Communication between devices, computers and peripherals

Communication between devices can be classified to wired and wireless communication. Common wired connection includes UART, I2C, SPI and USB. Common wireless connection includes Bluetooth and Wi-Fi. This essay discusses their communication methods, speed, hardware requirement and applications.

Wired connection

UART (Universal asynchronous receiver/transmitter) is a common one-to-one device low speed wired connection. There are three wires: Tx(Transmission), Rx(Receiver) and Gnd(Ground). The main advantage is the connection between devices is simple. The main disadvantage is the data rate is too low (around 115.2kbps for the most common version) because it is asynchronous, which means additional information of start and stop of packet need to be inserted.
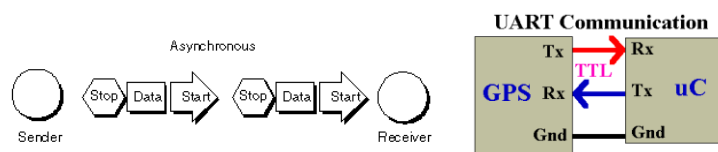

Figure 1: UART connection. From webopedia and [1]

I2C (Inter-Integrated Circuit) is a protocol for one-to-many connection. The speed is up to 5Mbps. There are three wires: Vdd, SDA (Serial Data Line) and SCL(Serial Clock Line). One of the disadvantage is that it is originally designed for the communication of chips on a PCB but not for different devices. Hence, the transmission length should keep short. Another disadvantage is that, it is not possible to send and receive data simultaneously, which is not a problem for UART. An advantage is that it requires few wires. It is often used in connecting sensors for embedded system.

SPI (Serial to Peripheral Interface) is developed by Motorola, which is also one-to-many connection with higher speed than I2C (around 10Mbps) and can also send and

receive data simultaneously. It also draws less power than I2C. The disadvantage is that the number of cable needed for connection is much higher than the other communication protocol. Specifically, N+3 wires are needed, where N is the number of slaves. It is often used in connecting EEPROM, Flash and some LCD display.
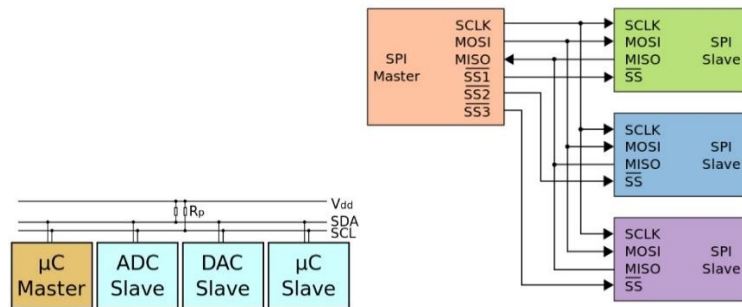

Figure 2: I2C and SPI connection. [1]

USB (Universal Serial Bus) is an industrial standard for computers to connect with peripheral devices with both communication and power supply.

For USB type A and type B, there are 4 pins: VBUS, D-, D+ and GND. D+ and D- are data bus that are twisted that can cancel the electromagnetic interference. For USB type C, there are 24 pins: 4 pairs of VBUS-GND, 2 pairs of USB 2 connection 4 pairs of USB 3.1 SuperSpeed data bus and 2 pairs for sideband use [2].

The speed is extremely high, which up to 20 Gbit/s for USB 3.2 that released in Sep 2017. It is very durable, which has a minimum lifetime of 1500 and 10000 cycles of insertion and removal for standard USB and type C respectively [3,4].
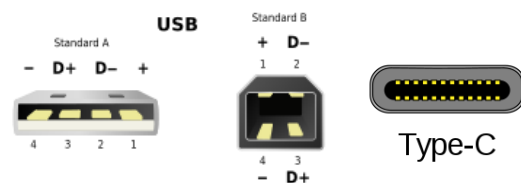

Figure 3: USB type A, B and C connector (from wiki)

In summary, if high speed is needed, choose USB; if simple one-to-one connection is needed, choose UART; if one-to-multiple connection and low power consumption are

needed, choose SPI; if one-to-multiple connection is needed but we have few wires, choose I2C.

Wireless connection

Bluetooth and Wi-fi 802.11

Bluetooth and Wi-Fi are standardized technology that use 2.4GHz unlicensed frequency band for communication. The main advantage of Bluetooth is its low transmission power, which is only 3% of power comparing to WiFi when performing same task. This is because the transmission range of Bluetooth is very limited – around 10 meters for class 2 Bluetooth, which is only 10% of that of Wi-Fi [5, 6]. The data transfer rate of Bluetooth 4.0 is 25Mbps whereas that of Wi-Fi is 250 Mbps [7]. The main application of Bluetooth nowadays is Internet of Things (IoT) which requires vast amount of communication between devices. The main application of Wi-Fi is sending data from devices to internet.

In summary, Bluetooth is good for the communication between devices in a relatively short-range and low power network. If we need longer transmission range, higher data transfer rate, internet connection or connect devices to each other, Wi-Fi is better choice.
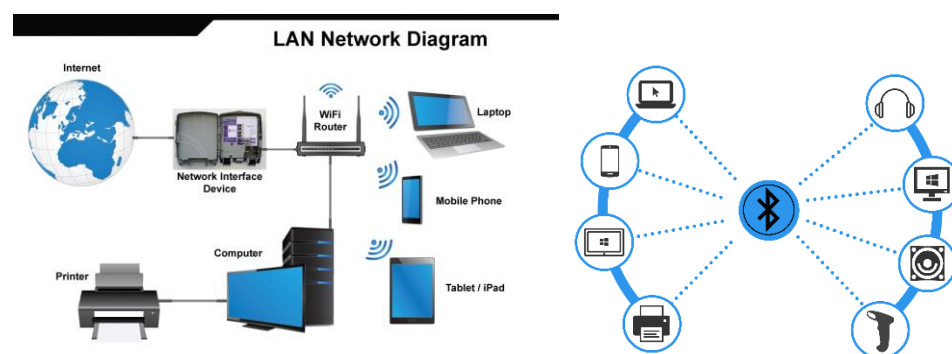

Figure 4. Wi-Fi network and Bluetooth nerwork [8][9]

[1] https://makerpro.cc/2016/07/learning-interfaces-about-uart-i2c-spi/
[2] Howse, Brett. "USB Type-C Connector Specifications Finalized". AnandTech. Anadtech. Archived from the original on 18 March 2017.

[3] "Universal Serial Bus Cables and Connectors Class Document Revision 2.0" (PDF). usb.org. August 2007. Archived (PDF) from the original on 11 June 2014.

[4] "Technical Introduction of the New USB Type-C Connector". Archived from the original on 29 December 2014.

[5] https://itstillworks.com/bluetooth-vs-wifi-power-consumption-17630.html

[6] Lawrence Harte (2004). Introduction to Bluetooth: Technology, Market, Operation, Profiles, &Services. ALTHOS.

[7]https://www.lifewire.com/bluetooth-vs-wi-fi-4088218

[8] http://home.heartofiowa.net/support/links/wireless-network-support/

[9] https://www.datexcorp.com/bluetooth-technology-for-warehouse-operations/