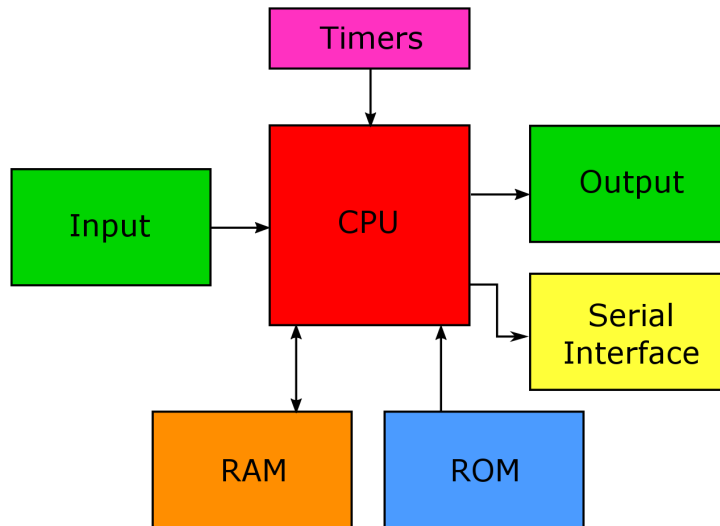


95-733 Internet of Things Microcontrollers and WPAN Protocols

Microprocessors and Microcontrollers

Microprocessor: CPU and several supporting chips.



Microcontroller: CPU on a single chip.

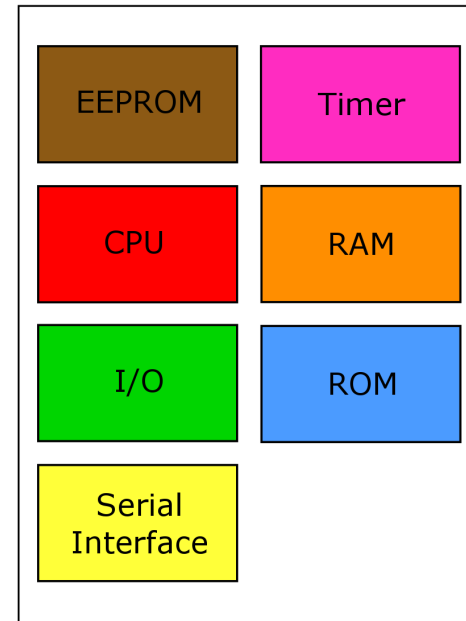


Image Credit: Kenneth C. Reese, III

Microcontrollers from Wikipedia

- A **microcontroller** (or **MCU** for *[microcontroller unit](#)*) is a small [computer](#) on a single [integrated circuit](#). In modern terminology, it is a [system on a chip](#) or SoC. A microcontroller contains one or more [CPUs](#) (processor cores) along with memory and programmable [input/output](#) peripherals.
- Microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, implantable medical devices, remote controls, office machines, appliances, power tools, toys and other [embedded systems](#).
- By reducing the size and cost compared to a design that uses a separate [microprocessor](#), memory, and input/output devices, microcontrollers make it economical to digitally control even more devices and processes. [Mixed signal](#) microcontrollers are common, integrating analog components needed to control non-digital electronic systems.
- In bulk, may be purchased for .25 USD. These are constrained devices. May be combined with a relay.
- A relay may be used to control large motors or machines.

Microcontroller from Wikipedia

- A microcontroller can be considered a self-contained system with a processor, memory and peripherals and can be used as an [embedded system](#).^[13] The majority of microcontrollers in use today are embedded in other machinery, such as automobiles, telephones, appliances, and peripherals for computer systems.
- Many use Advanced RISC Machine (ARM) processors. British company ARM holdings develops the architecture and licenses it to product design companies.
- Over 100 billion ARM processors produced as of 2017.

AN EXAMPLE MICROCONTROLLER THE Particle Photon

- Advanced RISC machine (ARM) Cortex M3 Microcontroller
- Broadcom Wi-Fi chip
- 18 GPIO pins
- Web based IDE at particle.build.io (develop code and flash to Photon)
- Particle is an open source platform
- Has example code for connecting to MQTT , see [mqtttest.ino](#)

Particle Microcontroller advertisement

We made more progress on our first day with Particle than we had in months without them, and within six months we began collecting data from thousands of connected brewers in the hands of consumers. Michael Cunningham, CIO, Keurig



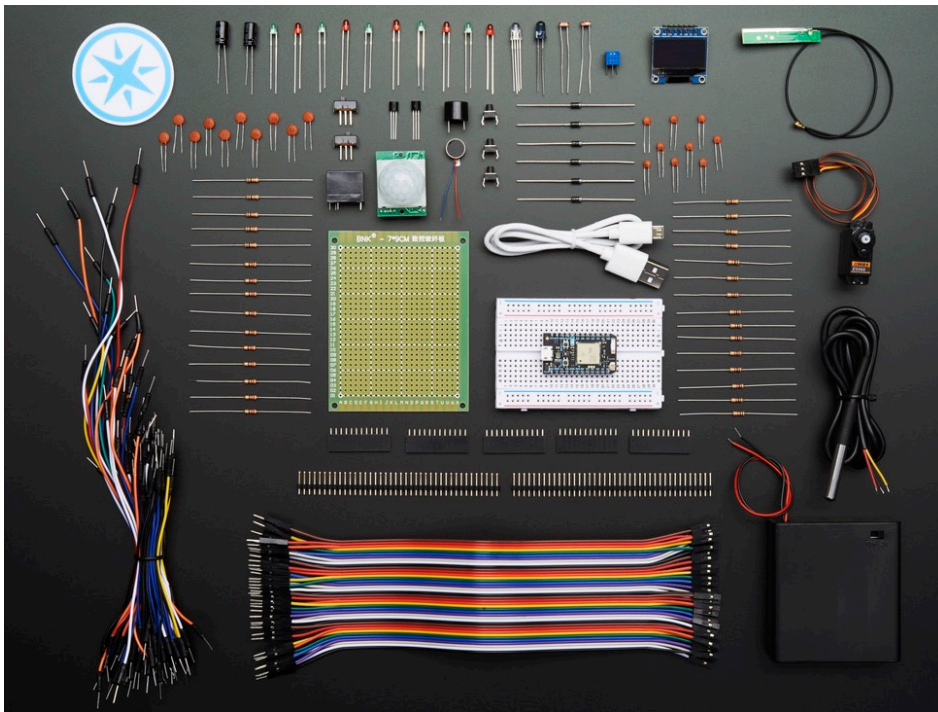
This is “usage data”.

