CS4222/CS5422 Semester 2, 2022/2023

Tutorial for Week 11 (March 27th 2023)

Answer 1:

(a) N = 17, Prob = 1 – 365!/(365^17(365-17)!) ~ 1 – 0.685 = 0.315
(b) N = 141, Prob = 365!/(365^141(365-141)!) ~ 2.3 * 10^(-14)

Answer 2:

(a)

Pros:

There are several advantages, but two main are as follows:

- Better propagation characteristics owing to lower frequency
- Less interference from other wireless devices
- More bandwidth available than typical sub-GHz frequency bands

Cons:

- May not be available in every part of the world. Authorities need to allow the use
- Even within the same country, the specific frequency may vary from region to region
- Need specialised hardware like software defined radio. Commodity radio chipsets may not be designed to operate in TV whitespace bands

(b) Numerous applications, including (a) deploying IoT sensors for agricultural assistance, (b) providing internet connectivity in rural regions, and (c) environmental monitoring, benefit from communication over extensive distances and areas where the television band may have unutilized portions of the spectrum.

(c) In urban areas, where more television channels might be present, there may be a reduced portion of the TV frequency band available for whitespace networking. Additionally, due to the higher density of wireless devices in such areas, there may be increased competition for the unused television band.

(d) The availability of whitespace frequencies may change depending on both location and time. Therefore, maintaining a database for the allocation of TV whitespaces is crucial. IoT and other wireless devices can query this database to verify the availability of whitespace frequencies and plan transmissions accordingly.

(e) Relevant authorities must grant permission for the utilization of unused TV spectrum. Regulations may differ from region to region, and some countries might not permit transmissions on such frequency bands. This contrasts with ISM bands, which do not require such approvals.

(f) To estimate, please use the Friis propagation equation and assume Gt and Gr to be 2 dB. A few disadvantages include the potential for larger antenna sizes in IoT devices and the possibility that commodity radio chipsets may not support operation on TV whitespace frequencies.

Answer 3:

(a) P(both active) = 0.1 x 0.1 = 0.01

Average = 1/0.01 = 100 slots or 20 sec.

(b) More frequent transmission may improve chances of discovery, but if there are more nodes in the neighbourhood, frequent transmissions can also result in frequent interference resulting in lower discovery performance.

Answer 4:

(a) We can expect requirement of few kilobits of datarate required from every sensor. Typically, the pollution levels can be represented in few bytes per reading. Considering the large scale deployment, we should look into wide area wireless networks such as LoRa, SigFoX.

(b)

Pros of 2-FSK:

- 2-FSK is inherently straightforward and enjoys widespread support among radio chipsets, making it a highly accessible option.
- Its substantial transmission range is sufficient for air quality sensing applications, ensuring effective monitoring over long distances.
- As it is not tied to any commercial network, 2-FSK offers maximum flexibility for network designers and eliminates the need for subscription fees.
- Capable of supporting high data throughputs, 2-FSK can handle a large volume of information.

Cons of 2-FSK:

- When compared to CSS-based LoRa transceivers, 2-FSK has a relatively shorter range (sensitivity).

- CSS offers orthogonality, enabling multiple transmitters to share frequency without negatively interfering with one another. This feature may not be possible with 2-FSK.

Pros of LoRa:

- LoRa provides the highest range and reliability, ensuring strong performance in various applications.
- Operating in an unlicensed band, LoRa avoids the need for costly licenses and permits.
- With numerous network service providers deploying LoRa networks, the existing infrastructure can be easily reused, reducing costs and streamlining implementation.

Cons of LoRa:

- LoRa has limited throughput capabilities, which may restrict the volume of data that can be transmitted.
- As a commercial standard, some aspects of LoRa are proprietary, potentially limiting accessibility and customization.
- LoRa is more complex than 2-FSK, which could lead to increased implementation challenges and maintenance requirements.

We assume that TDMA is not being considered.

One 2-FSK transmission: 125 KHz

Maximum number of FDMA transmissions: 3 MHz/ 125 kHz = 24 concurrent transmissions

For LoRa:

Since, we can have nodes with orthogonal spreading factors, we can have much larger number of transmitters than 2-FSK. Exact number requires additional information.

Answer 5:

Energy/bit

WiFi: (170 mA * 3)/ 11 = 510 mW/11,000,000 = 46.36 nJ/bit

ZigBee: (9.1 mA * 3V)/250,000 = 109.2 nJ/bit

LoRa: (87 mA * 3V)/27,000 = 9667 nJ/bit

1. It has lowest energy per bit. However, it has short range. Good for applications transmitting lot of data over short distances

2. ZigBee: Good for sending reasonable amounts of data over similar or slightly more range than WiFi. Commonly used in battery-powered IoT devices. Can also be used for mesh networks
3. LoRa: Good for applications requiring transmission of small amounts of data over hundreds of meters of distances. None of other standards support such high range.

For the presented applications:

1. Sensors in agriculture: Large range, small amounts of data -> LoRa seems most appropriate
2. Smoke alarms -> Might require smoke alarms to talk to each other, communicate over short range, are battery operated and need to last long, small amounts of data -> ZigBee seems appropriate
3. Security camera -> Large amounts of data, typically short range -> WiFi maybe appropriate