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2020 May 15

The Kepler Challenge

1. Troubleshooting at Bloop

The queries I would employ as Chief Troubleshooter must be understood in the framework of the three stages of processing that I would use. First, there is a queue of raw feedback in order of arrival. Next, this is labelled and is sent to the department that will resolve the issue and sorted by priority. Finally, once the feedback has been resolved, it is marked as such. Queries help select the ID for the next incoming feedback so that it can be added to the queue, pop feedback from the queue so that it can be labelled, and pop feedback from the priority heap so that it can be resolved. This process is illustrated in **Figure 1**.

The SQL code for the tables and queries is available at https://github.com/thedavidchu/2020_Kepler_Challenge as *bloop_feedback.sql*. Note that the code is designed to elucidate the process rather than actually keep track of a database.

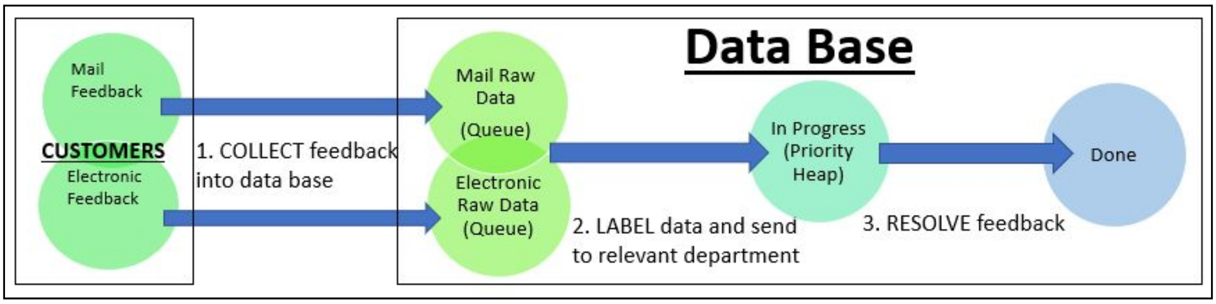

Figure 1. *The process involves queries to collect raw feedback, label it, and resolve it.*

Since 70% of the feedback forms are received in hardcopies, it would be wasteful to try to digitize all of these unless the process can be automated by a computer. Thus, we need to put all of the feedback in a queue and process both the electronic and paper feedback in the order in which they arrived. This means that we need to assign each piece of feedback an ID number in order of receival so that they can be processed, labelled, and then distributed to the relevant departments. This can be managed with a queue that pops the ID number and tells us which piece of raw feedback to process next.

2. Big Ol' Radioastronomical Imaging Station (Boris)

To determine if any of the passing satellites will interfere with Boris, we need to determine the magnitude, frequency, and polarization of their signal. First, the magnitude determines whether the satellite is emitting enough of a signal in the direction of the antenna to be detected. Second, if the satellite is not using the frequency we are trying to measure, then we simply apply a band-pass filter to remove the signal in which we are not interested. This cannot be done, however, if the satellites are using the same frequency that we are trying to measure. Finally, if the signal is polarized in a way that it can be filtered out from the signal that we wish to measure, then we can do this to reduce the noise.

Now, assuming at least one of the satellites can interfere with Boris's measurements, the level of interference can be calculated similarly to the link budget. In fact, these are the same, except for the fact that it is an unwanted signal that acts as noise.

The modern version of Friis's Law states that

$$P_R = P_T \cdot D_R \cdot D_T \cdot \left[\frac{\lambda}{4\pi d}\right]^2 \tag{1}$$

where P_R and P_T are the received and transmitted power; D_R and D_T are the receiver and transmitter directionality; λ is the wavelength; and d is the distance between the receiver and transmitter.

Given the ranges of values found in **Table 1**, we arrive at a lower bound of 9.9×10^{-18} W and an upper bound of 6.6×10^{-3} W of the noise generated by the satellite that is detected by Boris. Given that radio astronomers measures signal strength on the order of the units of a Jansky ($10^{-26} \frac{W}{m^2 Hz}$), we calculate that Boris (with a diameter of 100 m and collecting 30 GHz radio waves) is looking to measure signals on the order of 10^{-12} W[1] by dimensional analysis. This shows that strong satellite interference can be nine orders of magnitude stronger than the typical signals that Boris measures, while very weak satellite signals will be six orders of magnitude smaller than what Boris seeks to measure.

With more specific information about Boris, the satellite, and the strength of the radio signals from the Aries constellation, we could arrive at a more precise estimate of a power received and the level of interruption.

Table 1. *Typical ranges for the values in. These bound the interference by the satellite.*

Value	Typical Range
P_T [2]	20 W - 265 W
D_R [3]	10000 (high value of parabolic antenna's directionality)
D_T [3]	10 - 100 (low-to-intermediate values of parabolic antenna's directionality)
λ [4]	0.001 m - 10 m (range of radio waves used for radioastronomy)
d [5][6]	160 km - 35 800 km (low-Earth orbit to geostationary orbit)

3. Satellite Simulations

The code for the satellite simulations is available at https://github.com/thedavidchu/2020_Kepler_Challenge. It will prompt you to enter the TLE data of your chosen satellite line-by-line. Enter the TLE data in the format shown. The file *satellite_trajectory.py* will plot the satellite's orbit on the *World Map.png*. Note that you must have these two files in the same folder.

References

[1] https://events.asiaa.sinica.edu.tw/school/20160815/talk/sransom0818.pdf
[2] https://link.springer.com/article/10.1007/s00190-017-1082-2
[3] http://www.antenna-theory.com/basics/directivity.php
[4] https://www.britannica.com/science/radio-telescope
[5] https://www.universetoday.com/85322/what-is-low-earth-orbit/
[6] http://satellites.spacesim.org/english/function/communic/index.html