Poster Abstract: Hands-on Evaluation of Kinéis Satellite IoT Technology

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ABSTRACT

Satellite technology offers exciting new opportunities for IoT applications. This poster shows the performance one may expect using Kinéis – a leading operator – as a representative example. We use an implementation we provide as open-source for repeatability, and measure an end-to-end latency of 45 min, a battery lifetime of 1,000 packet when using a pair of AA batteries, and an end-to-end reliability of 23%/54%/99% when using 1/10/18 repetitions.

KEYWORDS

Satellite, IoT, hands-on evaluation, open-source, Kinéis.

1 INTRODUCTION

The Industrial IoT is the pinnacle of low-power wireless technology, with standardized solutions that offer wire-like reliability, a decade of battery lifetime and certified security [2]. Yet, today's local and cellular networks are not perfectly suited for deployments in remote areas with limited or no network infrastructure.

The "new space" trend is enabled by the development of affordable, durable and miniaturized Low Earth Orbit (LEO) satellites [1, 4]. The availability of Low Power Global Area Networks (LPGANs) wireless technologies enables devices on the ground to send their data directly to a satellite passing above [3].

Kinéis (https://www.kineis.com/en/), a startup company based in France, is one of the sensor-to-satellite leaders. They operate the popular historic ARGOS constellation (7 polar orbiting satellites launched between 1998 and 2019), and are preparing to launch a new 25-satellite constellation by May 2024. They offer a complete solution to end users, in particular the postage stamp-sized KIM1 module that can be soldered onto a board and that contains the radio to send data to the satellite.

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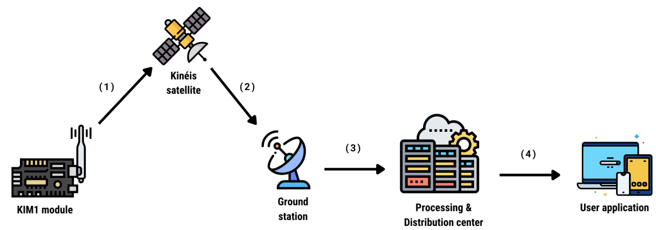

Figure 1: The "technology chain" of satellite IoT application, using the representative Kinéis terminology.

The contributions of this poster abstract are threefold:

- We provide a snapshot of the state-of-the-art in satellite connectivity, with the down-to-Earth angle of an end user;
- We develop and provide a full set of source code to drive the KIM1 module, published under an open-source license;
- We measure the key performance indicators of this technology: end-to-end reliability, end-to-end latency, battery lifetime.

2 SATELLITE FOR IOT

Fig. 1 depicts the "technology chain" in sensor-to-satellite solutions. While we describe it in the context of Kinéis's solution, all providers use the same general architecture. IoT devices are deployed somewhere on Earth. One big advantage of satellite connectivity is that it works even when the devices are in remote locations, such as deserts or in the middle of the ocean. A constellation of LEO satellites continuously orbit the Earth in about 128 min. In the general case, a device is in radio range of a satellite for 10-12 min. Since there are a limited number of satellites, the device needs to wait for one to pass overhead before transmitting. Once it has received a frame from a device, the satellite waits to pass above one of Kinéis's ground stations, and transfers the device's data to it. The ground station then forward the data to the company's processing and distribution center, which sends it to the end user using tradition Internet protocols such as MQTT.

Today, Kinéis operates seven LEO satellites. These form the well-known ARGOS constellation, used since 1978 for animal tracking and other environmental monitoring. The company will be launching a 25-satellite constellation in groups of five by May 2024.

Satellite technologies such as Kinéis enable a wide range of applications, including transport and logistics, network and infrastructure, smart agriculture, environmental monitoring, maritime activities, and smart water management.

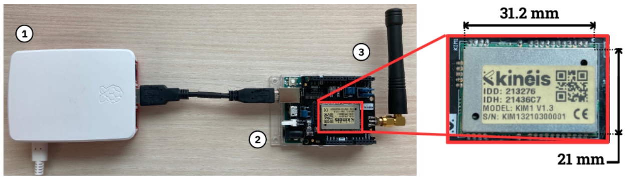

Figure 2: We use a Raspberry Pi and an Arduino to drive the KIM1 module.

