Vortex
Part of Marston Holdings

Internet of Things Network for Forest Observatory

(Sabah, Malaysia Borneo Island Deployment)

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2 Background

Danau Girang Field Centre (DGFC) (http://www.dgfc.life/home/dgfc/) is located in Sabah, Malaysia. The only access to the field centre is through the river. Similarly, all the research activities are conducted by going through the river. It is worth noting that Sabah, Malaysia is a high humidity region where electronic components could get damaged quite quickly due to environmental factors such as moisture. Further, in jungle terrains, insects could also get attracted to copper within electronic components and damage the equipment.

The primary objective of this project was to develop a better understanding of how to design and deploy a sustainable Internet of Things (IoT) network in a remote jungle environment with harsh conditions.

By undertaking this project funded by Cardiff University and the Engineering and Physical Sciences Research Council (EPSRC), it allows us to understand what type of IoT network would ideally be suited to establish a forest observatory to enable sensor data collection and wireless communication. More specifically, it allows us to gain a better understanding of the type of potential network design and topology, costs, energy requirements, and other constraining factors that may need to be considered when deploying an IoT network in a tropical dense jungle environment.

3 Technology Selection

For this project, a Vortex IoT sensor network was trialed - It is a standalone Wireless Mesh Network that has been proven in large scale deployment in the UK.

3.1 Vortex IoT

Vortex IoT specializes in environmental sensors, networks, and data solutions to support decarbonization efforts. Through real-time data and predictive analytics, we generate industry leading intelligence to help customers make smart decisions and innovations. Vortex has the largest IoT network in Europe, mentioned by Hammersmith and Fulham Council, with over 100 sensor networks deployed in London. Many other local authorities also have networks, as well as TATA steel manufacturing site in Port Talbot, which is considered a very harsh environment.

The VTX Air quality monitor provides accurate insights to support data-driven decisions and drive real environmental change. Our fit and forget technology provides accurate, street-level insights on air quality. The system is designed, manufactured, and assembled in-house and is cost effective. The Mesh network is self-healing, remotely managing system updates and calibrations.

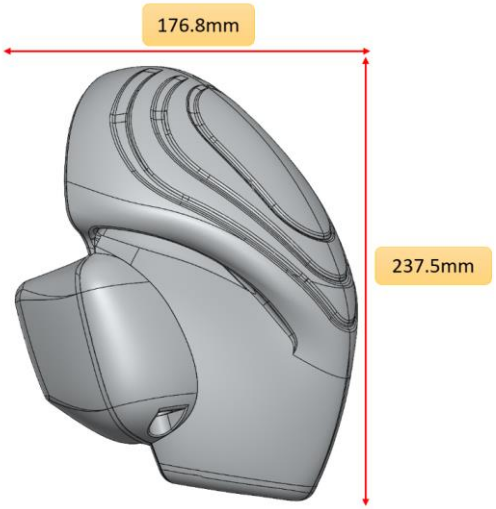
The product is ideal for use within local authorities who wish to obtain affordable, scalable, and reliable sensor networks as well as for industrial air quality monitoring for businesses who require emission data to stay compliant.

3.2 Vortex System

The system Vortex offered for this deployment consisted of 3 air quality monitoring sensors which require mains power, 3 routers with battery power for range extension, and a gateway device that requires mains power.

Vortex sensor hardware is built to operate within what is specified in the data sheets, and the conditions in Sabah Forest were much more demanding than those encountered in the UK. No guarantees were given on the performance or survivability in such extreme harsh conditions.

The Vortex system was first tested at Cardiff University and staff were trained on how to set it up. Then it was offered to the Cardiff university team to send to Malaysia, along with one of our Senior Engineering staff (BD), to set up and commission the network.



