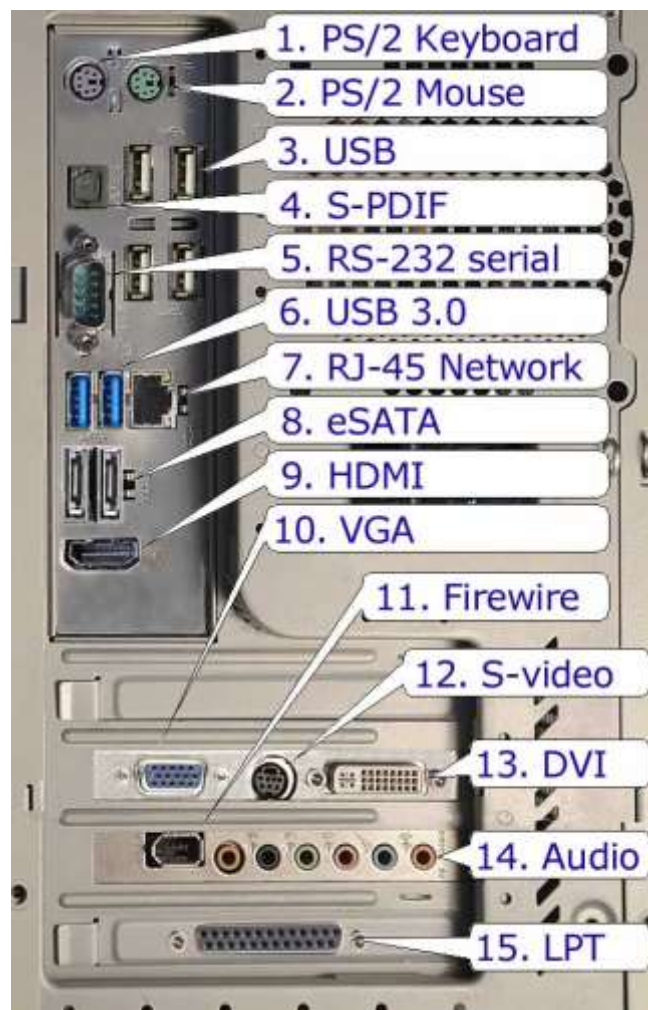


ARDUINO

Prof. dr Neđeljko Lekić, Prof. dr Zoran Mijanović

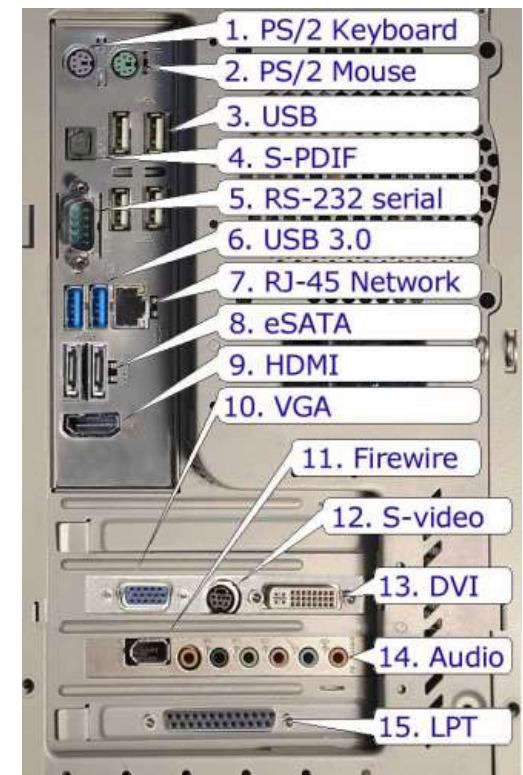
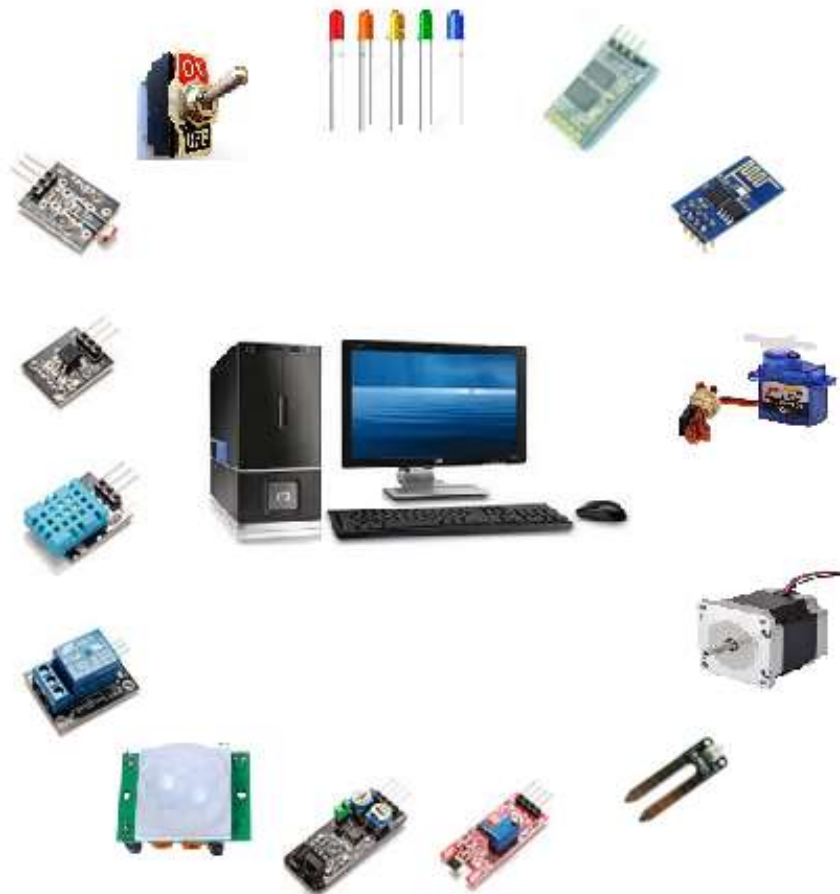
Računarski portovi



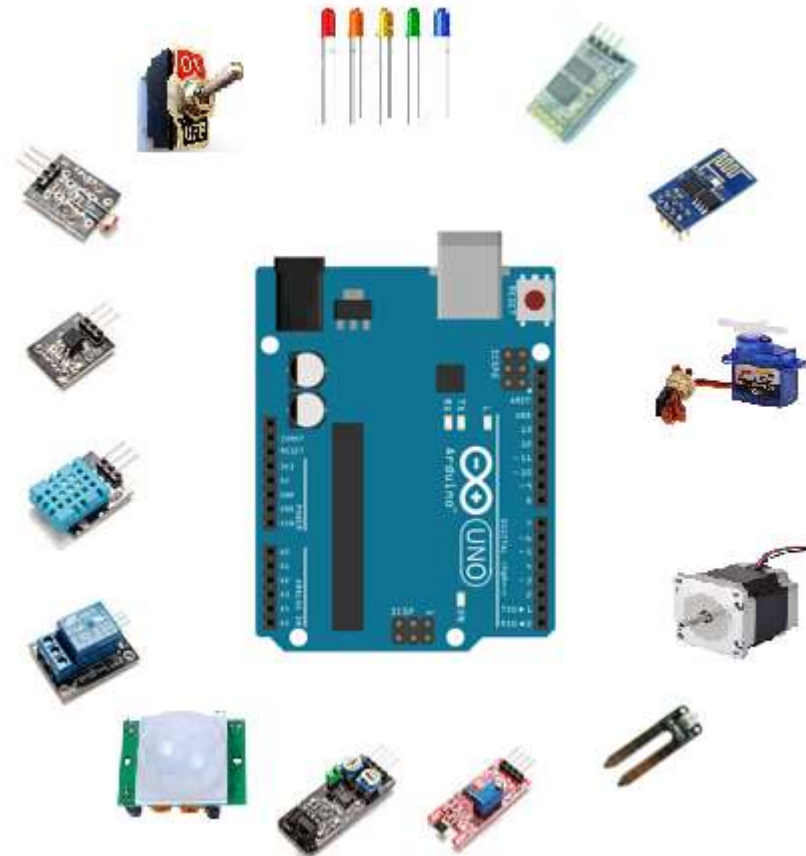
Senzori i attuatori



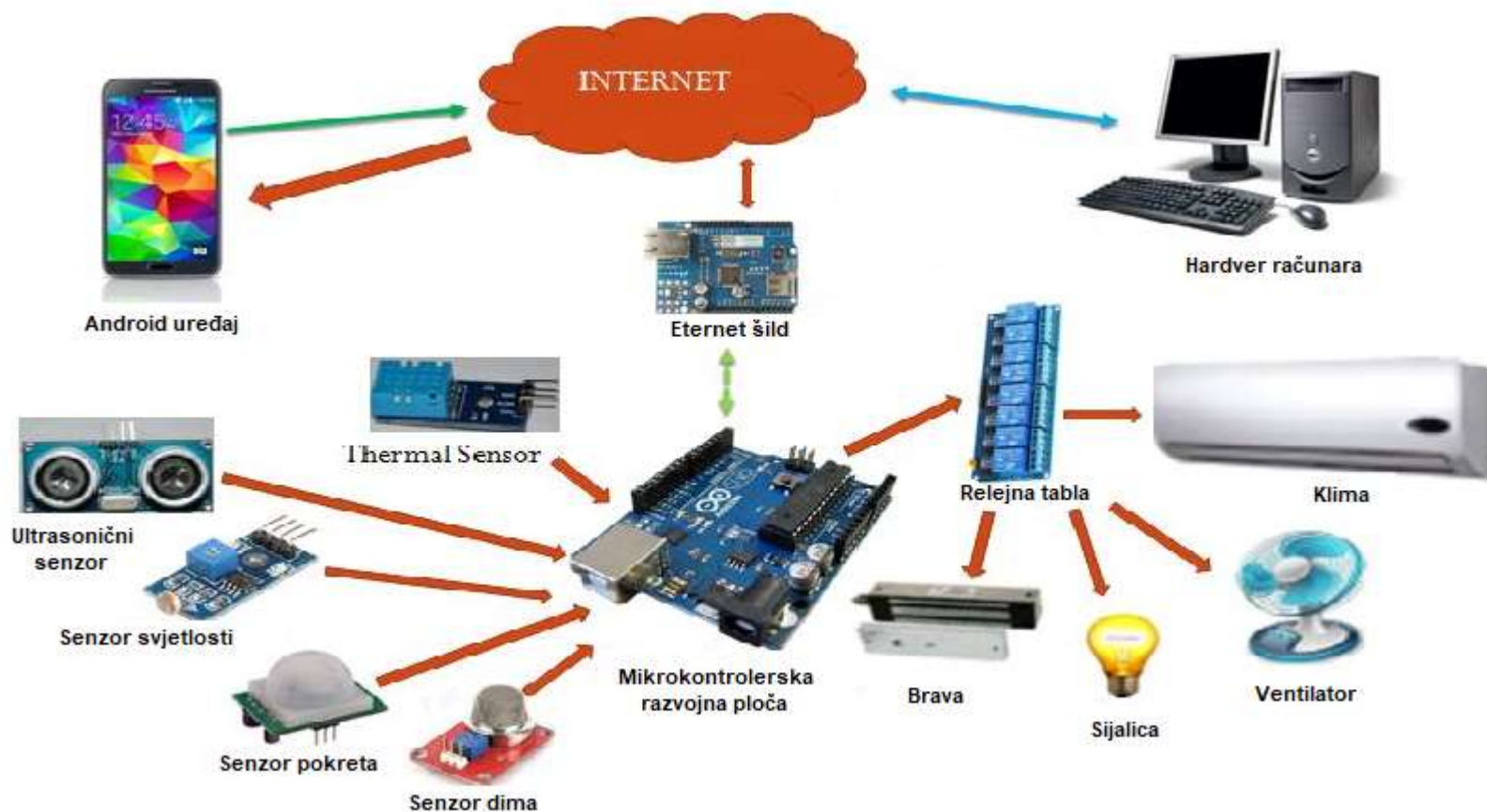
Kako povezati senzore i aktuator sa računarom i korisnikom?



