Emerging Trends in Mobile Communications

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1 Acoustic data transmission

> I tried to discover, in the rumor of forests and waves, words that other men could not hear, and I pricked up my ears to listen to the revelation of their harmony.
>
> Flaubert, (*November*)

1.1 Introduction

The rise of IoT devices in the home and workplace has created a world where data and connectivity are becoming increasingly complex. Lucero, (*IoT platforms: enabling the Internet of Things*) predicts a staggering 75 billion connected devices by 2025, up from 26 billion in 2019, as shown in Figure 1. As IoT technology advances and the demand for efficient ways of communicating data between these devices grows, the world has witnessed a rise in emerging new data transmission technologies which are looking to provide secure and effective solutions for sharing information. One solution rising to meet these new demands is data-over-sound.

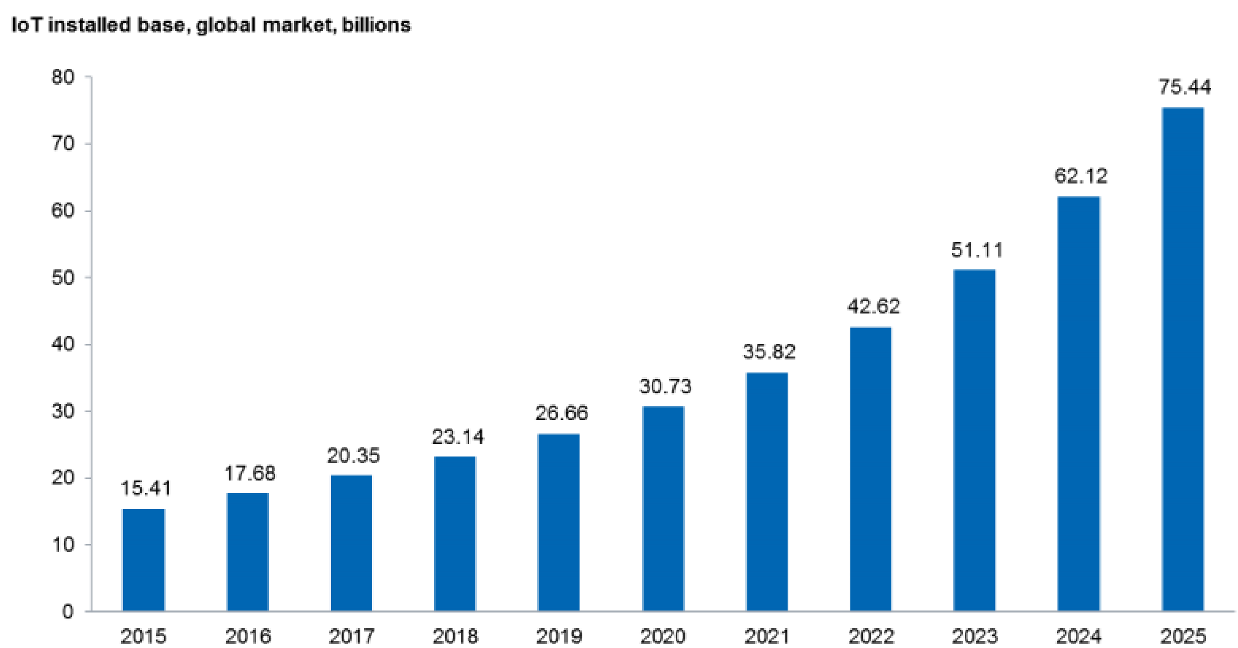

Figure 1: Number of IOT devices that will be installed worldwide from 2019 to 2025 (in billions).

Data-over-sound (DoS) presents a compelling solution for many device-to-device connectivity applications, particularly for use cases that require frictionless, low cost connectivity with nearby devices. DoS harnesses devices existing speakers and microphones to send and receive data over an acoustic channel. Because it doesnt require any additional networking hardware, DoS has captured the interest of companies interested in adding wireless connectivity functionality to existing devices. Some big names such as Google and Cisco already have point-product DoS integrations

There are a number of connectivity technologies available in the market today, including extremely short range (NFC and QR); short range, high bandwidth (Bluetooth and Wi-Fi). Each technology has its advantages which makes it more or less suitable for certain applications. An overview of these considerations are given in Table 1.

