CS4222/CS5422 Semester 2, 2022/2023

Tutorial for Week 6 (Feb 13th, 2023)

Question 1: What is the typical battery capacity of common devices that you use in your daily life such as wearables (Apple Watch/Fitbit), earphones, laptops, and mobile phones?

Answer 1:

Earphones (Apple airpods): 49.7 mAh

Wearable (Apple Watch Ultra): 542 mAh

Wearable (Fitbit Sense): 266 mAh

Laptop (Apple Macbook 13 M2): 58.2 Wh (Watt hour)

Mobile Phone (Galaxy S23): 3900 mAh

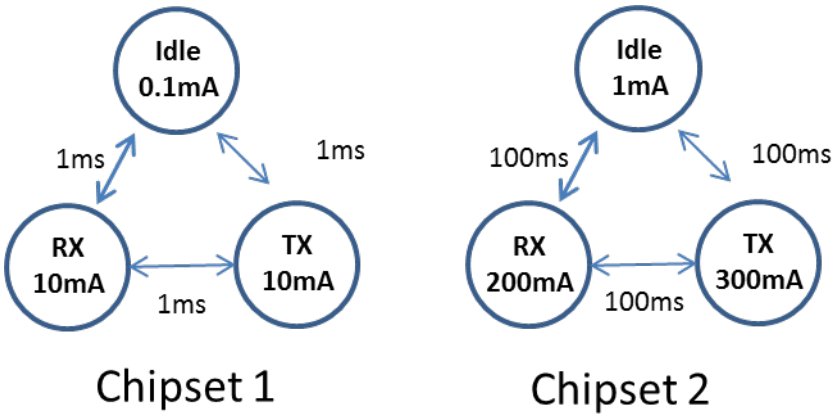
Mobile Phone (Apple iPhone 14 Pro Max): 4323 mAh

Oura Fitness Ring: 15 – 22 mAh

Question 2:

(a) In the figure representing state transition diagram, which chipset is more suitable for used in Internet of Things applications? Explain your reasoning.

(b) For the chipset chosen in the question above, assume that the devices are designed to operate at a very low duty-cycle (<0.01%) and you are allowed to reduce the current drawn from only one of the states (idle, receive (RX) or transmit (TX)). Which state would you reduce the current from?



Chipset 1 Chipset 2

Answer 2:

(a) Chipset 1 is more suitable for use in low-power wireless sensor networks. This is because it has a faster state-switching time and lower power consumption in all three states than chipset 2.

(b) You should reduce the current drawn from the idle state since most of the energy consumed is still in the IDLE states since it operates at a very low duty-cycle (<0.01%).

Question 3: Please find specification of following technologies:

Specification	Bluetooth	Zigbee	WiFi	LoRa	Lorea	Judo
VDD (V)	1.8	3	3.3	3.3	2	0.12
Transmit (mA)	60	30	220	28	0.035	0.7
Receive (mA)	50	25	210	13.8	NA	N.A
Bitrate (Mb/s)	1.2	0.25	54	0.027	0.003	0.1

(a) Calculate the energy (in Joule) require transmitting 1 bit for different technologies listed above.

(b) For low power IoT devices, should you always select the network technology with the lower transmission energy per bit? Explain your answer

(c) In addition to energy needed to transmit/receive a bit, what other criteria(s) should you take into account when selecting a network technology for use in a low power Internet of Things?

(d) What kind of applications would choose to use above technologies?

Answer 3:

(a) BL: 1.8*60/1,200,000 = 0.00009
ZigBee: 3.0*30/250,000 = 0.00036
WiFi: 3.3*220/54,000,000 = 0.00001344444
LoRa: 3.3 * 28/27,000 = 0.00342222222
LoRea: 2 * 0.035/3000 = 0.00002333333
Judo: 0.12*0.7/100,000= 8.4e-7

(b) No, depends on the application type. For example,

- if there are lots of data to transfer, go for lowest energy per bit (Wifi)
- if idle period dominates and data to be transferred is low, choose ZigBee, BLE or Backscatter

- If operation on small batteries or energy harvesting chose Backscatter
- If high communication range is required chose LoRa

(c) In addition to energy needed to transmit/receive a bit, what criteria(s) should you consider when selecting a network technology for use in a low power wireless sensor network?

We can consider the following as well:

- Ability to turn active/idle/off quickly (shortest time)
- Form factor (size of antenna)
- Maximum current draw (high current draw might make small batteries infeasible)
- Ability to form network?

(d) What kind of applications would choose to use Bluetooth technologies?

One that requires more data than ZigBee, LoRa, shorter range and small current draw. Good example is Earphones.

(e) What kind of application would choose to use LoRa technology?

One that requires transmitting data to large distances (much more than ZigBee and BLE). We may consider data transmissions over hundreds of meters to few kilometers using LoRa technology.

(f) What kind of application would choose to use Backscatter technology?

These applications typically require drawing minimal current and transmitting information frequently. They also require a sticker or a similar form factor. Usually, these applications are powered by energy harvested from the environment and do not use batteries.