IoT Workshop

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What is IoT

What is IoT

- Not "a computer connected to the internet"
  - Then it is really just another computer connected to the internet
- Must be something else
  - It is simply devices that are resource constrained
    - Usually in more than one way
- Autonomous operation, the connection might not be permanent

IoT is just a concept

- *The Internet of Things (IoT) is the network of physical devices, vehicles, home appliances and other items embedded with electronics, software, sensors, actuators, and connectivity which enables these objects to connect and exchange data.*[1]

What is an IoT Device?

As for their definition.

What differentiates a computer from an IoT device?

What is an IoT Device?

- Constrained in (one or more of):
  - Memory
  - CPU
  - Network bandwidth and/or latency
  - Storage

[1] Wikipedia "Internet of Things"

Typical IoT chips - Bluetooth 4/5

Chip	CPU	Freq	RAM	Flash	Price
nRF52810	Cortex-M4	64 M	Hz 24k	192k	$1.88
High perf	ormance,	entry	-level Bl	uetooth	4/ANT/2.4GHz SoC

nRF52832 Cortex-M4F 32k 256k $2.54 64k 512k $2.59 High performance Bluetooth 4/ANT/2.4GHz SoC

nRF52840 Cortex-M4F 256k 1024k $3.85 Advanced multi-protocol System-on-Chip Supporting: Bluetooth 5, ANT/ANT+, 802.15.4 and 2.4GHz proprietary

All quantities are 1000 pieces

nRF51: https://www.digikey.no/products/en/rf-if-and-rfid/rf-transceiver-ics/879?k=nrf51822

nRF52832: these have different packagings, not only difference price

https://www.digikey.no/products/en/rf-if-and-rfid/rf-transceiver-ics/879?FV=1c0001%2Cffe0036f&quantity=

Typical IoT chips - Wi-Fi

Chip	CPU	Freq	ROM	RAM	Price
ESP8266	Tensilica L106	160 MHz	N/A	~50 kB	< $1

ESP32 - dual cpu, Wi-Fi, Bluetooth 4 ESP32-D0WDQ6 2x Xtensa @ 160MHz $ 4.53 @ 10

The ESP8266's RAM depends on which firmware stack is used. Physical is probably 128k or most likely 64k.

ESP8266 details - Power usage

State	Current usage
Off	0.5 µA
Deep sleep with RTC	20 µA
Light sleep (with Wi-Fi)	1 mA
Sleep with peripherials	15 mA
TX	170 mA

Datasheet page 18

ESP8266 details - Arduino

https://github.com/esp8266/Arduino

Going back to basics

What is the internet again?

OSI model

1. Physical Layer
2. Data Link Layer
3. Network Layer
4. Transport Layer
5. Session Layer
6. Presentation Layer
7. Application Layer

- Wikipedia: OSI model
- Wikipedia: OSI model#Examples

Does not match the TCP/IP stack very closely.

Layer 1: Physical Layer

- 10BASE5, 10BASE2
- 10BASE-T / 100BASE-TX / 1000BASE-TX
- 802.11a/b/g/n PHY
- RS-232

Ethernet: Hubs and switches (that act on this level) is not on it's own layer. It is more of a implementation detail in the architecture diagram.

RS-232 signaling is used in *all* MCUs, many have several ports available. It is extremely flexible, both used for implementing applications and debugging. Frequently an easy way to hack embedded devices. "USB dongles", "USB TTL" all use RS-232 signaling.

Note that this only applies to its logical signals, not voltage levels. The signaling does not specify any max data rate, very high rates (>= 1Mbps) is often supported.

Layer 2: Data Link Layer

- Ethernet
- WiFi
- Bluetooth
- Token Ring

Layer 3: Network Layer

- IP
- ICMP
- IPX

Layer 4: Transport Layer

- TCP
- UDP

Layer 5: Session Layer

- “sockets”
- NetBIOS

Layer 6: Presentation Layer

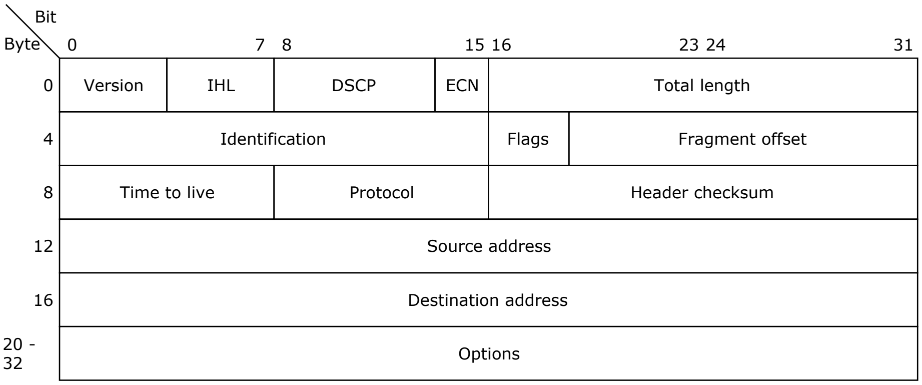
- SSL

This layer is not really much used in the IP stack

Layer 7: Application Layer

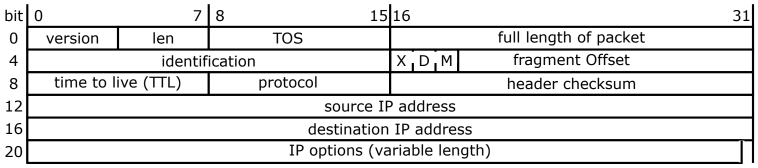
- HTTP
- DNS
- MQTT
- CoAP
- (everything else..)

Details: IP



Note that the “total length” field is 16 bits, 2 bytes, it’s maximum value is 64k, 65536.

Details: IP



Lecture: ESP8266 aka NodeMCU aka ESP-12

Lecture: MQTT

MQTT

- *Message Queuing Telemetry Transport*
- Wikipedia: MQTT

MQTT Implementations

- Mosquitto
- Eclipse Paho
- Redis with MQTT connector

MQTT Cloud Connectors

- Cloud
  - Amazon IoT
  - Google Cloud IoT
  - Microsoft Azure IoT
  - CloudMQTT
- DIY
  - ThingMQ
  - HiveMQ

In between are:

- self hosted
- Generic bridges

Notes

Assignments

- Measure round trip time/latency. Measure UDP, TCP. Measure when the packet size is greater than the MTU
- Measure ISR timing