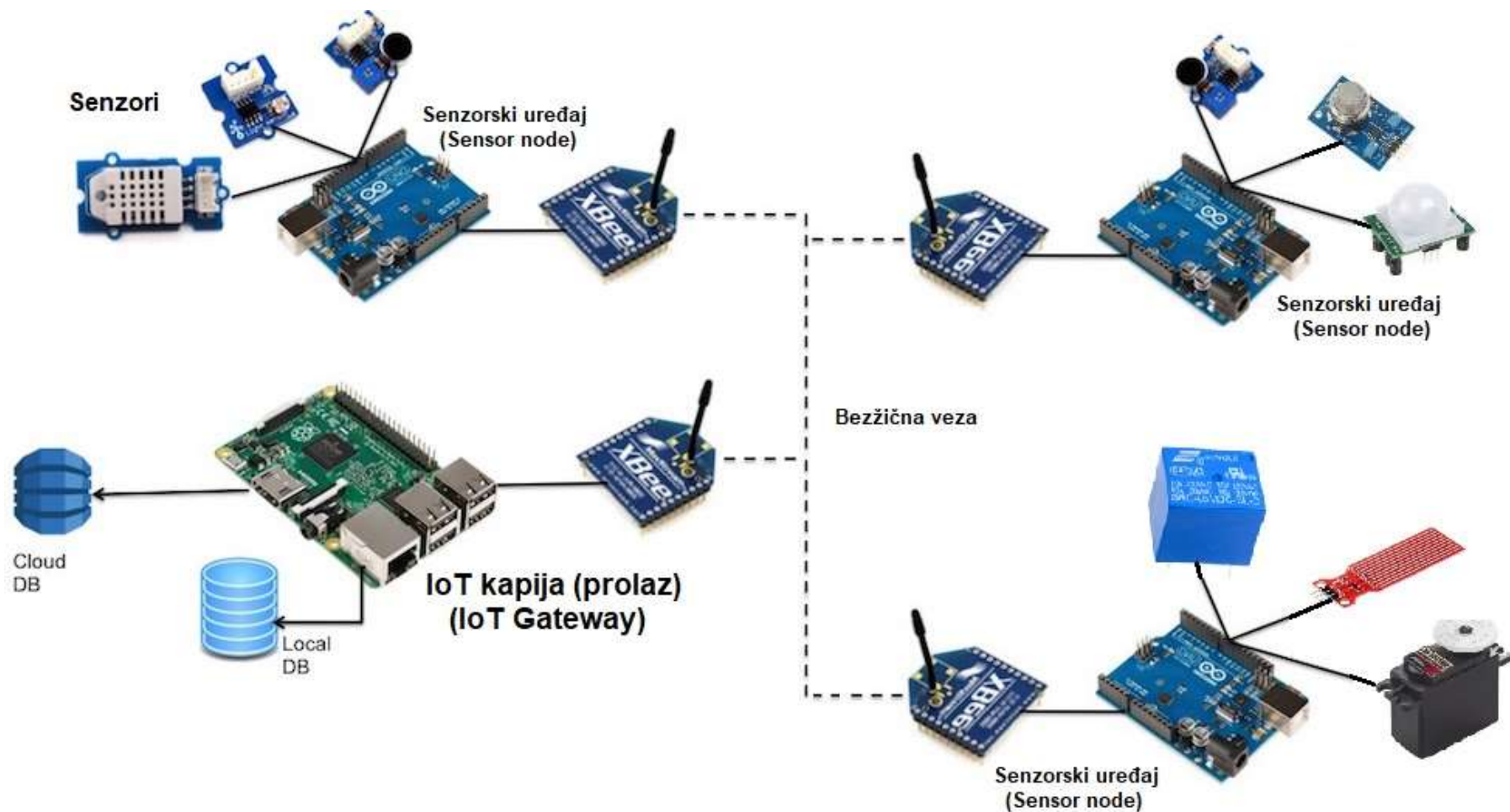
Mogu se povezati sa mikrokontrolerskom razvojnom pločom.



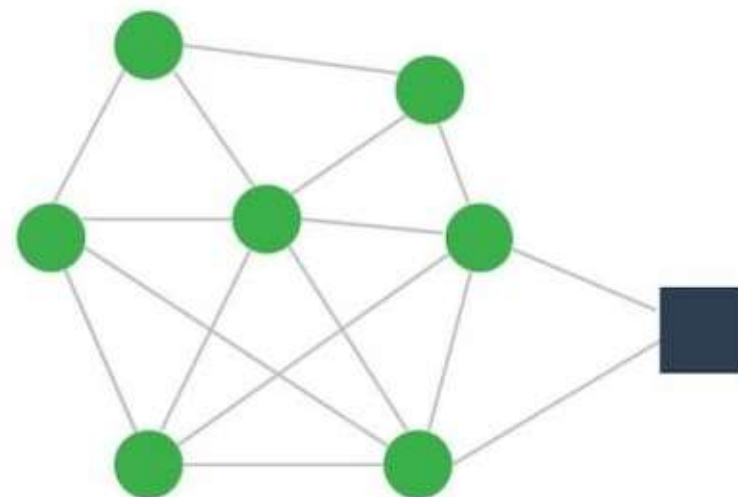
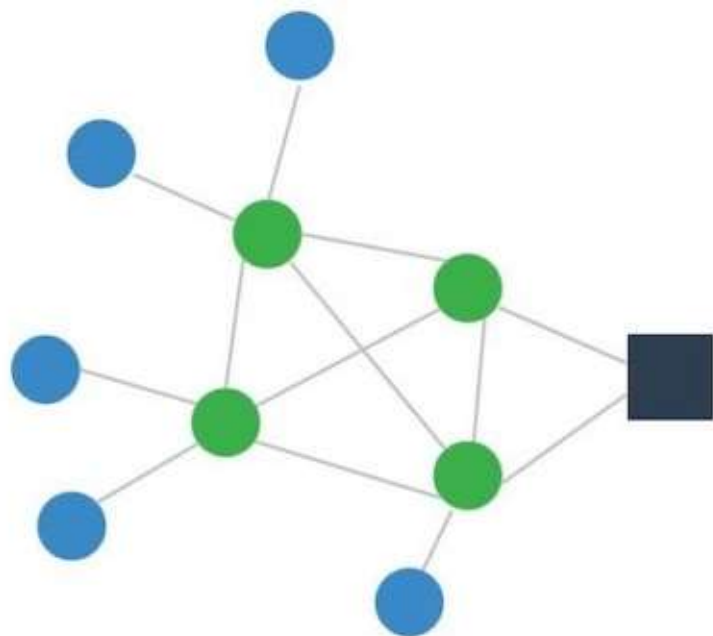
Povezivanje Arduino uređaja u sistem



Ne mora svaki Arduino uređaj direktno na internet.



