System Scalability

By Jennifer Brana

I can very quickly address the issue of scalability in the system: given the fact we are using the USB ports on the RPi to aggregate data, if we wanted to increase the number of sensors we would need to select from these solutions:

1. Purchase a USB extended that adds more ports. There is a variety of solutions on Amazon here: https://www.amazon.com/usb-extension-hub/s?k=usb+extension+hub. Tradeoffs that we would have to consider in this solution include:
2. Increase in power drawn from the single Raspberry Pi. There are fundamental limits to how much power can be drawn directly from an RPi. If this is in the scope of our project, we will need to bring in an expect in power engineering who can perform power analysis tests to determine the power limits of an RPi and the power consumption of each individual device (including every sensor, arduino, etc). The amount of time to perform this type of analysis would like represent a semesters worth of work for an EE student.
3. Limited availability of power in Malawi. At the field station, power is severely limited according to the CE/ME team. Therefore, there exists a hard limit on the amount of power that can be drawn. The CE/ME team has stated there is a limit, however, they have neglected to provide concrete numbers on this and therefore they would have to provide these numbers to proceed with this solution.
4. Reliability of USB extenders is sketchy. This would likely require a surge protector solution. There would likely be crashes due to the extender itself. However, I cannot address this question as I have no background in power systems design.
5. Limited network transmission bandwidth. LoRa modules have a hard maximum on the number of bytes they can transmit per second. If we were to take the approach of using USB connectors, the network transmission bandwidth would eventually become a bottleneck for the system as it limits the amount of data that can be transmitted per second.
6. Limited compute throughput on Raspberry Pi. We are currently using Raspberry Pi Model 3B. These have Quad Core 1.2GHz Broadcom BCM2837 64bit CPU's. These use ARM Cortex-A53 processor cores which have an 8-stage dual issue instruction pipeline and execute in-order. That is fancy words for the RPi's can process a maximum of 8 threads of execution at a time, however given the fact it is an in-order issue and execute pipeline, this really means a RPi can execute 4 threads of execution at a time. This means if we are streaming in continuous data, we will only be able to stream data in from 4 sources. This puts another hard limit on how many sensors can be attached to the RPi and processed at a time.
7. If compute throughput is the limiting factor, an alternative solution would be to take a hierarchical approach which would require the install more Raspberry Pi's. This would look like the image below.
8. Issues in this approach: there are no Raspberry Pi's for sale anywhere in the world.
9. If LoRa bandwidth is the limiting factor, an alternative would be to create a more "classical" distributed network of Raspberry Pi's. This would require replicating the entire system by creating copies of all of the following: field station RPi, LoRa module connections, service station RPi.
   1. Issues in this approach: there are no Raspberry Pi's for sale anywhere in the world.

I do not believe the team has the 1. time, 2. resources, or 3. necessary background to address the issue of scalability this semester and therefore will not be initiating any plans to address this issue.