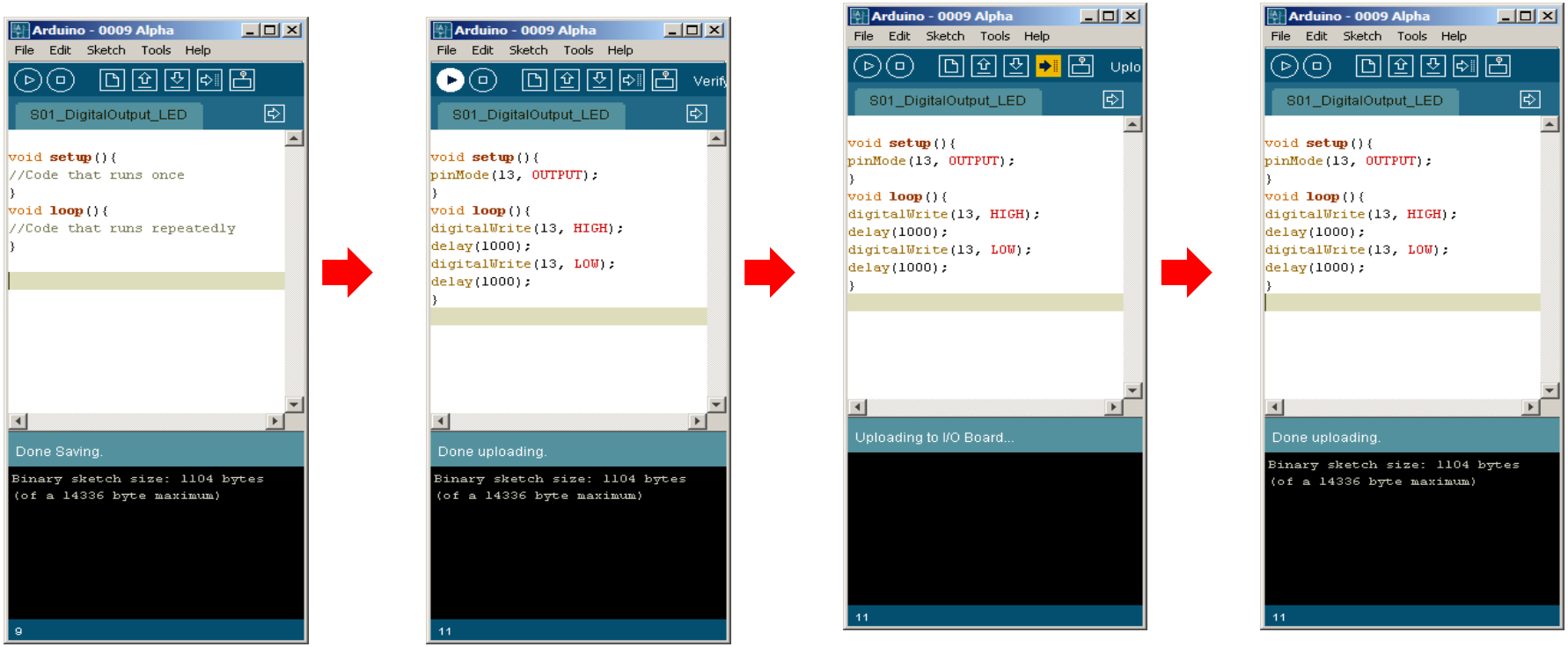
Arduino-Checking the Right Board



Arduino-Checking the Right Port



Arduino-Compiling and Uploading Code



1. Write the code
2. Compile the code
3. Check Arduino Port Connection
4. Upload the Code
5. The Arduino and Connected Circuits start to show behavior based on the uploaded code

Photoresistor (LDR)

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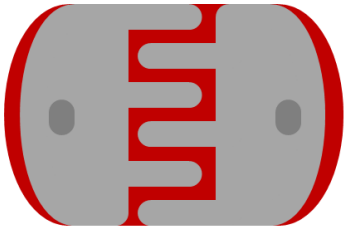
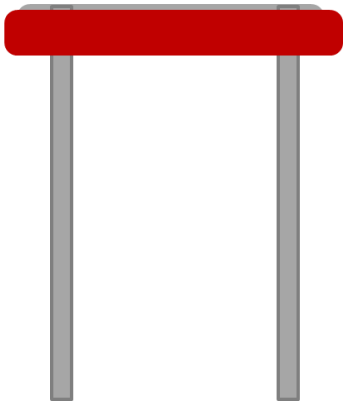