Različite vrste senzorskih mreža



Senzorski uređaj

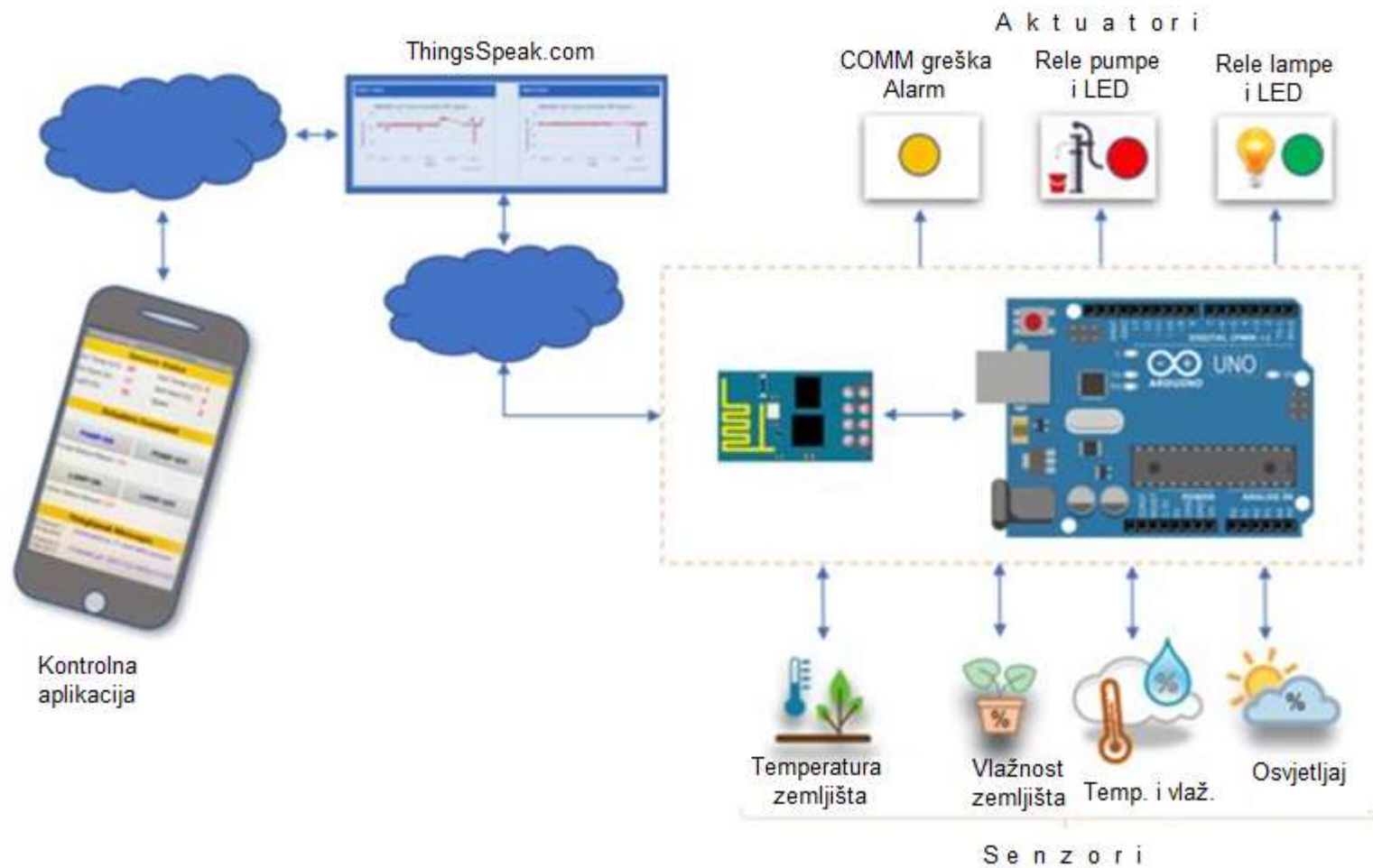


Senzorski uređaj sa funkcijom prenosa / ruter



Gateway

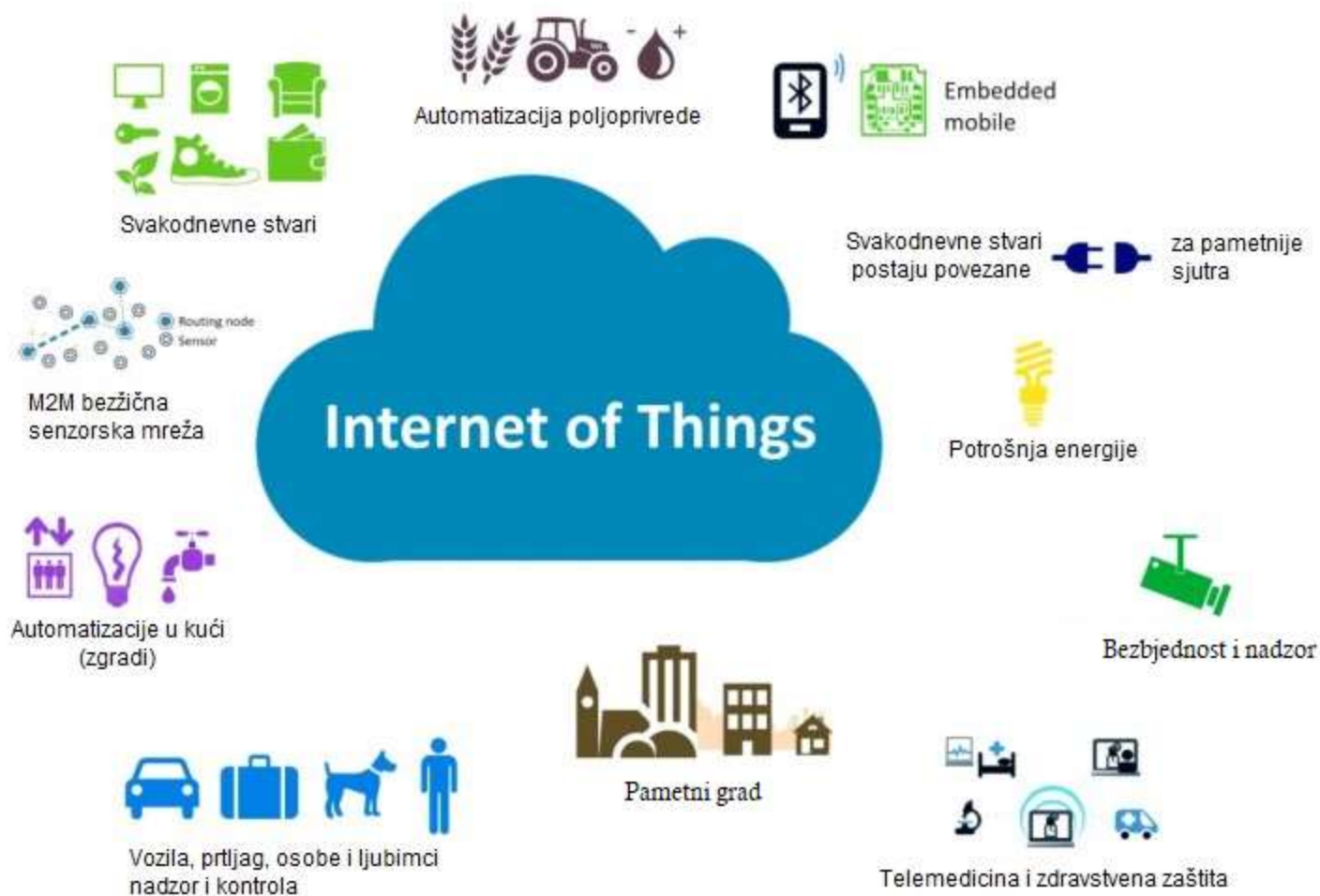
Povezivanje u oblak



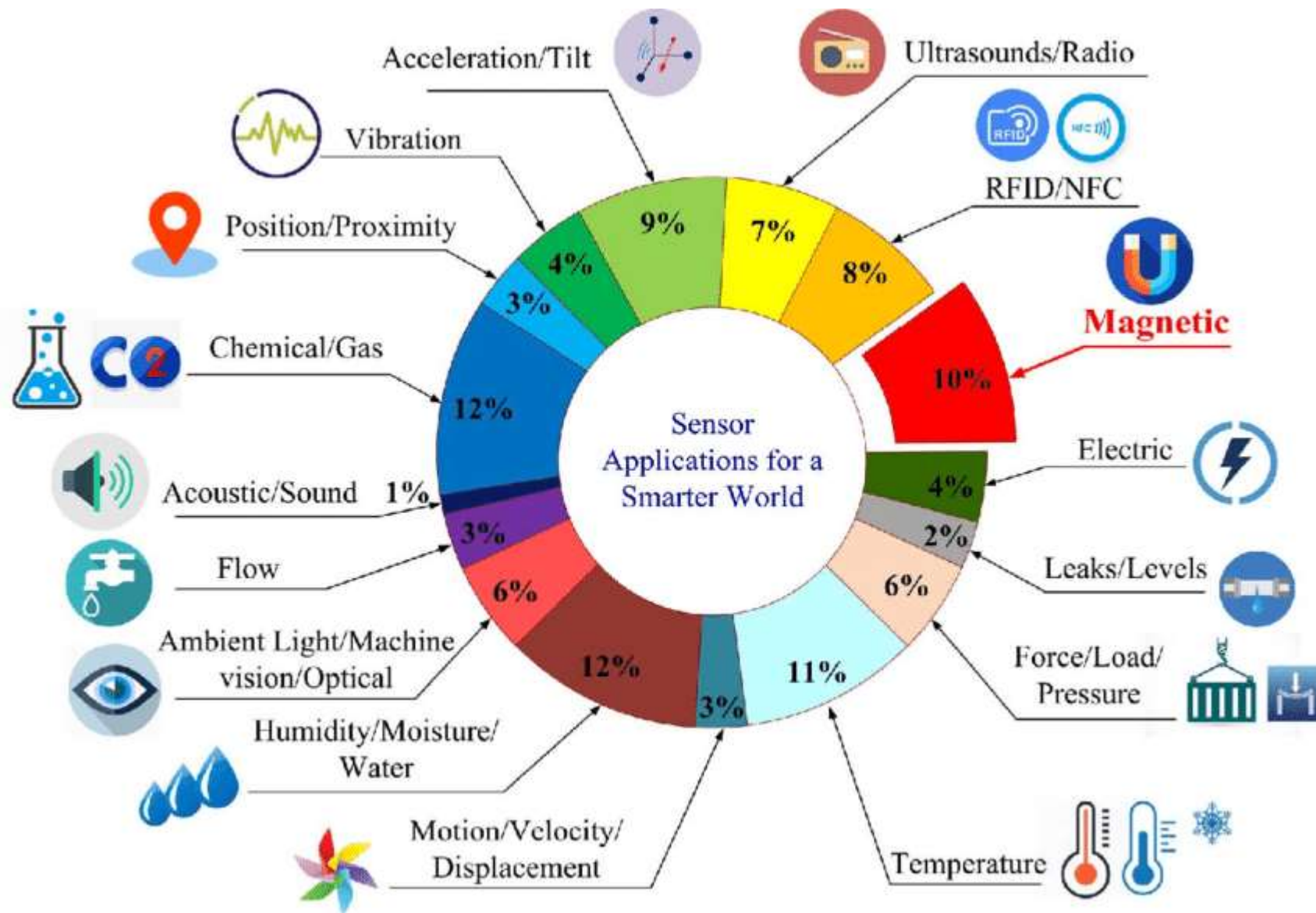
IoT projekti



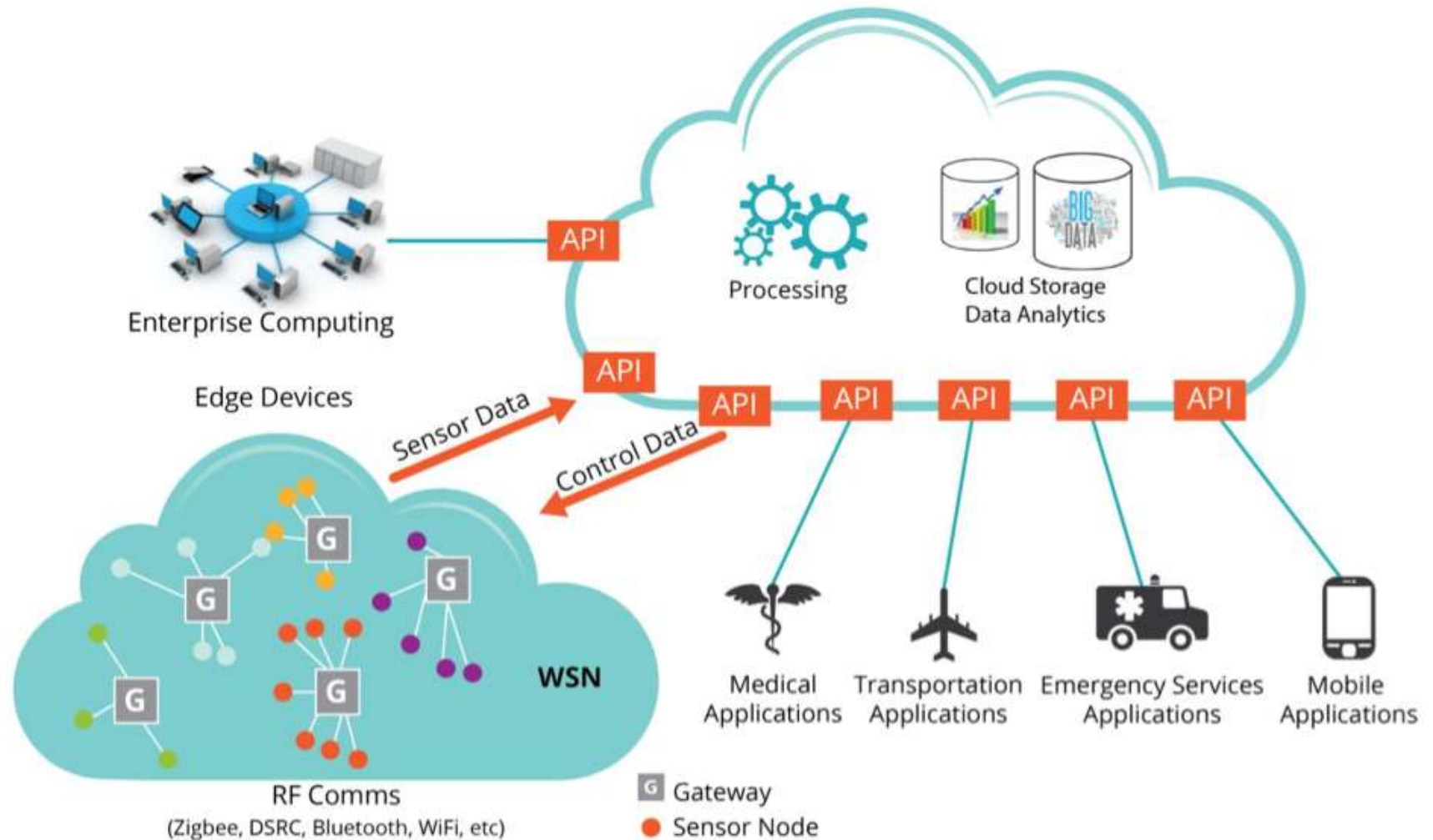
IoT oblasti primjene



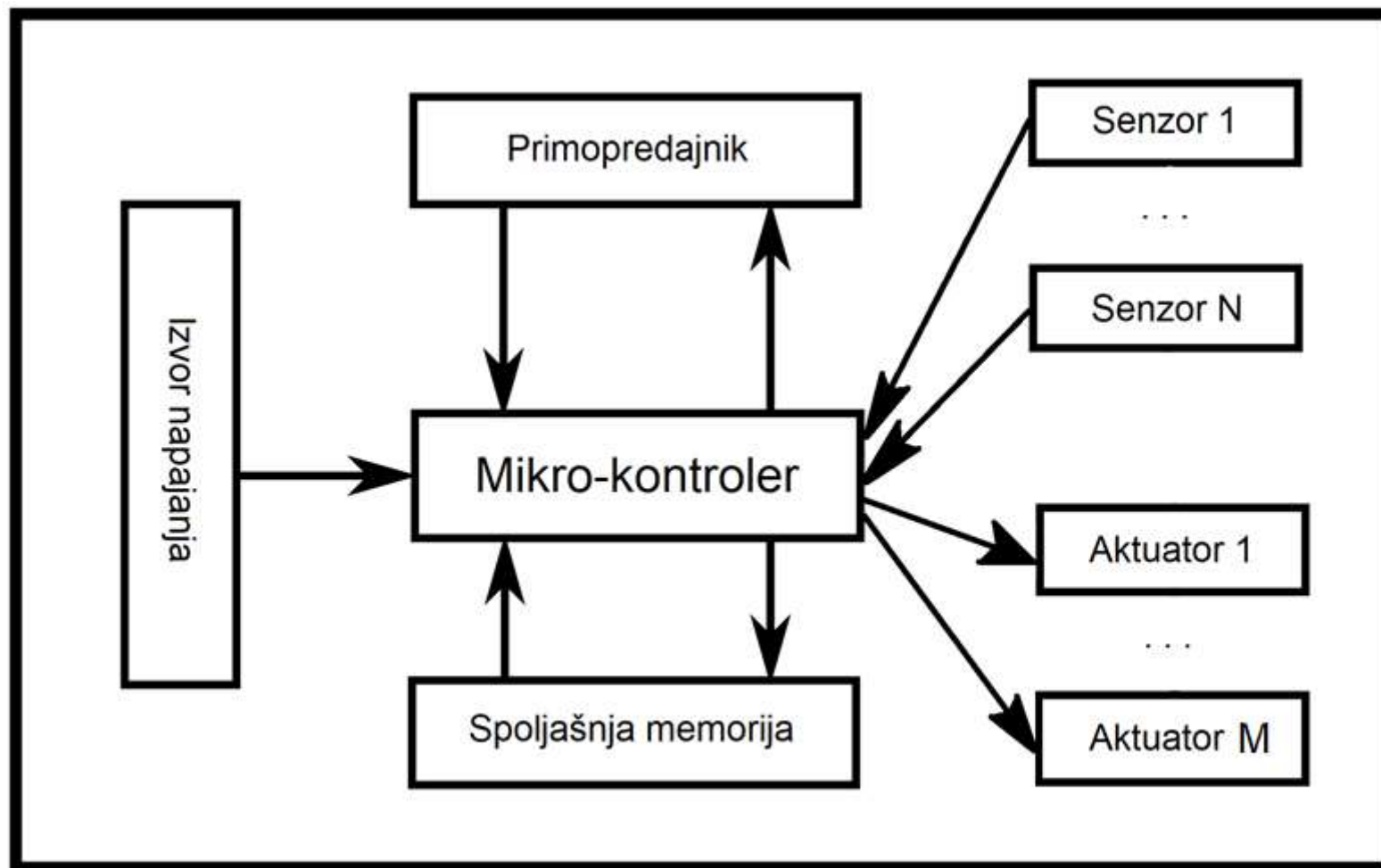
Senzorske aplikacije za pamatniji svijet



IoT infrastruktura



Mikrokontrolerski uređaj (Senzorski čvor – Sensor node, Mote)



Arduino – Zvanična definicija

- Uzeto sa zvaničnog web sajta (arduino.cc):

Arduino je open-source elektronska prototipna platforma zasnovana na fleksibilnom, jednostavnom za upotrebu, hardveru i softveru.

Namijenjen je dizajnerima, hobistima, i svima drugima koji su zainteresovani za kreiranje interaktivnih objekata i okruženja.