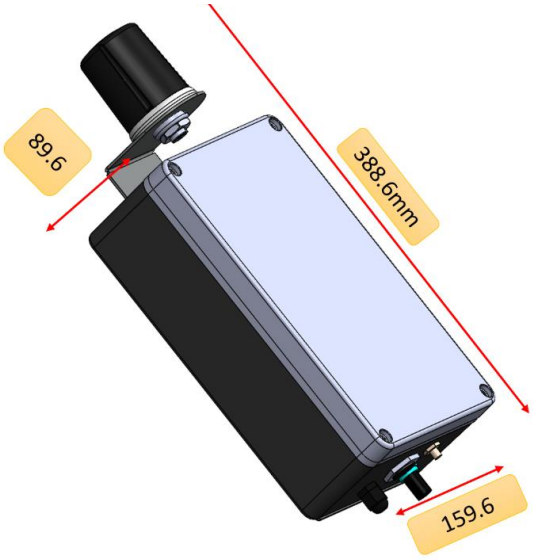
3.2.1 VTX Air Sensor Unit

- Dimensions: H: 240mm x W: 180mm x D: 210mm
- Mounting: Brackets for pole mount / wall mount
- Operating Temperature: -10°C to 60°C
- Operating Humidity: 0-100% RH
- Pollutants Measured: O_3, NO_2, $PM_{2.5}$, PM_{10}
- Main Power Input: 5V

3.2.2 VTX Air Router

- Dimensions: H: 170.5mm* x W: 108.1mm x D: 30mm
- Mounting: Brackets for pole mount / wall mount
- Operating Temperature: -10°C to 60°C
- Operating Humidity: 0-100% RH
- Main Power Input: 240V AC

*430mm with antenna



3.2.3 VTX Air Gateway

- Dimensions: H: 390mm x W: 160mm x D: 115mm
- Mounting: Brackets for pole mount / wall mount
- Operating Temperature: -10°C to 60°C
- Operating Humidity: 0-100% RH
- Transmission Power: Up to 17dBm
- Wireless Options: 4G LTE, WiFi (2.4 GHz)
- Main Power Input: 240V AC

4 Pilot Deployment

From 30-06-2022 to 10-07-2022, BD travelled to Malaysia to carry out the deployment. The client was Cardiff University; however the deployment site was maintained by Danau Girang Field Centre, which is heavily funded by Cardiff University. The Facility is in Kinabatangan.