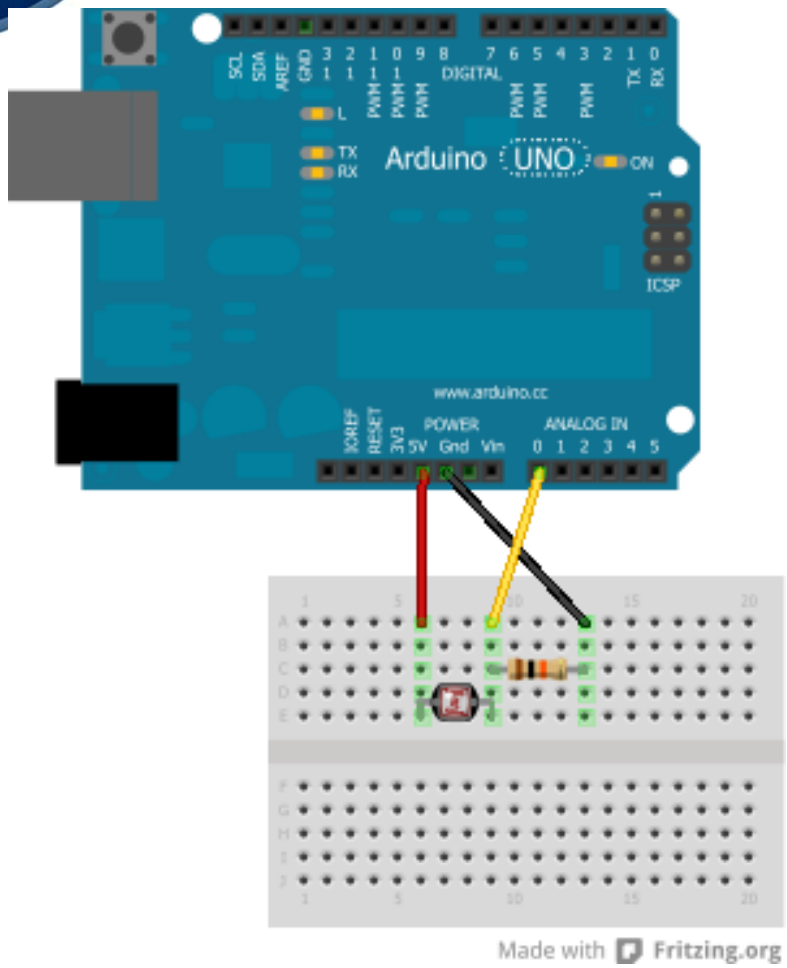


A photoresistor or **LDR** (**l**ight **d**ependent **r**esistor) is a resistor whose resistance depends on light intensity

An LDR can be used as a simple, **analog sensor**

The orientation of an LDR does not matter

Wiring an LDR with Arduino



Note: this setup is a *voltage-divider*, *as* the 5V total voltage is divided between LDR and resistor to keep 0V < **A0** < 2.5V

Photoresistor (LDR)
10K Ω resistor
5V
GND
A0

Analog input with Arduino


```
int sensorPin = A0; // e.g. LDR

void setup () {
   Serial.begin(9600); // setup log
}

void loop () {
   int sensorValue = analogRead(sensorPin);
   Serial.println(sensorValue); // log value
}
```

Open the Arduino IDE serial monitor to see log output

Note: use e.g. Excel to visualize values over time

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ATtiny85

- Low Power AVR® 8-Bit Microcontroller
- Small package (8-pin)
- Inexpensive (less than a dollar)
- Arduino sketch compatible (mostly)