Zašto Arduino?

- Bez obzira na razlog, Arduino platforma je postala defakto standard.
 - Postoji puno realizovanih, dostupnih, projekta koji koriste arduino platformu.
- Teži ravnoteži između jednostavnosti upotrebe i korisnosti.
 - Programski jezici se uglavnom vide kao glavna poteškoća.
 - Arduino C je značajno uproštena verzija C++.
- Nije skup.

Što je mikrokontroler?

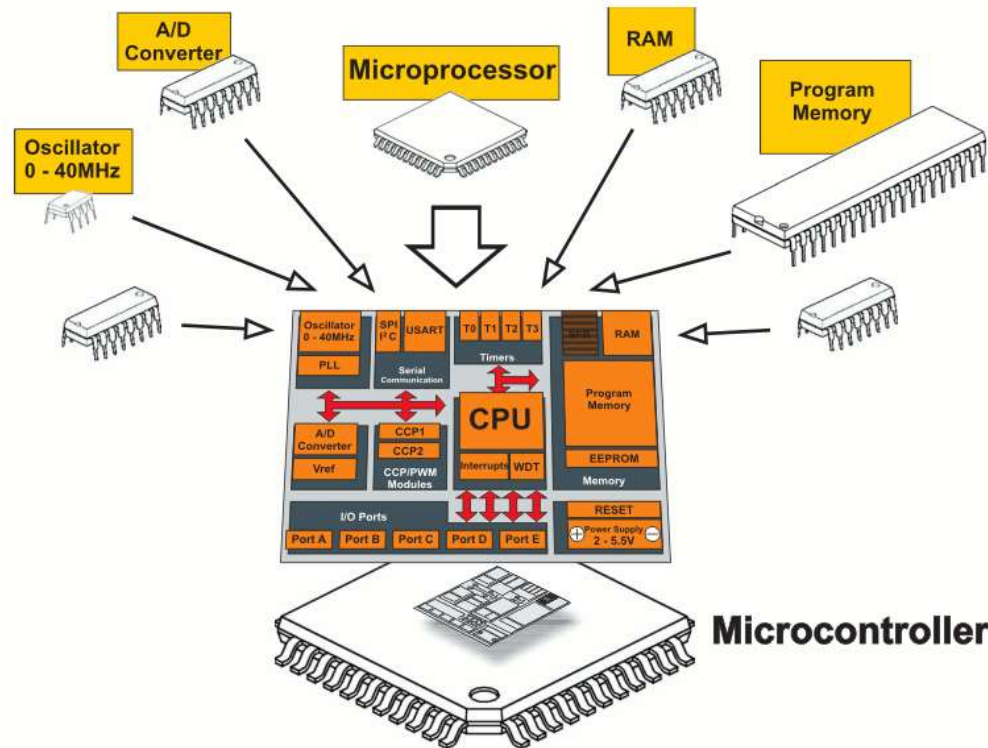
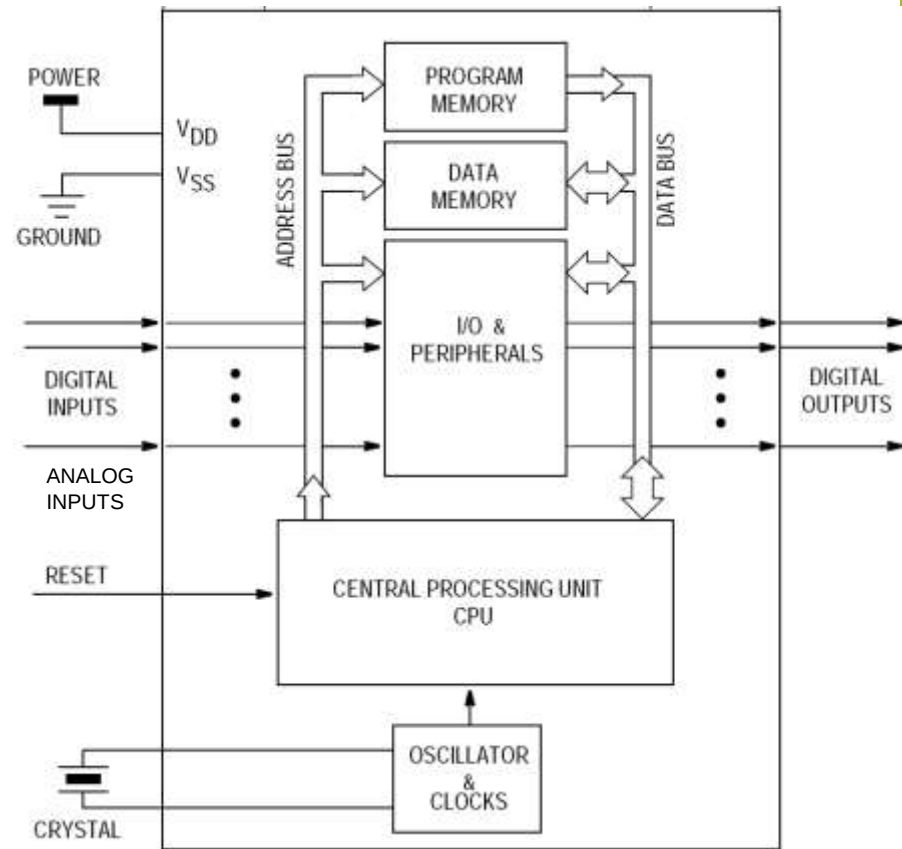
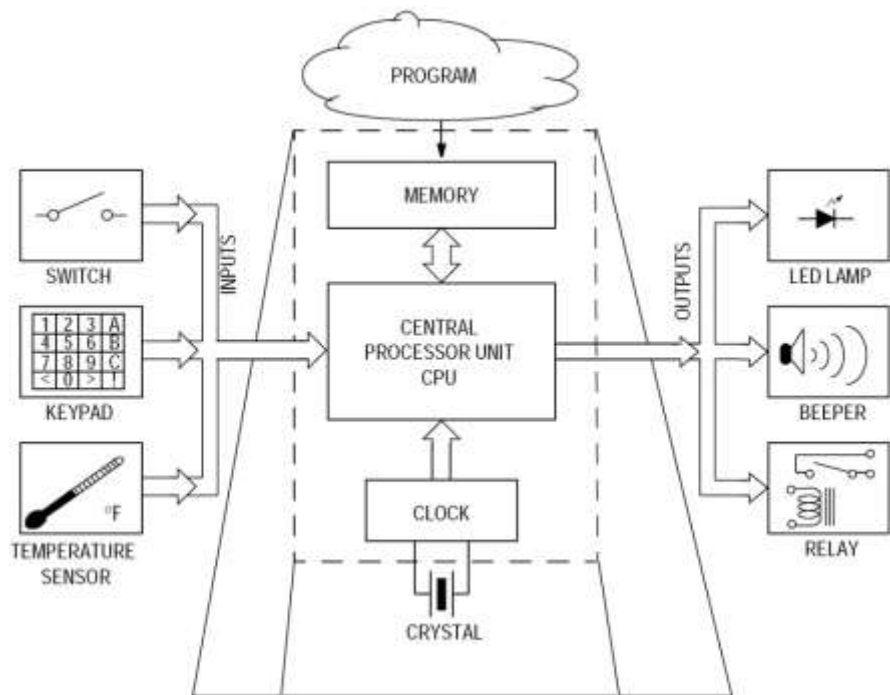


Fig. 0-1 Microcontroller versus Microprocessor

- Mali kompjuter u jednom čipu
Sadrži procesor, memoriju, i ulaze/izlaze
- Tipično je „**ugrađen**“ unutar nekih uređaja i kontroliše njihov rad
- Mikrokontroler je često mali i jeftin.