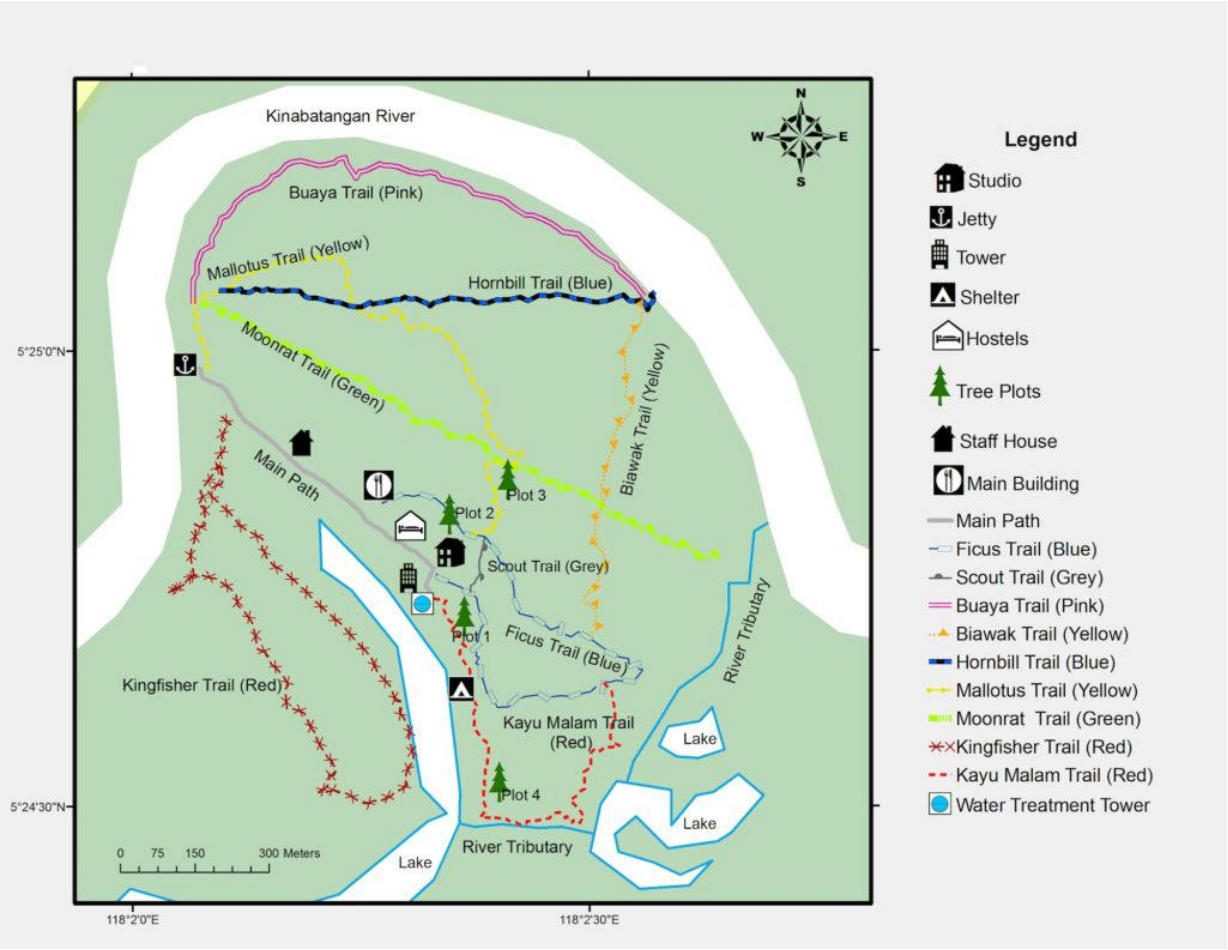


Figure 1. *A map showing the location of the deployment site.*

4.1 Installation Location 1 – Main Building

The gateway was installed on the front of the Main Building on the right side of the main entrance (Figure 2, left). The sensor was installed on a pole with the router on the back of the same pole (Figure 2, right).

- Lat/Long: N 05.41382 / E 118.03771
- VTX-Air Sensor: SN-0265
- VTX-Air Gateway: SN-0524
- VTX-Air Router

Figure 2.1. *Photos of installation location 1, the main building with annotations to show locations for the sensor, router, and gateway. Figure 2.2 below shows a closeup of the sensor and router, in the yellow dashed square.*

Figure 2.2. *A closeup of Figure 2.1 showing the sensor and router installed on a pole.*

4.2 Installation Location 2 – Dense Jungle

A router was installed in the jungle, approximately 62 m away from the main building. The router was approximately 7 m up a tree. Steel banding and nails were used to secure this to the tree (Figure 3, right) following the advice of the site workers who carried out the installation. The Battery Pack was installed at the bottom of the tree and tied down to make it monkey proof (Figure 3, left).

- Lat/Long: N 5°24'50.22 / E 118° 2'19.72
- VTX-Air Router: SN-0233

Figure 3. *Photographs showing the deployment of the battery pack (left) and the router (right) for deployment location 2.*

4.3 Installation Location 3 – Dense Jungle

A sensor with a router was installed in the jungle approximately 64 m away from deployment location 2 and approximately 122 m from the main building. The sensor and router were installed at heights of approximately 4 m and 7 m, respectively (Figure 4).

