Measuring How Much IoT Devices Upload via Traffic Analysis

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ABSTRACT

We examine the problem of whether Amazon is being honest with users in presenting the audio data it collects. Amazon Echo is Amazon's smart speaker that has an always-on microphone. It starts recording after hearing a certain wake word (Alexa, Echo, etc.) and then sends the recorded audio to its server for further processing. Amazon allows users to browse and delete all audio data sent to them. We suspect that the audio data made available to users might only be a subset of the audio collected and transmitted to the server, and our initial experiments suggest that this might be the case.

1 INTRODUCTION

Physical devices connected to the internet, also known as Internet-of-things (IoT), have gained popularity in recent years. Among numerous types of IoT devices, smart speakers with voice assistants, such as Amazon Echo and Google Home, are widely seen in users' home. These devices detect and respond to voice commands. They normally have always-on microphones, which theoretically start recording after hearing a wake word and then send the voice data to a server via internet for further processing [1].

This behavior has sparked many privacy concerns, including but not limited to what is being recorded, how the collected data is used and stored, and whether it is being protected well [4–6, 8, 9]. Much of previous work has been centered around protecting sensitive information from being leaked to adversaries [4–6]. As for what data is being collected, Amazon has made it possible for users to view, play and delete their voice data stored on its server [7]. However, our intuition is that Amazon may reveal to users only part of the voice data being collected by its smart speakers. Up until now, little has been done to verify whether Amazon is being honest with us or not—is Amazon making public exactly the audio data it collects?

Our preliminary experiments with Amazon Echo have found that the recorded part of the same command is not consistent across different trials. This stimulates us to question and examine the behavior of Amazon Echo and dig into what is exactly being collected by it. We plan to use network traffic measurement for our work, through which previous researchers have been able to infer users' activities [6], and establish network signatures for Amazon Echo [7]. If this approach does work, we will be able to answer a whole set of research questions with it.

2 BACKGROUND

Amazon Echo is a smart speaker developed by Amazon that is connected to the internet [3]. It has an always-on microphone that starts recording automatically after hearing certain wake word (Alexa, Echo, etc.). Voice commands following the wake word are streamed to Amazon's cloud-based intelligent command handling program, known as Alexa, for further processing. Alexa will then try to respond to users' commands. Amazon also keeps copies of the voice commands and responses, together known as response cards [7]. These response cards have been made available to users by Amazon so that they can be viewed, played, and deleted [2].

3 GOALS

We want to quantify how far beyond the bounds (start and end) of a particular command the smart speaker records and transmits to the cloud. We want to test how the ambient noise levels (e.g. music or conversation) surrounding the command affect the length of this extra recording.

We also want to know how the smart speaker decides when to stop recording and transmitting to the cloud. Finally, we want to know if recordings are being made and sent to the cloud without being reported to the user by the service provider (e.g. through an app or API).

3.1 Devices

Our main device for testing will be the Amazon Echo, as it is the most popular smart speaker.

If available, we would also like to test the Apple HomePod, as Apple places a much greater emphasis on security and privacy than its competitors.

4 METHODOLOGY

We will begin by measuring the baseline traffic from the smart speaker in a silent environment. This should allow us to identify the regular traffic patterns of the smart speaker when it is not transmitting voice data.

Once we have baseline traffic patterns we will begin more detailed measurements. We will test pre-recorded commands of varying lengths many times, to establish correlations between recording length and traffic speed and/or duration. We will then repeat these tests in the presence of several different forms of background noise, including at least podcasts, music, and discussion among ourselves.

To determine how the speaker decides to terminate its recording, we will use several different pathological commands. We will use incomplete commands, very long commands, and commands spoken very unclearly. By correlating the traffic patterns of these commands to the more normal commands previously measured, we hope to calculate the rough length of time the recording lasts.

We will obtain whatever information we can from the cloud (e.g. through an app or API) to compare such information to our traffic pattern analysis and determine whether they match within whatever margin of error we can achieve. We will also test the behavior of the speaker in noisy environments without any commands being given to determine the rate of false recordings.

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