Što je mikrokontroler?

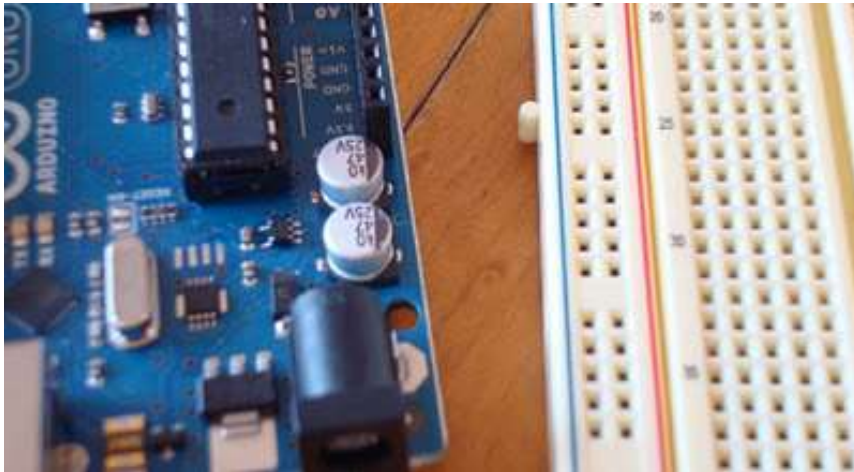


Što je razlika između ‘*Digital Input*’ i ‘*Analog Input*’?

Mikrokontroleri – definicija

- Programeri rade u virtuelnom svijetu.
- Uređaji rade u fizičkom svijetu.
- Kako povezati vituelni i fizički svijet?
- Uvedite mikrokontroler.
- Mikrokontroler je u osnovi mali računar koji posjeduje programabilne ulaze i izlaze opšte namjene.
- Ulazi mogu biti upravljani od strane fizičkog okruženja dok izlazi mogu upravljati fizičkim okruženjem.

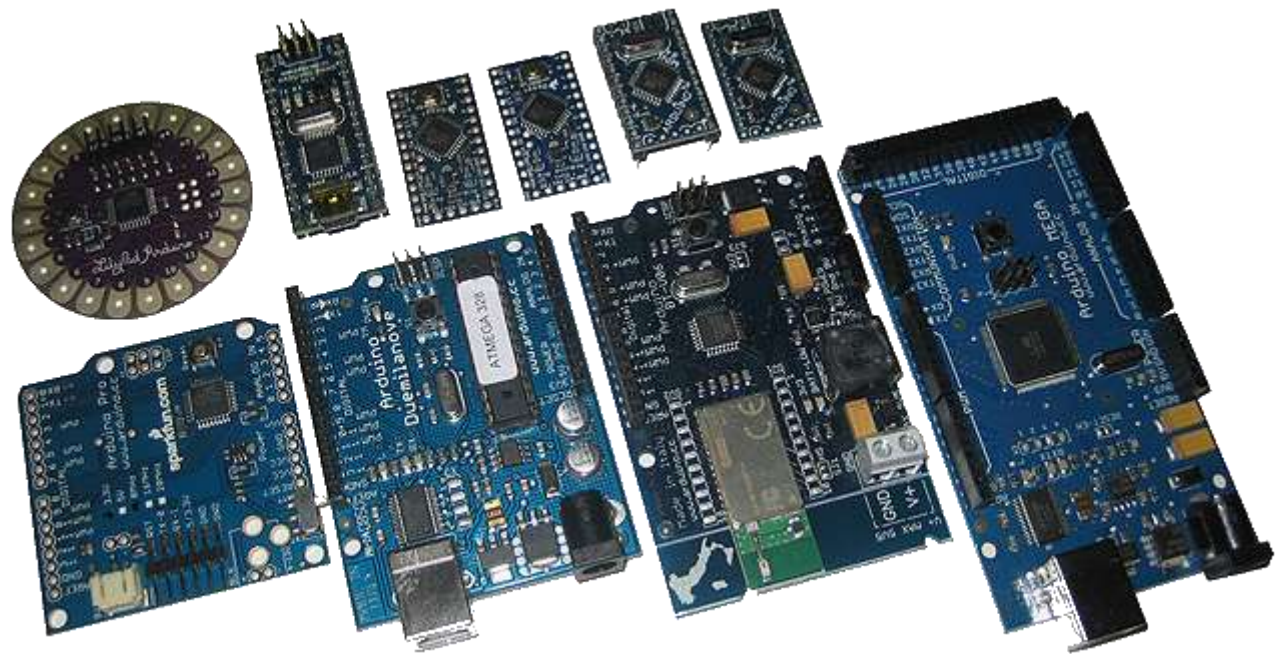
Što je razvojna ploča?



- Štampana matična ploča dizajnirana da olakša rad sa mikrokontrolerom
- Razvojna ploča tipično uključuje:
 - napojno kolo;
 - programerski interfejs;
 - Lako dostupne ulazno/izlazne pinove.

Tipovi Arduino-a

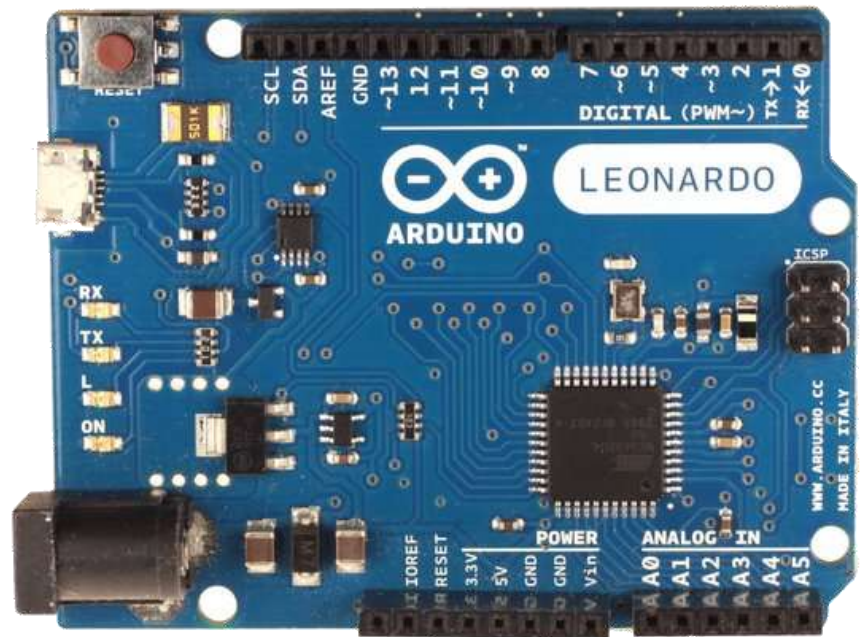
- Više različitih verzija
 - Broj ulaznih/izlaznih kanala
 - Oblik (gabariti)
 - Procesorska snaga
- Leonardo
- Due
- Micro
- LilyPad
- Esplora
- Uno



Leonardo

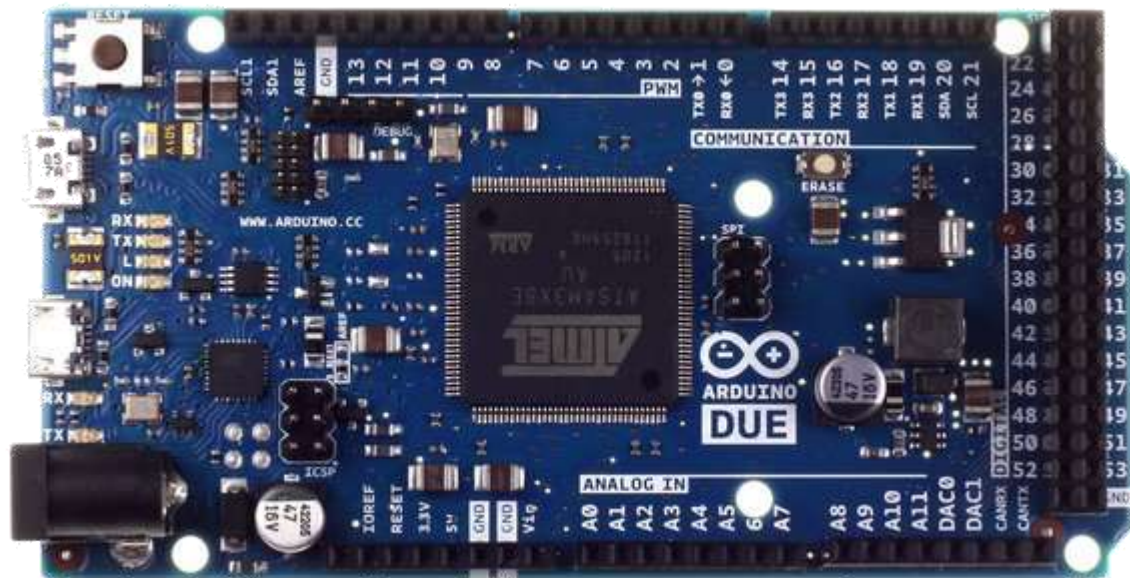
- U poređenju sa Uno, malo unaprijedjen.
- Koristi ATmega32u4 mikrokontroler koji ima ugrađenu USB komunikaciju

- Nema potrebe za dodatnim mikrokontrolerom
- Može se prikazati PC-u kao miš ili tastatura



Due

- Mnogo brži procesor, mnogo više pinova
- Radi na 3.3 volta
- Izgledom sličan Mega



Micro

- Kad je veličina važna: Micro, Nano, Mini
- Uključuju sve funkcionalnosti Leonardo-a



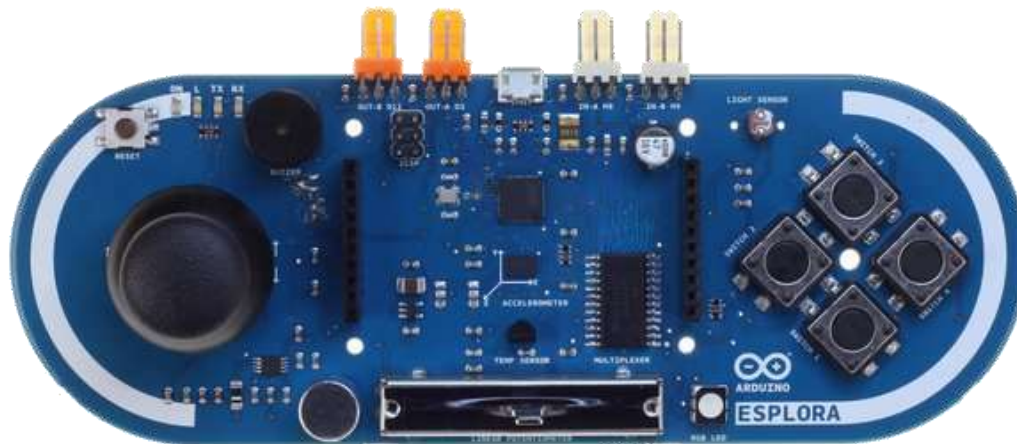
LilyPad

- LilyPad je pogodan za primjenu na odjeći.