- Lat/Long: N 5°24'50.22 / E 118° 2'19.72
- VTX-Air Sensor SN-0261
- VTX-Air Router

Figure 4. *Photograph showing installation location 3.*

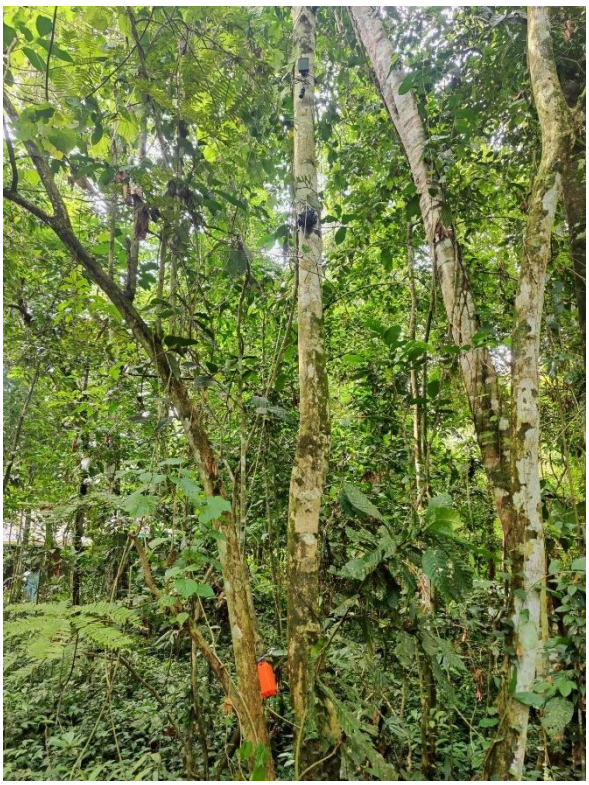


Figure 5. *Photograph showing installsation location 4.*

4.4 Installation Location 4 – Dense Jungle

A sensor was installed approximately 158 m from the main building. The sensor and router were installed at heights of approximately 4 m and 7 m, respectively. The battery pack was installed approximately 1.5 m up the tree and attached using metal banding (Figure 5).

Lat/Long: N 5°24'52.31 / E 118° 2'11.33

VTX-Air Sensor SN-0272

VTX-Air Router

5 Installation and Network Commissioning Challenges

5.1	Connectivity	The Vortex Gateway was offered with 3 types of internet connectivity as the set up in the base camp was not known prior to the deployment. There was an international SIM for connecting to cellular networks, WiFi and Ethernet port for wired LAN. However, the gateway was not able to connect to WiFi and the only option was 4G. The 4G Vortex International SIM did not have coverage, therefore a base camp site personnel had to procure a local SIM card with data bundle that would give coverage for the Sabah region.
5.2	No WiFi configuration Instructions	Due to the lack of 4G, BD attempted to connect the gateway to WiFi. Due to the lack of internet, BD had to walk 1km to google instructions and then test them back on site. This took a long time.
5.3	GTW Overheating	The daytime temperatures were very intense and could reach as high as 45ºC in direct sunlight. Since the metal enclosure was black it made the situation much worse. The gateway was moved into the shade and painted white to help with any sunlight that might reach the gateway during different times of the year.
5.4	Attaching the equipment	As no banding or instruction were provided on attaching the devices to trees a makeshift solution of using metal banding was used. A pull test was carried out on each device after installation.
5.5	No armored cable	To avoid the wildlife getting injured, a shield was installed over the main cable for the gateway to discourage any of the animals, in particular the monkeys, from biting though the cables and injuring themselves.

6 Tests and Findings

The entire network was able to connect. During mid-day, when the sun was the strongest and the humidity was the lowest, the gateway was able to see router SN-0233 and sensor SN-0261 and its router directly, from 12PM – 2PM. Installation of the routers higher up the trees helped to avoid the lower foliage.

It is recommended that a sensor is always deployed with a router that is approximately 7 m high, and no further than 100-125 m apart to ensure a stable connection.

Looking at Figure 6, we see an example of the data being produced and sent successfully to the network. Looking at Figure 7, we see an example of data being shown on the Vortex Dashboard.

