White Paper: Enhancing Weather Monitoring in Africa - The Role of NRENs and IoT Technologies

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The low-cost weather station solution in Africa

Low-cost weather stations based on IoT are useful in the African context because these stations offer an affordable and effective solution to the limited weather data access in many parts of Africa. Moreover, due to the continent's vulnerability to extreme weather events such as droughts and floods, having access to accurate and up-to-date weather data can be a crucial tool in managing the risks of these events and mitigating their impact on agricultural production, food security, and public health. Furthermore, by using low-cost weather stations based on IoT technologies, it is possible to collect and analyse real-time weather data that can be used for early warning and prediction, allowing communities to take proactive measures before the onset of extreme weather events. Low-cost IoT-based weather stations can also improve climate change research in Africa by providing valuable data for modelling and forecasting future climate trends.

Sustainability of existing weather station solutions

The sustainability of existing weather station solutions in many parts of Africa has been a concern due to their high cost and maintenance requirements. This has resulted in limited coverage and availability of weather data, particularly in rural areas where many smallholder farmers reside. In addition to their initial high cost, traditional weather stations can also be difficult to maintain and often require a recurring cost for communications (for example by using a GSM SIM card for each weather station and for any additional sensor). This poses a significant challenge for African economies where resource constraints are prevalent, and investments in costly weather stations are often difficult to justify. Low-cost weather stations based on IoT can address this issue by providing an affordable and sustainable solution that requires minimal maintenance and reduced recurring communication expenditures.

LoRa technology

The use of the Lora Technology brings great advantages to IOT-based low-cost meteorological stations: LoRa provides long-range, low-power communication abilities which can efficiently transmit data over long distances. This makes it possible to use fewer gateways for collecting real-time weather data from multiple stations, thereby reducing network communication costs. Additionally, LoRa-based weather stations do not require a SIM card or any other recurring communication costs. Additional sensors can be easily added over time, allowing for flexibility and customization based on the needs of different communities. In fact, the LoRaWAN infrastructure can also be used for other applications, for instance emergency communications, air quality assessment, poaching mitigation and so on. There are several commercial enterprises offering LoRa based communication services at different price levels, but thanks to the use of unlicensed bands, any organisation armed with the required knowledge can install its own LoRA infrastructure using readily available equipment from several manufacturers.

Data Transmission and LoRa Network

The LoRaWAN technology is increasingly being used for IoT systems and can be a suitable choice for building private or locally managed networks in an unlicensed band with long-range communication using low power devices. In order to ensure reliable data transmission in a LoRa-based weather monitoring system, it is crucial to consider factors such as the terrain profile between the Gateway and the sensors, signal strength, interference and power consumption. Although the LoRa Gateway must have Internet connectivity, either by GSM, satellite or any other technology, the sensor fitted end nodes can be sited even in places without GSM coverage, as long as they are within the coverage area of the LoRa Gateway. Additional LoRa gateways can be added if needed to improve the coverage area.

Implementation of IoT-based Weather Monitoring System

Implementing an IoT-based weather monitoring system requires the following components:

1. a LoRaWAN-enabled weather station, calibrated following the WMO standards
2. a LoRaWAN gateway to collect data from the weather station and from any other sensor
3. an MQTT broker where data coming from the gateway can be published and accessed by authorised subscribed clients
4. one or more MQTT clients that subscribe to the MQTT broker's data and can then store them in a database and/or graph for analysis.

Weather monitoring in Ghana

In Ghana, weather monitoring and forecasting is crucial for various sectors such as agriculture, energy, transportation and disaster management. However, the lack of reliable and accurate weather data has posed challenges for decision-making in these sectors. To address this challenge, a LoRa-based weather monitoring system could be implemented to collect and transmit real-time weather data for analysis and effective decision-making. Utilising LoRaWAN technology for weather monitoring in Ghana can offer many benefits, including low power consumption and wide-range connectivity, suitable for covering large areas. The lack of weather stations in the country makes the implementation of LoRa-based weather monitoring systems all the more important in providing reliable and accurate weather data for various sectors.

First steps have been taken in a recent collaboration between the Ghana Meteorological Agency (GMet), the West and Central African Research and Education Network(WACREN) and the International Centre for Theoretical Physics (ICTP).

The role of NRENs in scientific data collection

African National Research and Education Networks (NRENs) are vital in advancing scientific research by enabling seamless data collection, sharing, storage, and collaboration. As the volume of scientific data grows, the high-speed networking capabilities offered by NRENs become increasingly essential for efficient and effective data transfer. Within the realm of weather monitoring, NRENs have the potential to make a significant impact by facilitating the real-time collection and transmission of weather data from diverse LoRa-based weather monitoring systems. Leveraging their high-speed networking capabilities, NRENs can ensure the seamless flow of information from these systems, enabling accurate and timely weather forecasts.

To deepen NREN impact, WACREN is exploiting the AfricaConnect3 project to assume a pivotal role in promoting the adoption of Internet of Things (IoT) technologies, including LoRaWAN-based weather monitoring systems. By providing the necessary infrastructure and high-speed networking capabilities, WACREN and member NRENs will support the deployment of LoRaWAN gateways and weather stations in their respective countries. This effort will improve the precision of weather forecasts, which will aid decision-making in critical sectors such as agriculture, disaster management, and transportation.

Specifically, NRENs can make the following contributions to the future of weather monitoring:

- **Improve the accuracy of weather forecasts.** By collecting and transmitting weather data from a wider range of locations, NRENs help to improve the accuracy of weather forecasts. This is especially important in Africa where most regions are currently underserved by traditional weather monitoring systems.
- **Enable real-time weather monitoring**. NRENs enable real-time weather monitoring by providing the infrastructure to transmit weather data in real time. This can be used to warn of impending weather events, such as storms or floods.
- **Foster research and innovation**. NRENs foster research and innovation in weather monitoring by providing researchers with access to high-speed networking and data storage. This helps to accelerate the development of new weather monitoring technologies.

By extending their services and collaborating with national meteorological agencies and other stakeholders to deploy LoRaWAN gateways and weather stations, NRENs empower researchers and enhance the accuracy of weather forecasts, thereby making valuable contributions to various fields and promoting socioeconomic progress in the region.