Esplora

- Game controller
- Sadrži džojstik, četiri tastera, linearni potencijometar (klizač), mikrofon, svjetlosni senzor, senzor temperature, tro-osni akceleromatar.
- Nema standardi set IO pinova.



Mega

- U poređenju sa Uno, Mega:
 - Mnogo više komunikacionih pinova
 - Više memorije

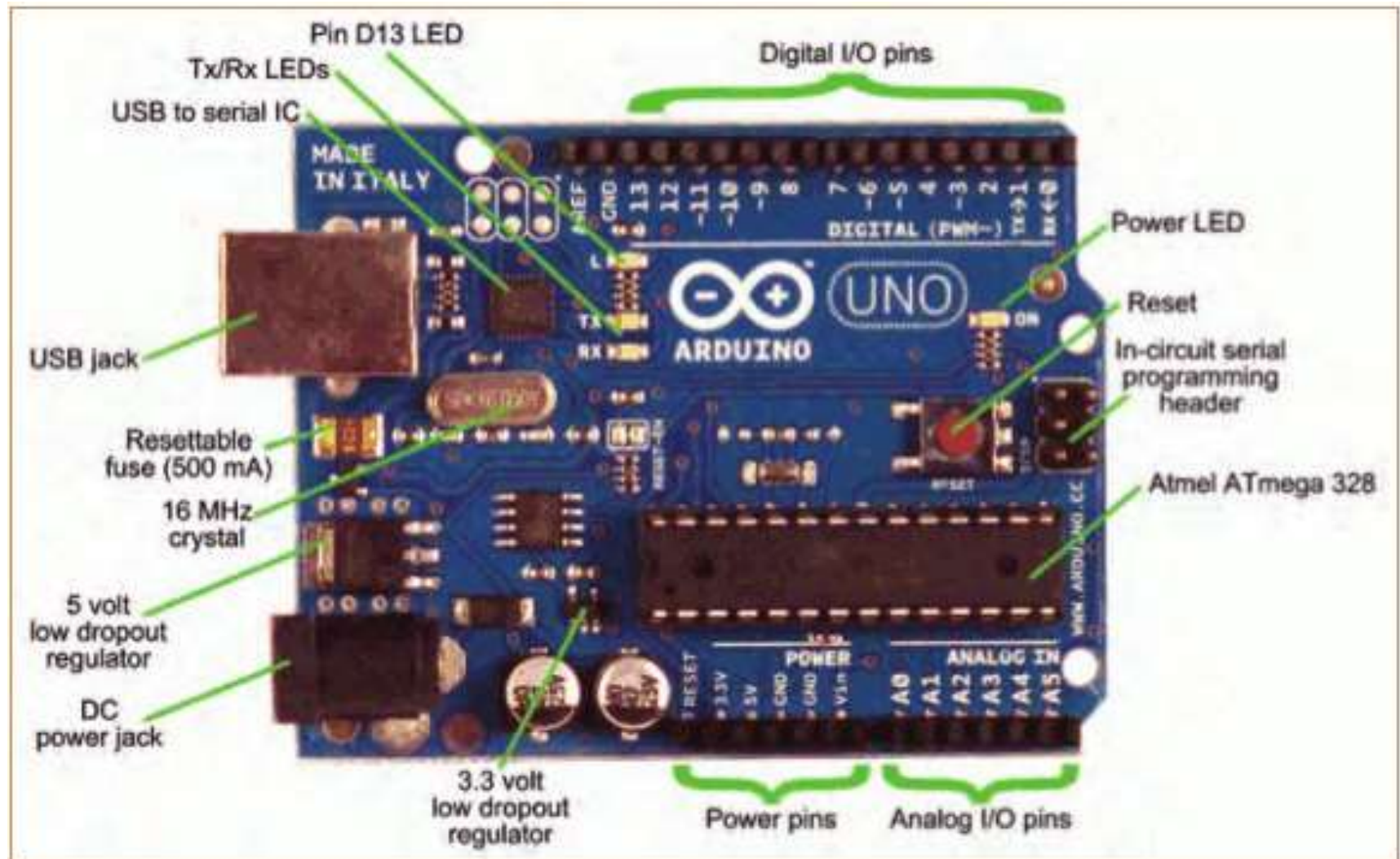


Arduino Uno

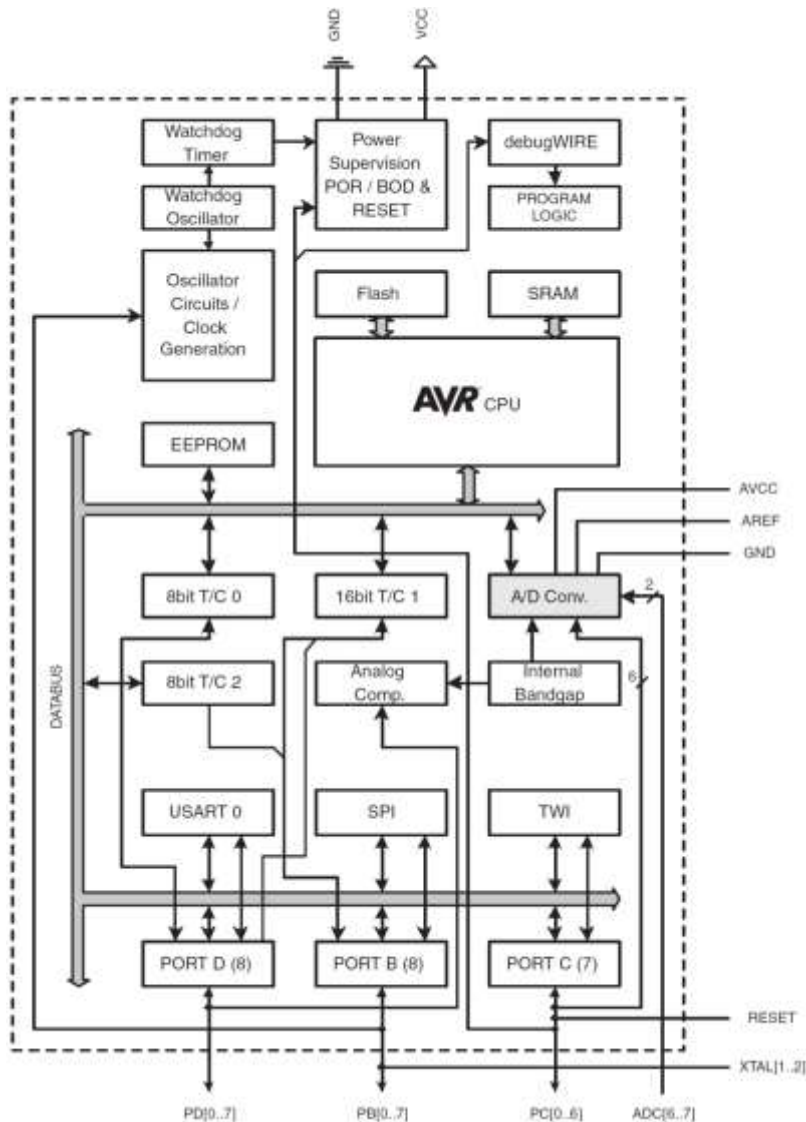
- Pinovi su grupisani u 3 grupe:
 - 14 digitalnih pinova
 - 6 analognih pinova
 - Napajanje
 - Pojavio se 2010



Arduino Uno razvojna ploča



ATmega328 unutrašnja architektura



(PCINT14/ $\overline{\text{RESET}}$) PC6	1	28	PC5 (ADC5/SCL/PCINT13)
(PCINT16/RXD) PD0	2	27	PC4 (ADC4/SDA/PCINT12)
(PCINT17/TXD) PD1	3	26	PC3 (ADC3/PCINT11)
(PCINT18/INT0) PD2	4	25	PC2 (ADC2/PCINT10)
(PCINT19/OC2B/INT1) PD3	5	24	PC1 (ADC1/PCINT9)
(PCINT20/XCK/T0) PD4	6	23	PC0 (ADC0/PCINT8)
VCC	7	22	GND
GND	8	21	AREF
(PCINT6/XTAL1/TOSC1) PB6	9	20	AVCC
(PCINT7/XTAL2/TOSC2) PB7	10	19	PB5 (SCK/PCINT5)
(PCINT21/OC0B/T1) PD5	11	18	PB4 (MISO/PCINT4)
(PCINT22/OC0A/AIN0) PD6	12	17	PB3 (MOSI/OC2A/PCINT3)
(PCINT23/AIN1) PD7	13	16	PB2 ($\overline{\text{SS}}$ /OC1B/PCINT2)
(PCINT0/CLKO/ICP1) PB0	14	15	PB1 (OC1A/PCINT1)