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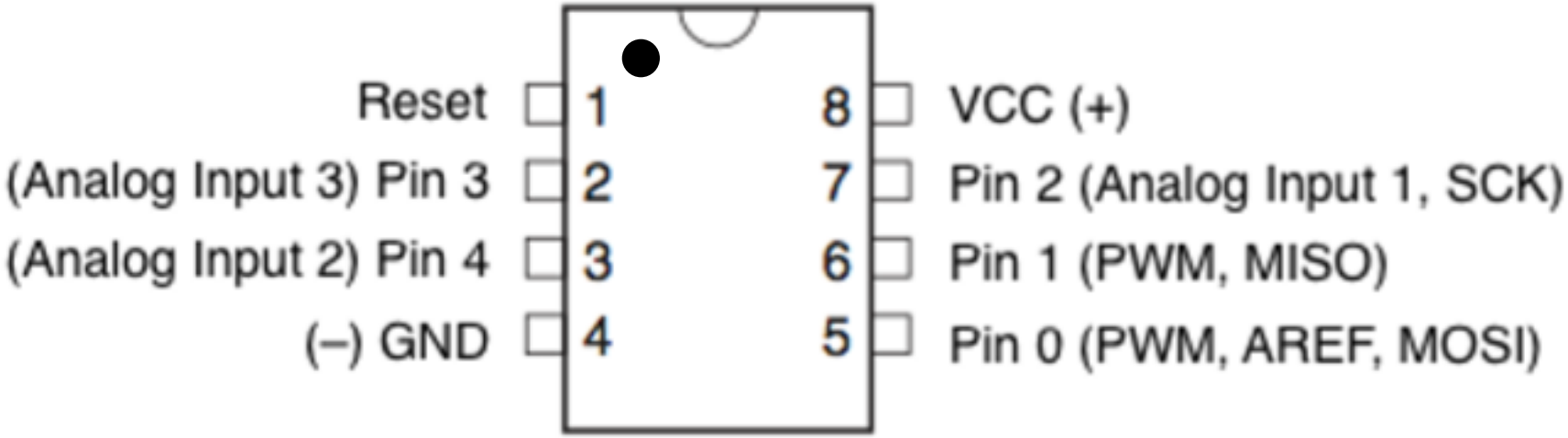
ATtiny 85 Pinout (simplified)



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Comparison to ATmega328

Feature	ATmega328	ATtiny85	ATtiny84
Flash	32KB	8KB	8KB
SRAM	2048B	512B	512B
EEPROM	1024B	512B	512B
Pkg pins	28	8	14
Cost*	$1.608	$0.72	$0.768
I/O pins	20 (or 23)	5 (or 6)	11 (or 12)
Analog	6	3 (or 4)	8

* DIP package in qty 100 from Digikey

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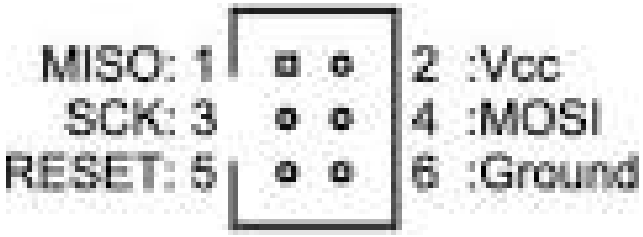
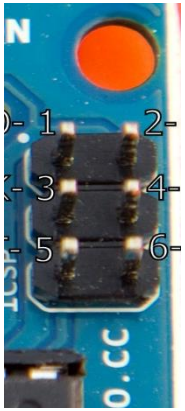
AVR Programming Methods

- Bootloader
  - Arduino programming w/ IDE via USB
- High voltage serial program (HVSP)
  - The way to reprogram RESET fuse
- HVPP, JTAG, PDI, TPI, …
- ISP (In System Programming)
  - The topic of this talk
  - Uses SPI pins (SCLK, MISO, MOSI)

AVR Programming Methods (cont.)

