Homework PAE 4

In order to compute the number of bits needed to transmit all that data, we will first have to analyze each individual measurement and understand how many bytes it requires.

1. GPS data

   1.1. Timestamp (complete)

   Usually, the way a complete timestamp (date and time) is transmitted is by using the Unix timestamp. This, in short, represents the total number of seconds that have passed since January 1, 1970 (called epoch time) and is the industry standard. A Unix timestamp is usually a 32-bit integer, **which is 4 bytes** (enough to tell the date and time from December 13, 1901 to January 19, 2038).

   1.2. Latitude and Longitude

   Since the latitude and longitude are being multiplied by 100 and stored as integers, they will have a range of -18000 to 18000 and -9000 to 9000 respectively. These values can be stored in 16-bit integers, **which is 2 bytes each**.

2. Temperature readings

   Per the Fossasat-1 data which was given to us and common knowledge about launching satellites into space, the following are true:

   - T_{EXT} is attached to the superior panel, T_{CPU} belongs to the OBC and T_{BATT} measures the battery temperature;
   - Telemetry data from T_{CPU} has been discarded, as Fossa Systems recommended it because of a lack of data integrity;
   - While for T_{BATT}, a range of -128°C to 127°C (**corresponding to 1 byte** of information) should be more than enough, for T_{EXT} (which is the temperature of the fuselage) this range is risky since in space temperatures can get both colder and hotter than that. So, for T_{EXT} **we will consider 2 bytes** per transmission, which corresponds to a range of -32768°C to 32767°C.
   - The telemetry data from Fossasat-1, between 7 December 2019 and 26 January 2020, comprised of **16 samples from T_{BATT}** and **20 samples from T_{EXT}**.

3. Voltage readings

   For voltage readings, taking into account that we might have readings of over 255 mA, **we will consider 2 bytes** of information per reading, giving us a very safe range of 0 to 65535 mV (65.535 V).

4. Current readings

   The same deal as with the voltage readings, **we will consider 2 bytes** of information per reading for a range of 0 to 65535 mA (65.535 A).

Taking all of this into account, our final total number of bytes that are needed is:

4 (timestamp) + 2*2 (lat/long) + 2 (T_{EXT}) + 1 (T_{BATT}) + 2*2 (Volt) + 2*2 (Amp) =

= **19 bytes/complete transmission**

Now, taking into account the number of samples given to us by the Fossasat-1 data, we could look at it in 2 ways:

1. The 20 and 16 temperature samples, respectively, are being sent in the same "batches" of data, leaving us with 20 transmissions: 16 where both T_{BATT} and T_{EXT} are being transmitted and 4 where only T_{EXT} readings are being sent:

Because the final result will be pretty manageable, as we'll see, we will consider that all the other data is also being sent with each batch. So, the total size of data sent:

16 * 19 (complete transmissions) + 4 * (19 – 1) (no T_{BATT}) = 304 + 72 = **376 bytes**.

2. The temperature samples are sent in different batches, giving us 36 total batches, giving us a total calculation of:

20 * (19 – 1) (no T_{BATT}) + 16 * (19 – 2) (no T_{EXT}) = 360 + 272 = **632 bytes**.

The reason why I said that these values are manageable is because, basing my statement of the calculations done by the NanoSatLab team which are available on the wiki, during a pass, considering all possible variables, "the estimated maximum of downloaded data in a pass is **23,56 Kbytes**."

This means that, during a pass, both our 0.37 and 0.63 KB estimates would be easily transmitted and downloaded.