ATmega328 data sheet pp. 2, 5



ATmega328 karakteristike

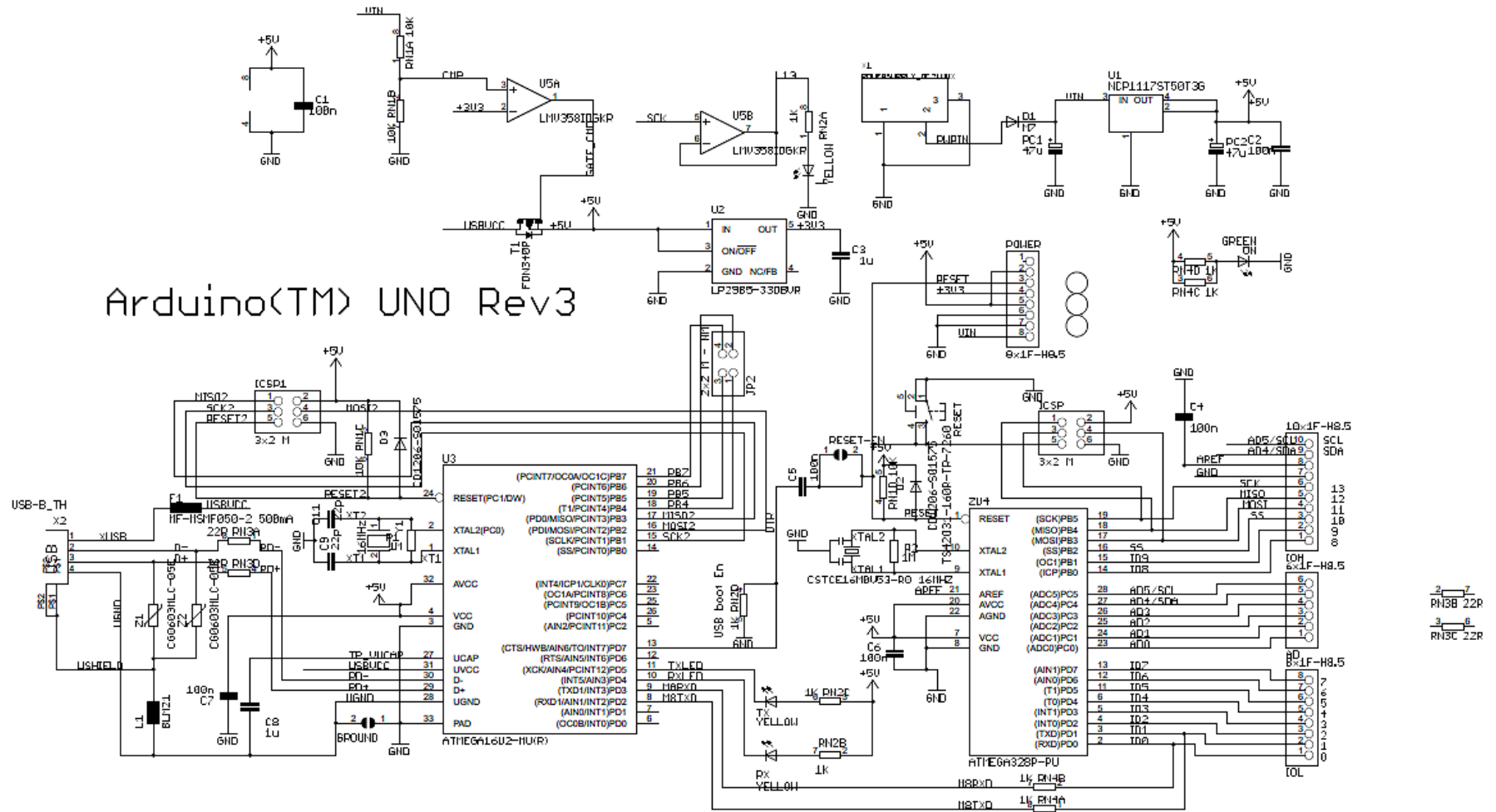
Features

- High Performance, Low Power AVR® 8-Bit Microcontroller
- Advanced RISC Architecture
 - 131 Powerful Instructions – Most Single Clock Cycle Execution
 - 32 x 8 General Purpose Working Registers
 - Fully Static Operation
 - Up to 20 MIPS Throughput at 20 MHz
 - On-chip 2-cycle Multiplier
- High Endurance Non-volatile Memory Segments
 - 4/8/16/32K Bytes of In-System Self-Programmable Flash program memory
 - 256/512/512/1K Bytes EEPROM
 - 512/1K/1K/2K Bytes Internal SRAM
 - Write/Erase Cycles: 10,000 Flash/100,000 EEPROM
 - Data retention: 20 years at 85°C/100 years at 25°C⁽¹⁾
 - Optional Boot Code Section with Independent Lock Bits
 - In-System Programming by On-chip Boot Program
 - True Read-While-Write Operation
 - Programming Lock for Software Security
- Peripheral Features
 - Two 8-bit Timer/Counters with Separate Prescaler and Compare Mode
 - One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
 - Real Time Counter with Separate Oscillator
 - Six PWM Channels
 - 8-channel 10-bit ADC in TQFP and QFN/MLF package
 - Temperature Measurement
 - 6-channel 10-bit ADC in PDIP Package
 - Temperature Measurement
 - Programmable Serial USART
 - Master/Slave SPI Serial Interface
 - Byte-oriented 2-wire Serial Interface (Philips I²C compatible)
 - Programmable Watchdog Timer with Separate On-chip Oscillator
 - On-chip Analog Comparator
 - Interrupt and Wake-up on Pin Change
- Special Microcontroller Features
 - Power-on Reset and Programmable Brown-out Detection
 - Internal Calibrated Oscillator
 - External and Internal Interrupt Sources
 - Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby, and Extended Standby
- I/O and Packages
 - 23 Programmable I/O Lines
 - 28-pin PDIP, 32-lead TQFP, 28-pad QFN/MLF and 32-pad QFN/MLF
- Operating Voltage:
 - 1.8 - 5.5V
- Temperature Range:
 - -40°C to 85°C
- Speed Grade:
 - 0 - 4 MHz@1.8 - 5.5V, 0 - 10 MHz@2.7 - 5.5V, 0 - 20 MHz @ 4.5 - 5.5V
- Power Consumption at 1 MHz, 1.8V, 25°C
 - Active Mode: 0.2 mA
 - Power-down Mode: 0.1 µA
 - Power-save Mode: 0.75 µA (Including 32 kHz RTC)

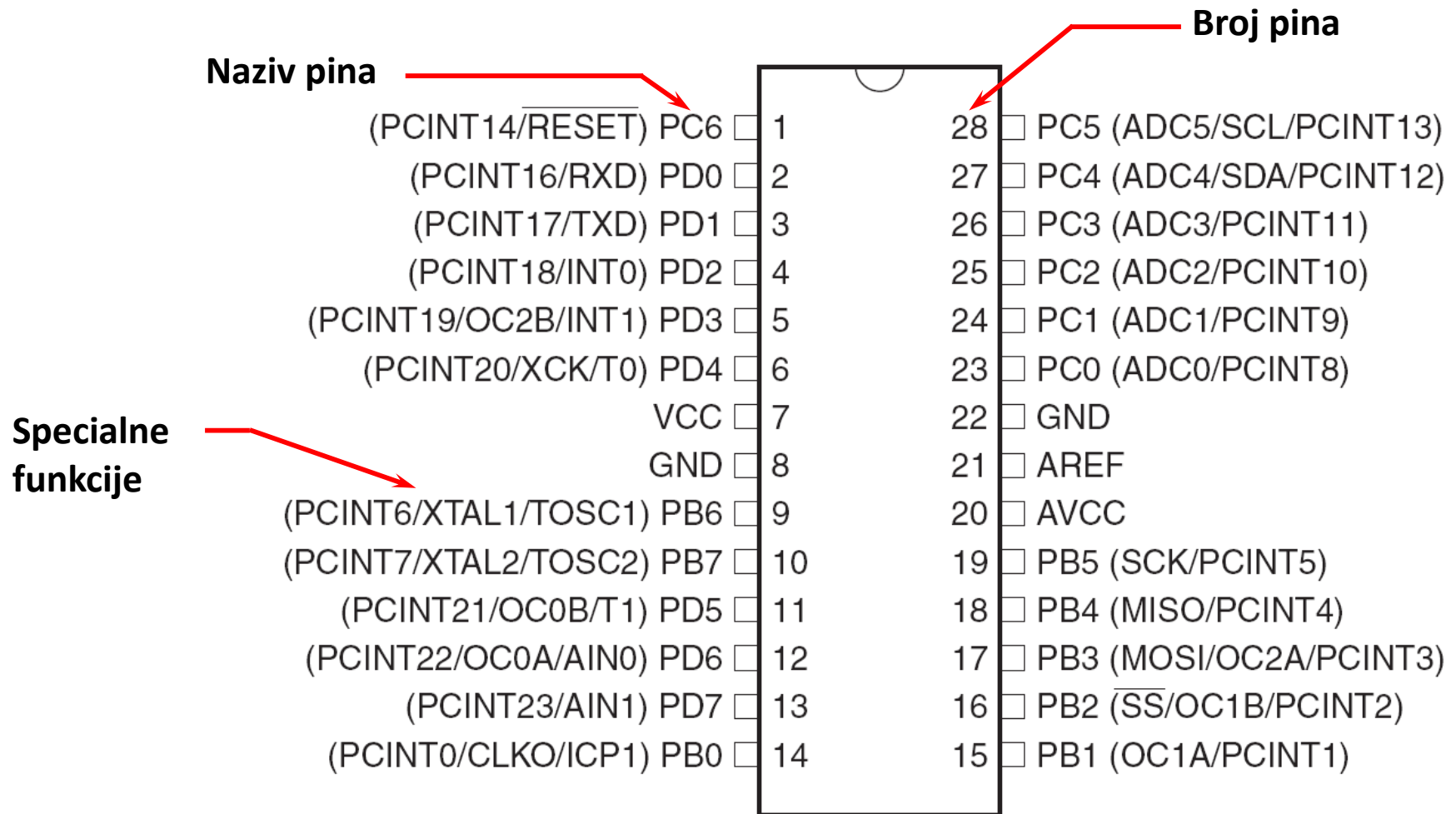
ATmega328 data sheet p. 1

<http://ww1.microchip.com/downloads/en/devicedoc/doc2467.pdf>

Arduino Uno – električna šema



ATmega328 Microcontroller



Absolutni maximumi

28.1 Absolute Maximum Ratings*

*NOTICE:

Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Operating Temperature -55°C to +125°C

Storage Temperature -65°C to +150°C

Voltage on any Pin except $\overline{\text{RESET}}$
with respect to Ground -0.5V to $V_{CC}+0.5V$

Voltage on $\overline{\text{RESET}}$ with respect to Ground..... -0.5V to +13.0V

Maximum Operating Voltage 6.0V

DC Current per I/O Pin 40.0 mA

DC Current V_{CC} and GND Pins 200.0 mA

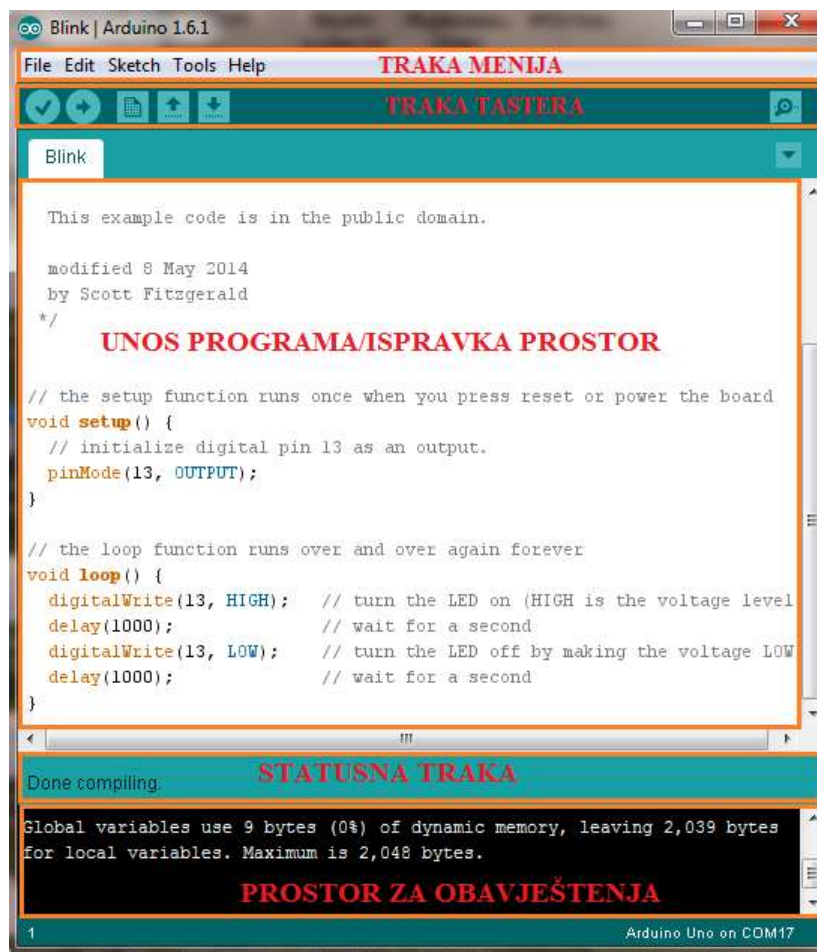
ATmega328 data sheet p. 316

Kako startovati?