- In System Programming (ISP)
  - Sparkfun has a programmer for $48
  - Works with AVR Studio
  - Connects to ICSP header
    - In Circuit Serial Programming





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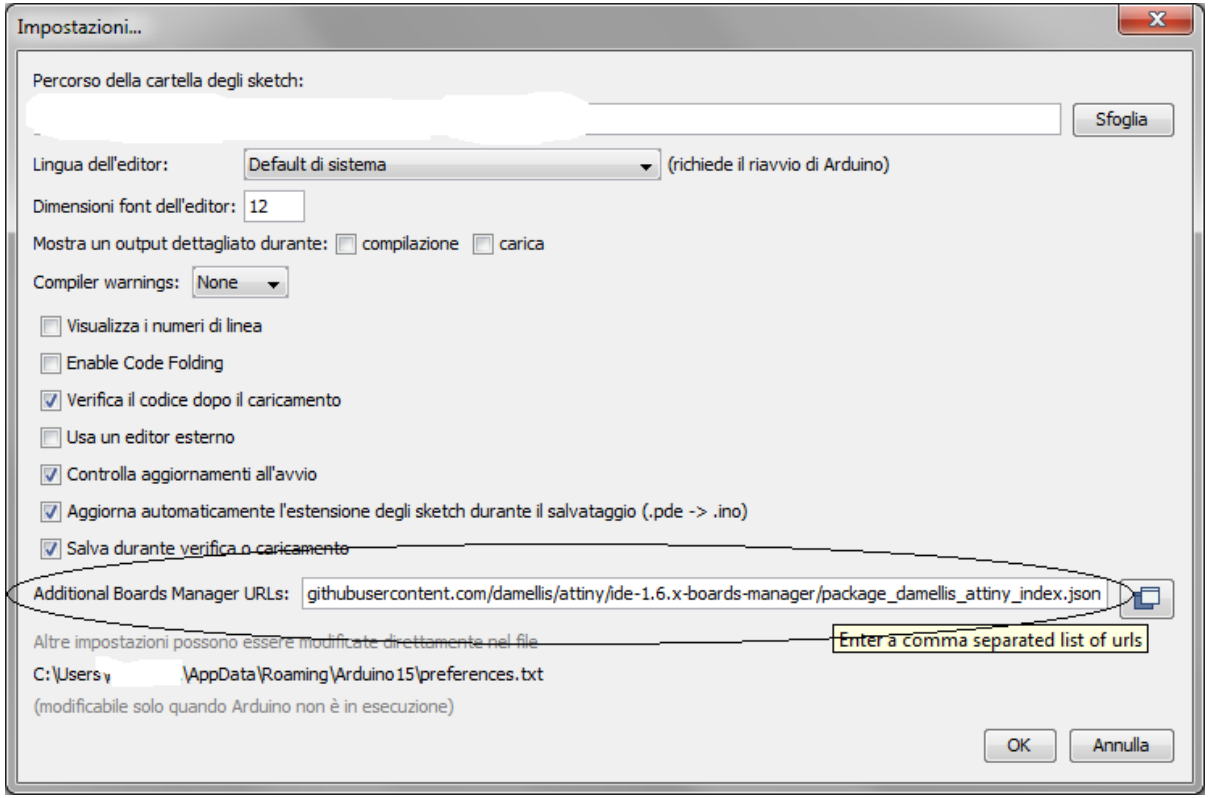
AVR Programming Methods (cont.)

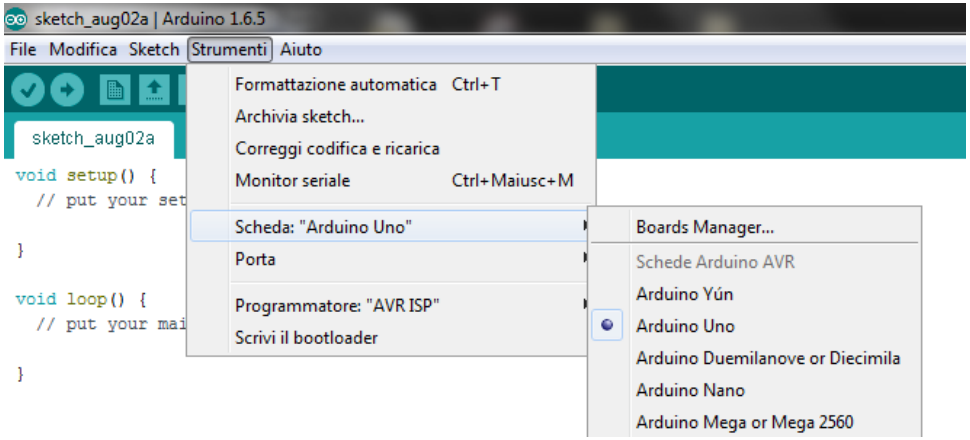
- We want to program bare chips, so we don't have an ICSP header
  - ArduinoISP
    - Arduino board acts as the programmer
    - ArduinoISP sketch
    - Wire up connections to bare chip
  - Sparkfun Tiny ISP Programmer ($20)
    - ATtiny84 handles USB
    - 8 pin socket for ATtiny85
  - Chipper, Little Wire, and others