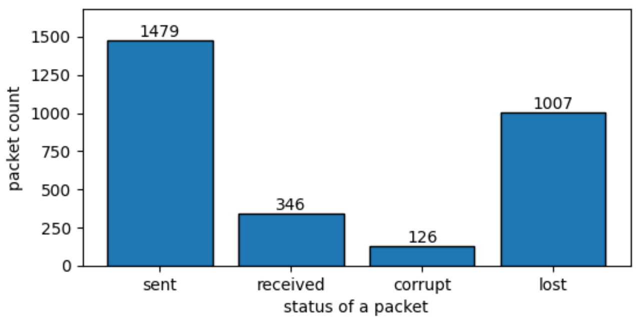

Figure 3: End-to-end reliability measured over one week.

3 OPEN-SOURCE IMPLEMENTATION

Fig. 2 shows the setup used. As an online addition to this paper, we publish all source code used under an open-source license at https://github.com/openwsn-berkeley/starwars, ensuring full replicability of our results. The setup is composed of three devices.

The KIM1 module *(3)* is the main element we are testing. It features a low-power radio and implements the ARGOS-2 physical layer and protocol. It is certified by the French Space Agency (CNES). On top of being able to send data to ARGOS/Kinéis polar satellites, it allow for GPS-free Doppler localization of the sending IoT device, with a localization accuracy of 150 m.

To simplify evaluation, Kinéis has integrated the KIM1 module in an Arduino shield that we connect to an Arduino board *(2)* On it, we implement the AT command-based interface of the KIM1.

The KIM1 doesn't know when a satellite is overhead; Kinéis provides C libraries to compute it. While one can use it on an embedded micro-controller, we chose to run our own Python library on a Raspberry Pi *(1)*.

4 EVALUATION SETUP AND RESULTS

We deploy the setup in Fig. 2 for a week, having the KIM1 send a 13 byte data frame every 90 s when a satellite is overhead.

Part of the payload we send is a sequence number, allowing us to measure the end to end reliability. As show in Fig. 3 the KIM1 module sent 1479 packets in total. 346 of these packets (23%) were successfully received by the user application. For this setup, we would need to retransmit the same packet 18 times to yield an end-to-end reliability above 99%.

The notification received from the Kinéis processing center contains several timestamps, allowing us to break down the end-to-end latency, as shown in Table 1. The largest contributions to the latency

waiting for a satellite to pass over	35 min
sending frame to satellite	5.103 s
satellite travels and sends to ground station	9 min 23 s
transfer from ground station to application	31 ms
total	**45 min**

Table 1: End-to-end latency of a representative packet.

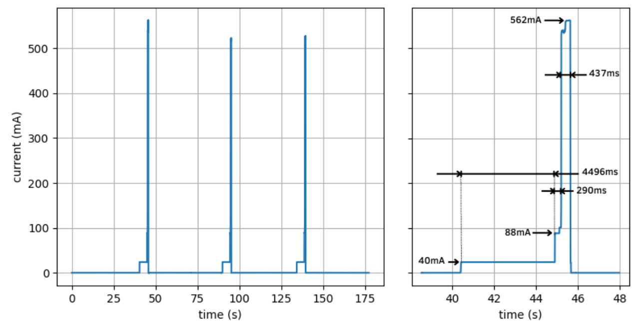

Figure 4: Current draw at 5 V of the KIM1 module when sending 3 frames (left). The right plot zooms onto one frame.

are the KIM1 module waiting for the satellite to pass overhead, and the satellite traveling to the ground station. We expect the end-to-end latency to linearly decrease with the number of satellites, which increases from 7 to 25 by May 2024.

Fig. 4 shows the current draw of the KIM1 module when sending multiple frames. One transmission draws a charge of $40 \cdot 4496 + 88 \cdot 290 + 562 \cdot 437 = 451\ \mu C$, or 2.25 J. Assuming a typical pair of AA batteries holding 2,500 J, powering the module allows for the transmission of approx. 1,000 packets.

5 DISCUSSION

Satellite IoT technology opens up new exciting opportunities. It is not meant to replace low-power wireless mesh technologies such as 6TiSCH in industrial applications (which require wire-like reliability), nor cellular technologies such as NB-IoT for smart city applications (which are readily available). Rather, it fills a technology gap for nodes deployed in remote areas without infrastructure. Ideal applications include pipeline monitoring, smart agriculture or wildfire detection. It is fantastic to see companies such as Kinéis providing ready-to-use solutions. The goal of this poster is to show the attendance the performance they can expect from such solutions, Kinéis being representative of other providers.

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