	DoS	QR	NFC	Bluetooth	Wi-Fi	Li-Fi
Two-way communication	1	0	0	1	1	1
One-to-many broadcast	1	0	0	0	0	1
Non line-of-sight communication	1	0	0	1	1	0
Zero pairing/set-up procedure	1	1	1	0	0	0
Low power operation	1	1	1	1	0	0
max data rate	1 kb/s	3 kb	424 kb/s	25 mb/s	70 mb/s	1 gb/s
max range	100m	10:1	20/cm	100/cm	50m	10m

Table 1: Feature comparison for DoS vs alternative technologies

1.2 Advantages of Data-over-Sound

According to Table 1 following advantages can be listed.

Device interoperability The simple hardware requirement of a speaker and/ or microphone make data-over-sound arguably the most wide-reaching wireless communication technology in terms of device compatibility. Mobile phones, voice controlled devices, and any device with an alarm speaker are able to communicate using data-over-sound. This includes many legacy devices. Data can also be transmitted over media channels such as radio and TV, and over existing telephone lines.

Frictionless UX Data-over-sound requires no pairing or configuration, making data transfer as simple as pressing a button.

Physically Bounded Because sound waves respect room boundaries, particularly in the near-ultrasonic range commonly used in data-over-sound, transmissions do not pass between neighbouring rooms. This means that it can be used for detecting the presence of a device with room-level granularity.

Zero power The advent of wake-on-sound MEMs microphones such as the Vesper VM1010 enables devices to communicate using data-over-sound, whilst draining virtually no battery power in between communications (< 10 A).

1.3 Applications of DoS

Based on these advantages, four key use cases for Chirp (a DoS implementation) are emerging, which are identified here.

IoT device provisioning Configuring a new smart device with network credentials and functional configuration remains a disproportionately complex task, particularly for headless devices. Chirp offers an approach to provisioning which is offline, locally-bounded, and does not require any infrastructure modifications. Credentials are encoded as audio, optionally layered with cryptography for secure scenarios, and broadcast over-the-air to nearby smart devices.

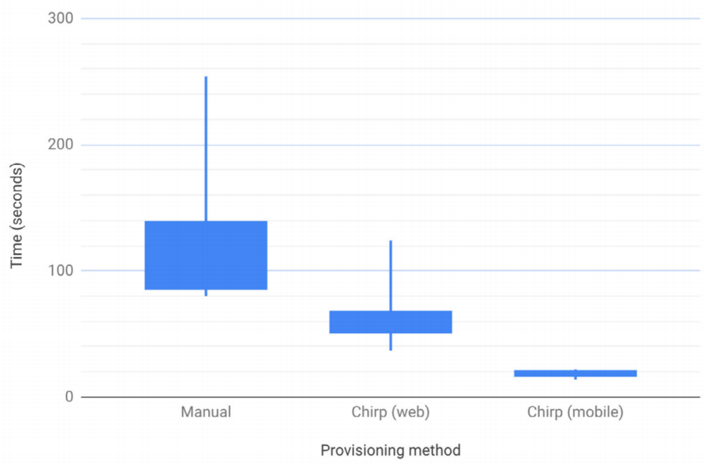

Figure 2: Time taken to provision a smart device.

Figure 2 shows the result of a study in which some experience of IoT were asked to provision a headless smart device using three methods:

A. Manually, by creating a temporary Wi-Fi hotspot on the device, connecting to the hotspot with a web browser, and entering credentials;

B. Using a Chirp-enabled web interface which asks the user to enter credentials and transmits them to the device via data-over-sound;

C. Using a Chirp-enabled mobile app which was able to use the devices existing knowledge of the credentials

The Chirp-enabled solutions reduced the provisioning time by 48% with the web-based scenario, and 86% with the mobile scenario.