Menu Arduino : File > Impostazioni >> in Additional Board Manager Urls aggiungere il seguente indirizzo:

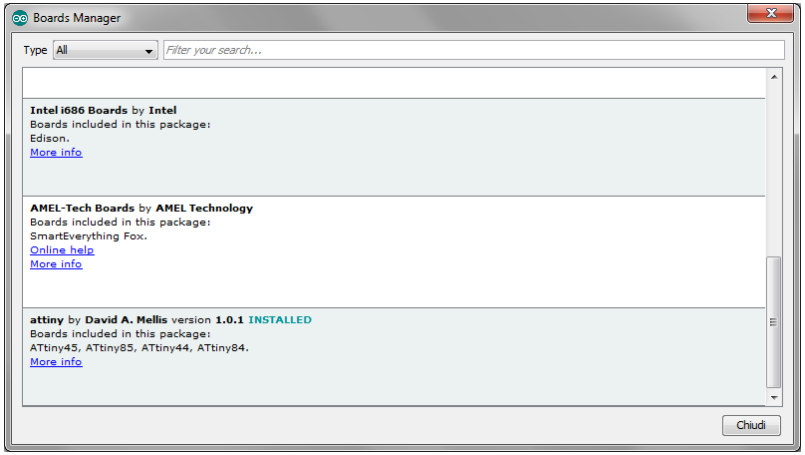
https://raw.githubusercontent.com/damellis/attiny/ide-1.6.x-boards-manager/package_damellis_attiny_index.json