Posjetite: <http://arduino.cc/en/Guide/HomePage>

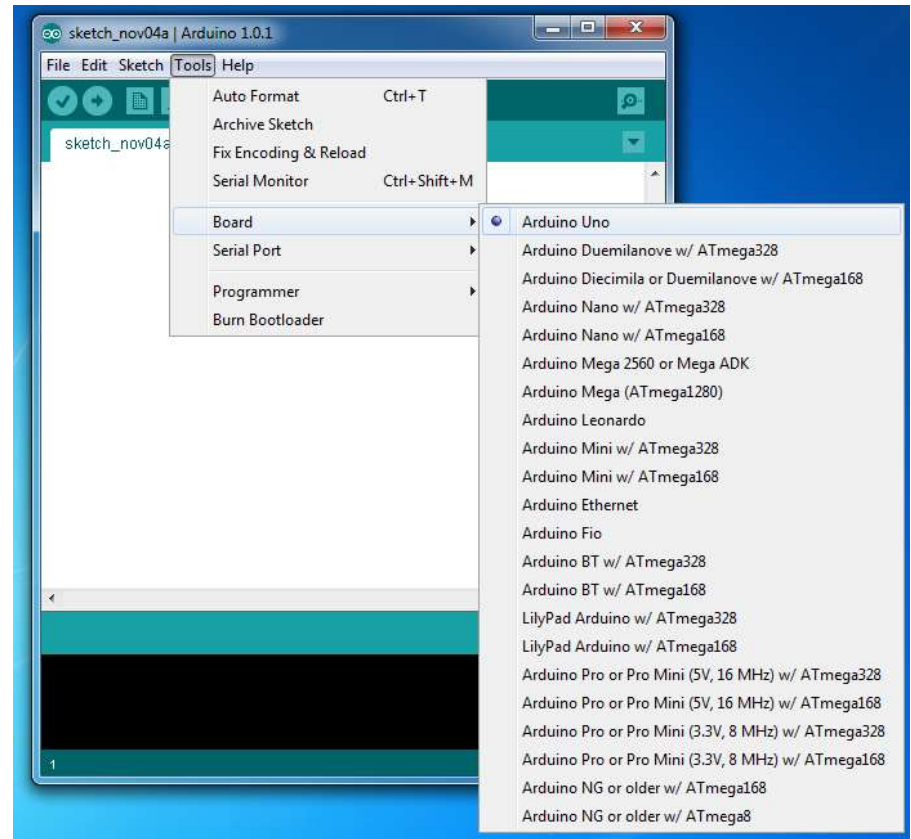
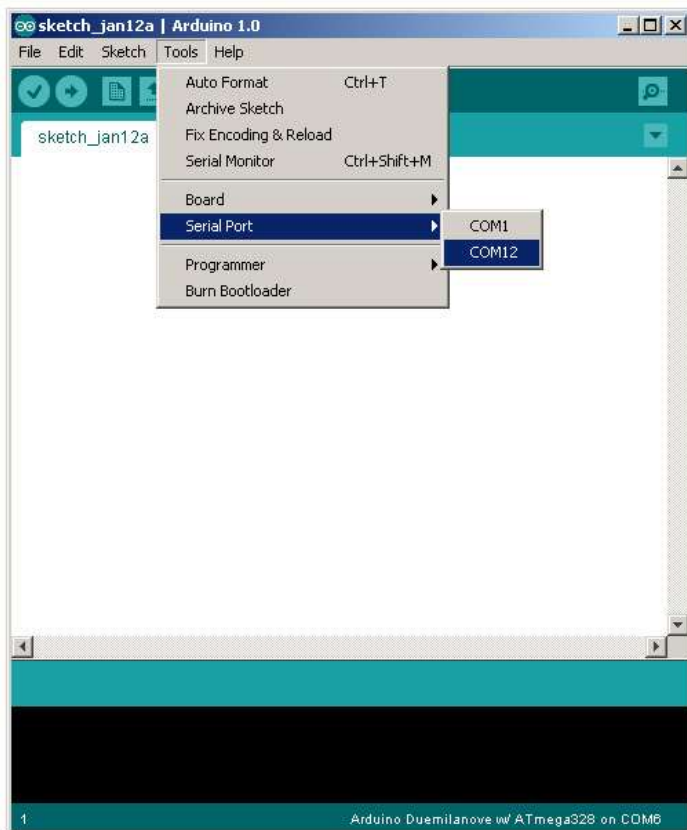
1. Preuzmite & instalirajte Arduino environment (IDE)
2. Povežite ploču sa računarom pomoću USB kabla
3. Ako je potrebno, instalirajte dodatne drajvere
4. Pokrenite Arduino IDE
5. Selektujte razvojnu ploču
6. Selektujte serijski port
7. Otvorite blink primjer
8. Upišite program u razvojnu ploču
- ...
9. Pisanje vlastitog programa
10. Nerviranje/Debugiranje/Primoravanje da radi
11. Oduševljenje i neposredno započinjanje novog projekta
12. (spavanje samo kad se mora)

Arduino IDE



Pogledajte: <http://arduino.cc/en/Guide/Environment>
za više informacija

Odaberite serijski port i ploču



Razvoj Arduino programa

- Zasnovan na C++ bez 80% komandi.
- Pregršt novih komandi.
- Programi se nazivaju 'sketches' (skečevi, skice) .
- Skečevi obavezno sadrže dvije funkcije:
 - void setup()
 - void loop()
- setup() se pokreće prvi i samo jedanput.
- loop() se pokreće neprestano, dok se ne isključi napajanje ili se ne učitava novi skeč.

Arduino C

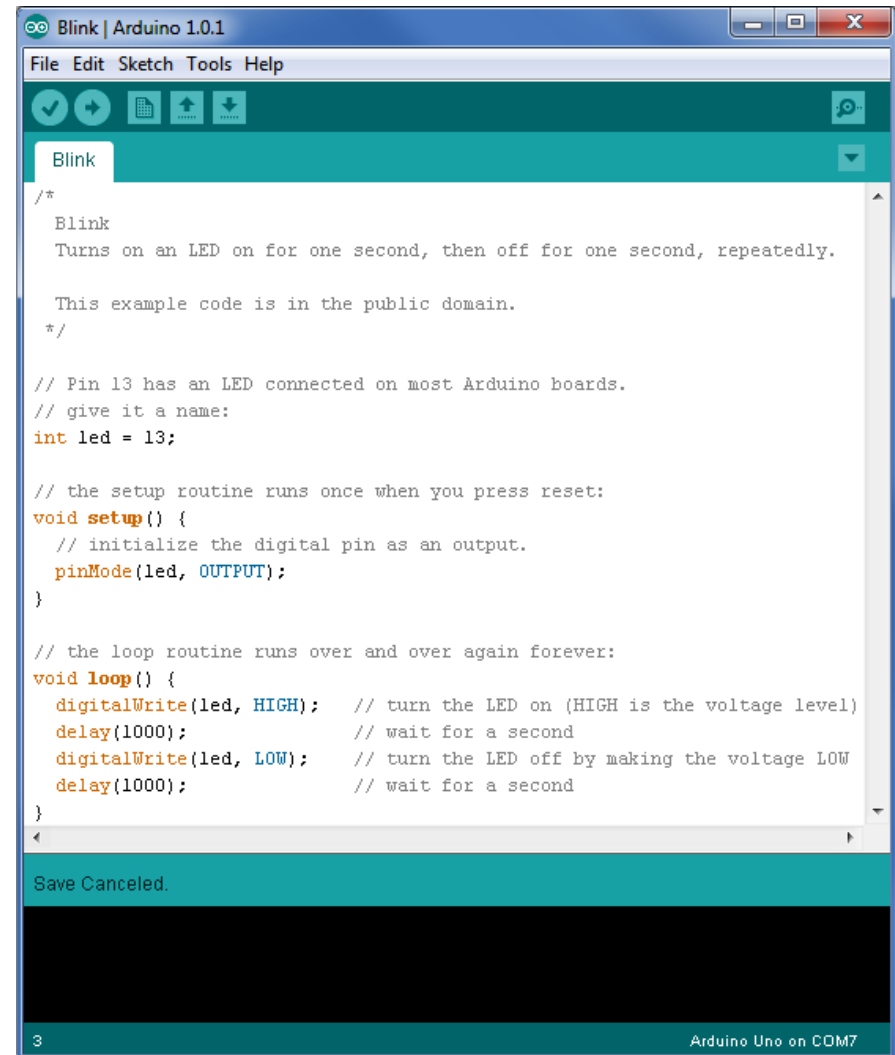
- Arduino skečevi uglavnom upravljaju pinovima na arduino ploči.
- Arduino skečevi su uvijek petlja.
 - void loop() {} je isto što i while(1) { }

Arduino tajming

- `delay (ms)`
Pauza nekoliko milisekundi
- `delayMicroseconds (us)`
Pauza nekoliko mikrosekundi
- Više komandi: arduino.cc/en/Reference/HomePage

Osobine kompajlera

- Brojni jednostavni skečevi su uključeni u kompajler
- Nalaze se pod opcijom File, Examples
- Kada je skeč napisan, može se upisati u programsku memoriju mikrokontrolera na Arduino štampanoj ploči kroz opcije File, Upload, ili pritiskom na <Ctrl> U



The screenshot shows the Arduino IDE interface with the 'Blink' sketch loaded. The code is as follows:

```
/*
  Blink
  Turns on an LED on for one second, then off for one second, repeatedly.

  This example code is in the public domain.
  */

// Pin 13 has an LED connected on most Arduino boards.
// give it a name:
int led = 13;

// the setup routine runs once when you press reset:
void setup() {
  // initialize the digital pin as an output.
  pinMode(led, OUTPUT);
}

// the loop routine runs over and over again forever:
void loop() {
  digitalWrite(led, HIGH); // turn the LED on (HIGH is the voltage level)
  delay(1000);             // wait for a second
  digitalWrite(led, LOW);  // turn the LED off by making the voltage LOW
  delay(1000);             // wait for a second
}
```

At the bottom of the window, a status bar indicates '3' and 'Arduino Uno on COM7'. A 'Save Canceled.' message is visible in the bottom left corner of the IDE window.