Quiz why is usage data valuable?

It can be used to impact future product designs.

We are moving from smart products to smart connected products.

Particle Photon Maker Kit



95-733 Internet of Things

PAN from Wikipedia

- A **personal area network (PAN)** is a [computer network](#) for interconnecting devices centered on an individual person's workspace. A PAN provides [data transmission](#) amongst devices such as [computers](#), [telephones](#), [tablets](#) and [personal digital assistants](#). PANs can be used for communication amongst the personal devices themselves, or for connecting to a higher level network and the Internet (an [uplink](#)) where one master device takes up the role as [gateway](#). A PAN may be carried over wired [computer buses](#) such as [USB](#).
- A **wireless personal area network (WPAN)** is a low-powered PAN carried over a short-distance [wireless network](#) technology such as [IrDA](#), [Wireless USB](#), [Bluetooth](#) and [ZigBee](#). The reach of a WPAN varies from a few centimeters to a few meters.

Important WPAN Protocols

Name	Battery Usage	Indoor Range	Mesh networking	Openness	Internet Integration	Comment
EnOcean	Very low energy harvesting	< 30 m	No	Low	No	Full stack. Buildings and industrial solutions
ZigBee	low	< 50 m	Yes	Low	No	Full stack. Based on 802.15.4
Thread	low	< 50 m	Yes	Medium (used by Google Nest)	Yes	6LoWPAN over 802.15.4
Bluetooth	Low with BLE	< 50 m	Yes pub/sub mesh networking over BLE	Medium	No but coming	Full stack. Not based on 802.15.4
Wi-Fi	High and Low variations	< 30 m	No (Star topology)	High	Yes	LAN

From "Building the Web of Things by Guinard and Trifa.
 If your device will be plugged in, use Ethernet or Wi-Fi or both.

Low Power Wide Area Networks (LPWAN)

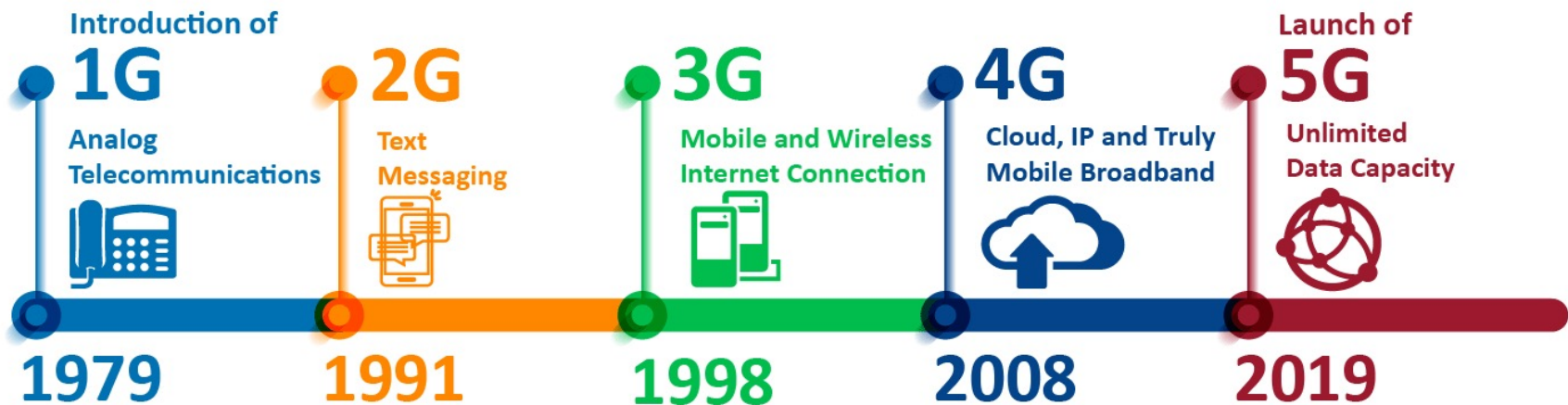
- LoRa (short for Long Range) is an important player – many others exist
- LoRa is at the physical layer and for long range communications
- Very low bandwidth 250 bps – 11 kbps (not JSON or ASCII but perhaps Google's Protobuf)
- Low battery use – transmit rarely
- May be mobile
- Talks to a gateway that connects to the internet
- LoRaWAN is a communications protocol above LoRa
- 128 bit end to end encryption
- Adopted at CMU, see OpenChirp

The case for LoRa



Wireless Wide Area Network

The Evolution of 5G



2020 Verizon deploys 5G in several cities