Proximity Detection A key property of acoustic signals is that their propagation respects room boundaries, particularly in the near-ultrasonic range. As a consequence, there is a growing uptake for near-ultrasonic acoustic beacons for presence sensing at room-level granularity

Two way acoustic NFC Data-over-sound also supports near-field communication scenarios whilst offering a two-way full-duplex mode of communication, thus addressing a critical limitation of NFC. Enabling two-way data exchange means that devices can perform challenge-and-response dialogues - for example, Diffie-Hellman key exchange for secure financial transactions, or securely sending un-spoofable receipts to a merchant or buyer.

Telemetry in RF-restricted environments In many sensitive environments, RF-based communications are prohibited due to the risk of sparks or interference with equipment that pre-dates RF regulation. Chirp overcomes these limitations, allowing the industrial IoT to harness the benefits of wireless communication without limitation.

1.4 How it all works?

The basic idea of data-over-sound is no more complex than a traditional telephone modem. Data is encoded into an acoustic signal - either audibly as bleeps and tones inaudibly above human hearing range or hidden as imperceptible modifications of existing speech or music - which is then played through a medium (typically the air, although it could equally be a wired telephone line or VoIP stream), and received and demodulated by a listening device. The listening device then decodes the acoustic signal and returns the original data. This process is described in Figure 3.

As with other data transmission protocols, the entire message can include specific sequences to indicate the start and expected length of a message, as well as additional bytes for error detection and correction, as

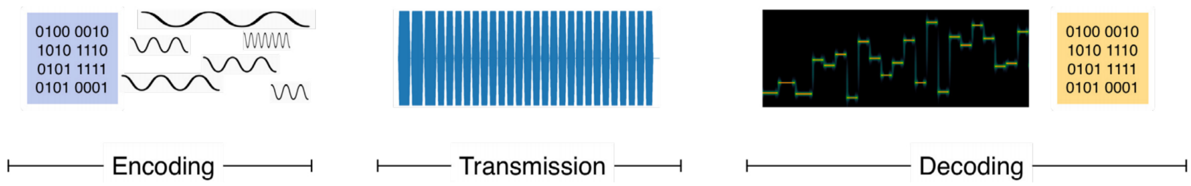

Figure 3: life-cycle of data-over-sound

shown in Figure 4. Messages are typically encoded using frequency-shift keying (FSK) modulation, which is robust to background noise and distortion from acoustic effects such as reverberation. Following extensive testing of a large range of consumer devices, Chirp considers the safe range to be between 1kHz-20kHz. This enables the production of audible messages, or near ultrasonic when limited to 17kHz-20kHz, which is imperceptible to most adult humans.

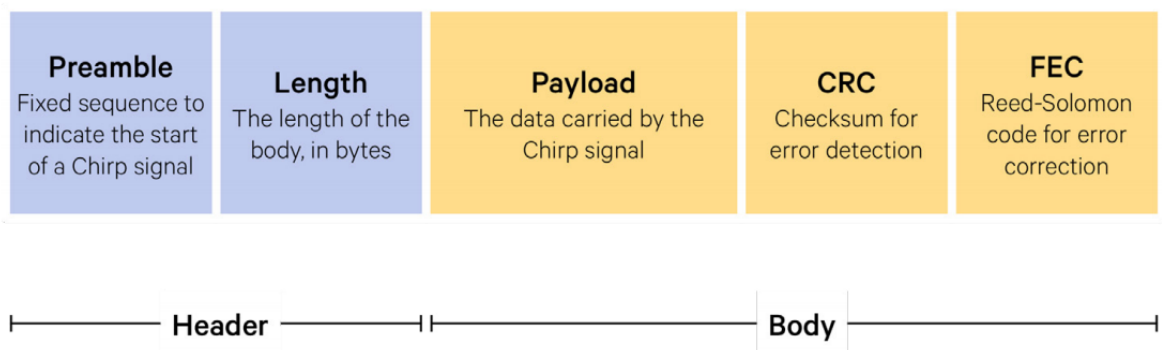

Figure 4: Makeup of the message

All of Chirps standard profiles are tested to perform at ¿99under normal operating conditions. Of the existing data-over-sound solutions on the market, the main differentiator for Chirp is this reliability and robustness of the internal decoding technology. This has been demonstrated and stress-tested in acoustically extreme environments, including nuclear power stations with upwards of 100dB(A) of background noise, across ranges exceeding 100m.

References

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2 test

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