2. Strumenti > scheda > Boards Manager…

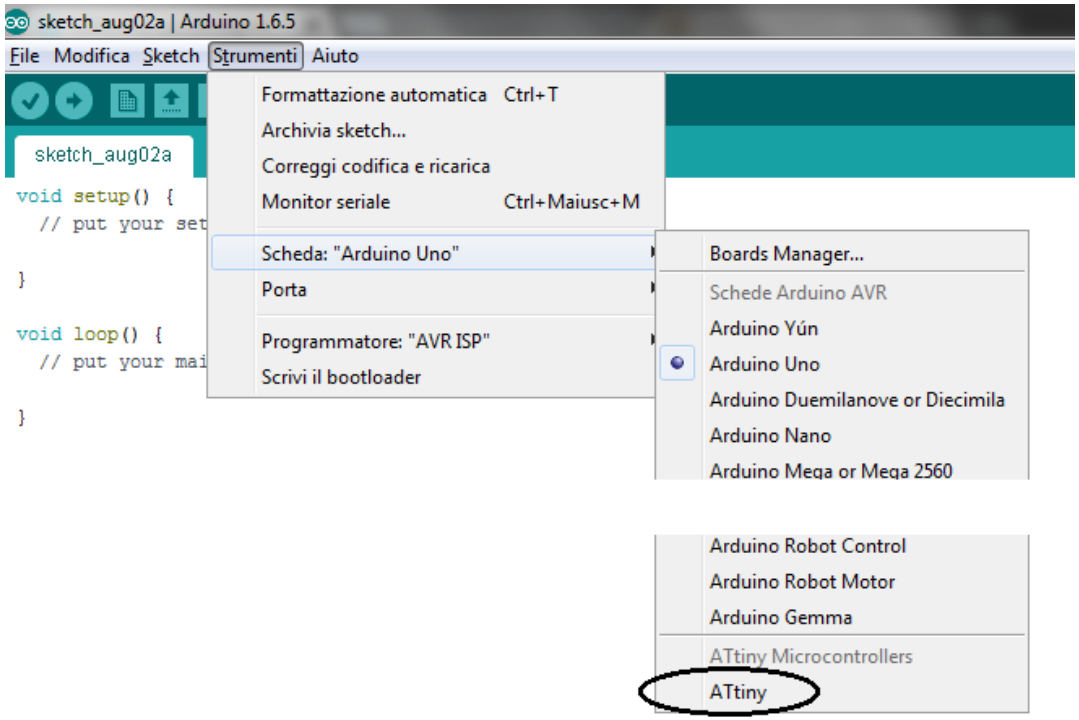


3. Scorrete fino alla casella Attiny selezionatela e cliccate installa



4. restart Arduino IDE

5. In Strumenti > Scheda you should see ATtiny



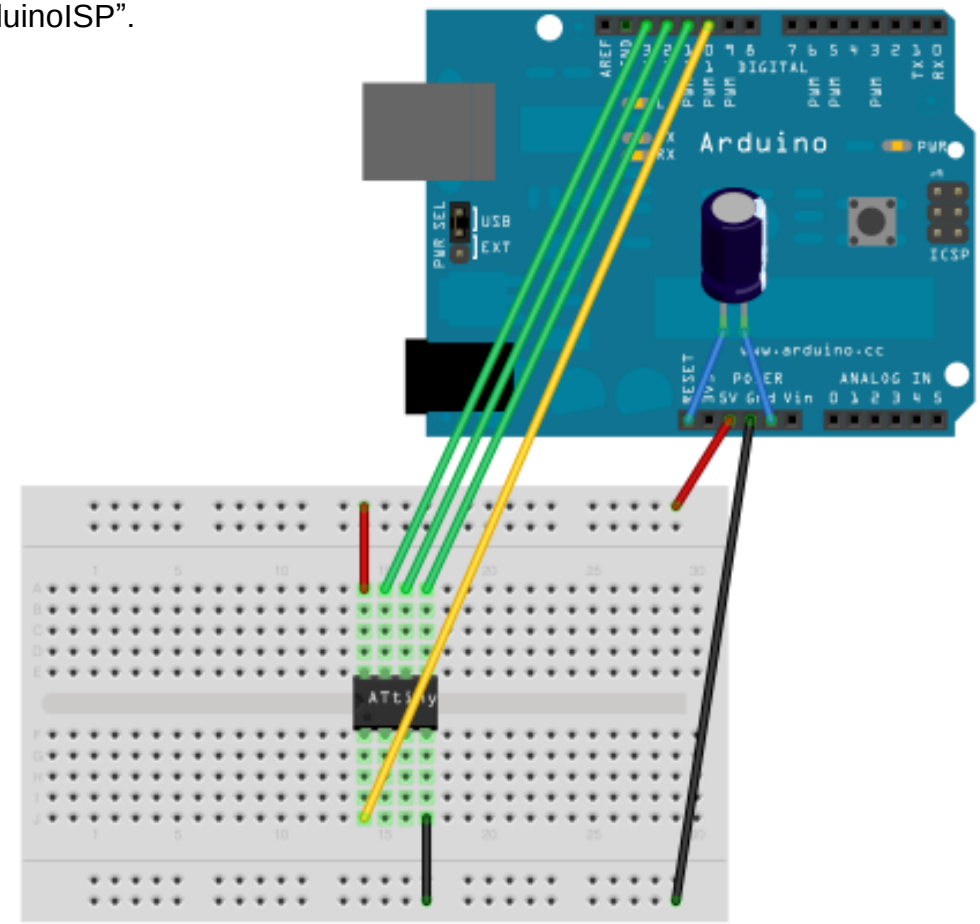
Arduino UNO as ATTINY PROGRAMMER

- On menù “Strumenti” select Board “Arduino UNO” (Select Programmer : «AVR ISP)
- Load sketch “ArduinoISP” from menù “File”, “Esempi”, “ArduinoISP”.
- Upload Sketch on Arduino UNO.

Now Your Arduino UNO is a ATTINY PROGRAMMER.

Disconnect Arduino and connect ATTINY with Arduino :

ATTINY85---ARDUINO
PIN1-------PIN10
PIN4-------GND
PIN5-------PIN11
PIN6-------PIN12
PIN7-------PIN13
PIN8-------5V



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