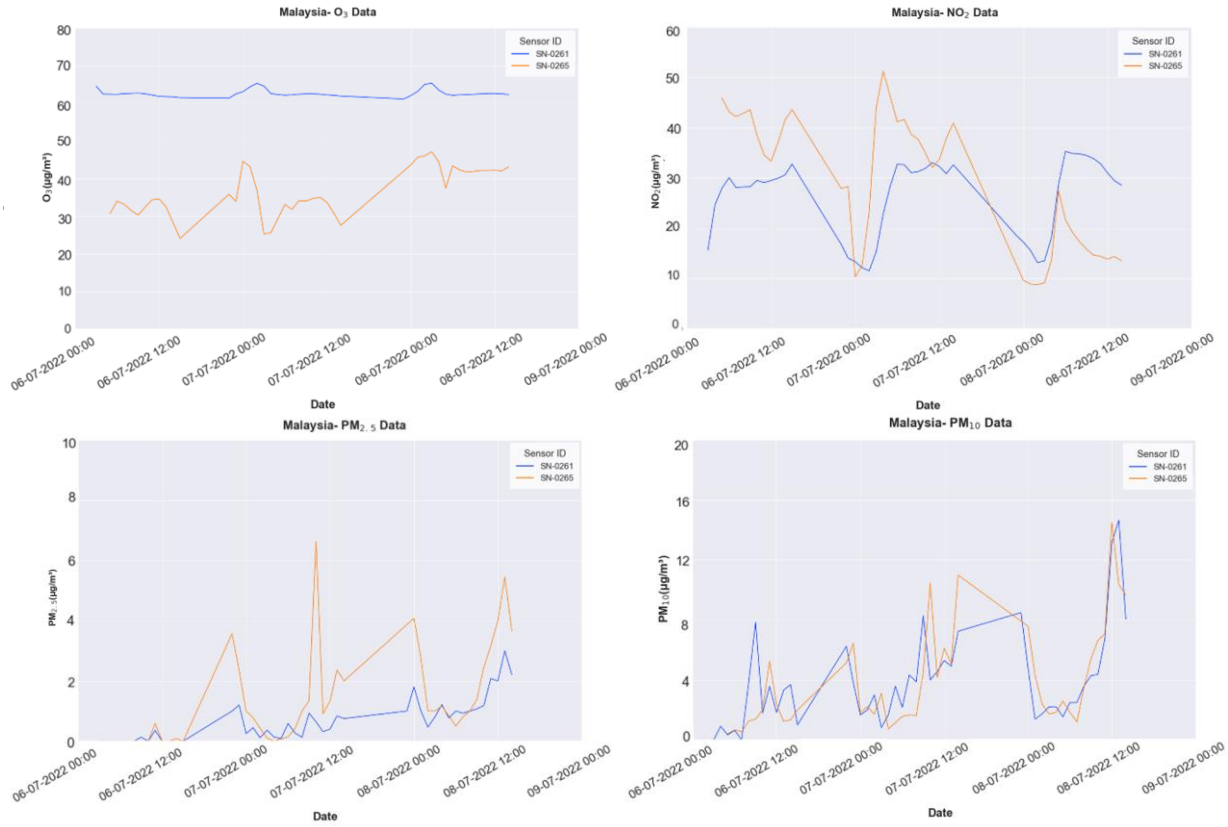


Figure 6. *Time series scatter plots for sensors SN-0261 (blue) and SN-0265 (orange) between 06-07-2022 and 09-07-2022 for NO_2 (top-left), O_3 (top-right), $PM_{2.5}$ (bottom-left) and PM_{10} (bottom-right).*

Figure 7. *A screenshot of the Vortex Dashboard, showing the Malaysia deployment.*

7 Other events

7.1 Elephant vandalism

After the equipment was installed, a herd of elephants walked through the site and ripped off the battery pack and power cable for sensor SN-0272. The sensor was broken and would require it to be returned for fixing.

8 Conclusion

In conclusion, this deployment has shown how to design and deploy a sustainable Internet of Things (IoT) network in a remote jungle environment with harsh conditions. Further studies could look deeper into how to extend the range of sensor network from the gateway and how it could be affected by the Mesh Network topology in such tropical environments. We have learnt that the harsh environment and terrain has a strong effect on the ease of the deployment and this work was first-of-its kind deployment for Vortex devices in a tropical jungle environment.