

ABSTRACT

The integrity of cold chain logistics is critical to the security and reliability of transporting temperature sensitive products such as vaccine, medicines, and perishable food items. One of the biggest sources of product quality deterioration and financial losses in the global supply chain is the unmonitored temperature fluctuation during delivery. The aim of this paper is to design and test a complete prototype of cold chain monitoring system based on Narrowband Internet of Things (NB-IoT) technology. The system is the only one that combines high precision location tracking and real time environmental sensing with ultra-low power consumption and, thus, solves the main disadvantages of conventional monitoring techniques such as high energy consumption and weak signal penetration.

A high-sensitivity temperature and humidity sensor is used by the created system design to obtain complicated data, with an STM32 microcontroller acting as the main processing unit controlling these operations. The system uses a GPS antenna combined with an NB-IoT module (BC20) for good visibility of assets. An important technical difficulty handled in this study is the naturally high-power usage of conventional GPS devices. To reduce this, the research uses a power-saving transmission scheduled by synchronizing data transfer intervals throughout the NB-IoT network using the MQTT protocol. The strategy exploits the better signal penetration of NB-IoT to allow the system to operate successfully even in distant locations or inside sealed shipping containers.

Session were tested using physical prototype to evaluate performance. The technique involved systematic firmware development with embedded programming, precise PCB design for hardware integration and complete integration testing with UART communication. The first results of the development phase show effective and steady data collecting and transmission through NB-IoT network, which was thoroughly tested by using SSCOM serial connection program. Command settings and apply systematic data formatting to reduce transmission errors. Thereby ensuring operational stability, and to address the usual communication delays and signal limitations. The final result show that the prototype is a very reliable, scalable and cost-effective way for monitoring things in real time. This method reduces

product loss in shipping and maximizes energy utilization, allowing for extended independent, portable operation in practical use.

KEY WORDS: Cold Chain Logistics, NB-IoT, STM32, GPS Antenna, Temperature Monitoring, Power Consumption.