Internet of Things for RF Noise Measurement

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Introduction

Since the mid-1970s, a systematic study of radio-frequency noise hasn't been conducted in the united states [1]. IoT, as an emerging and versatile technology, could be an interesting approach to help capture RF noise or RF pollution data to conduct these kinds of studies.

Problem

With the rise of mobile wireless network communications, one of the greatest interests is to study the impact of these electromagnetic emissions in the environment, our health and other technological systems. However, studying these impacts on a large scale has been difficult because there is very few data regarding RF noise [1]. Also, collecting this kind of data is usually a difficult task that requires expensive equipment, dedicated manpower and personnel with a certain level of expertise.

With the booming popularity of the *Maker movement* and (off course) the Internet, it's very easy to explore, prototype solutions to this kind of problem. This is why, we have chosen to use the *Internet of Things*, not only as a philosophy or framework, but as a tool fit for the future of computing, to propose a solution to the problem at hand.

Objectives

The main objective of this project is to propose an IoT solution to measure Radio Frequency (RF) Pollution, originating from Mobile Wireless Communications.

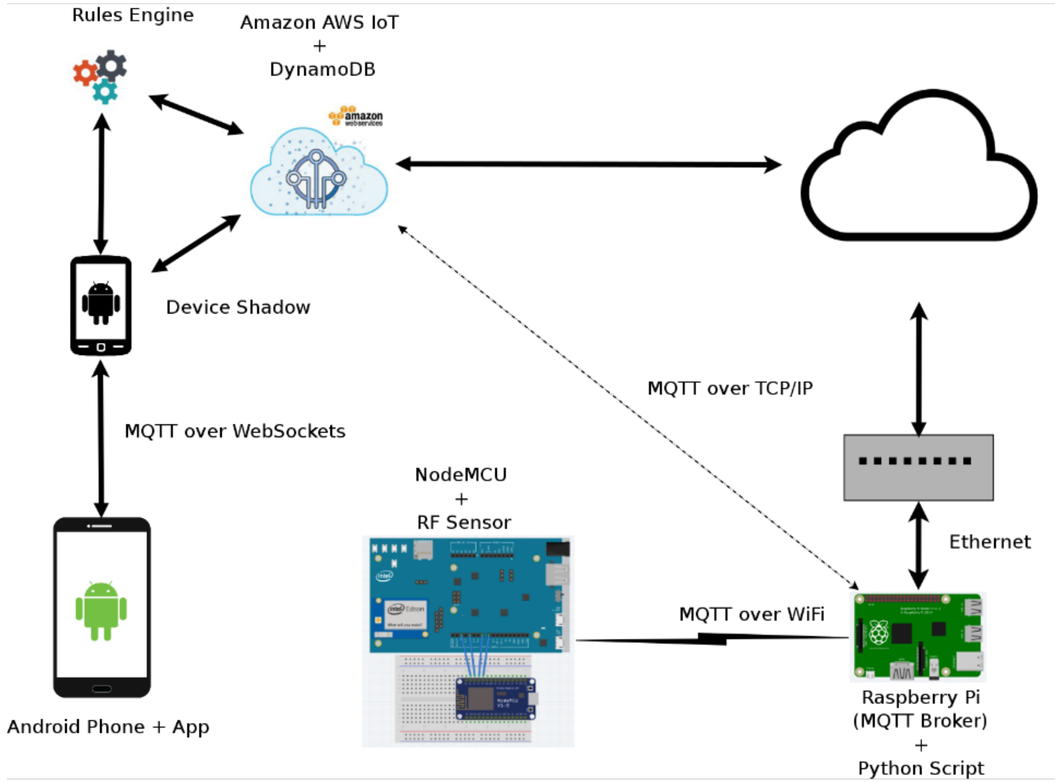
A wireless RF sensing circuit design will be proposed for implementation in each sensor node, however for the purpose of demonstration the sensor readings will be simulated.

The demonstrated system will be fully functional, meaning it will sense data (simulated), record it and store it. All of this in a distributed fashion, flowing from a sensor node, to a sensor hub and finally to a centralizing cloud data service. Also, the centralized data will be accessible by an mobile application, and the cloud service will be ale to push information to the mobile device if required.

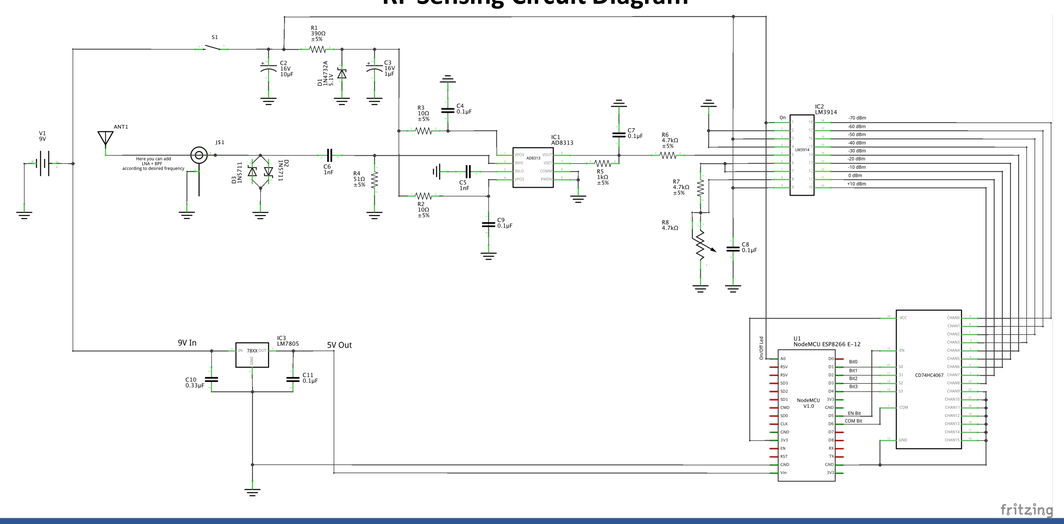
RF Sensing Circuit

The proposed RF sensing circuit design is based upon an RF power meter design by Iulian Rosu [2]. This particular circuit allows to measure any frequency (depending on signal amplification and filtering) with an intensity between -70dBm to 10dBm.
The RF readings are encoded using a multiplexor which interfaces with the sensor node's digital inputs, and are decoded via software before the node transmit the sensor data.

System Architecture



RF Sensing Circuit Diagram



Sensor Nodes and Hub

For the sensor nodes, a NodeMCU DevKit, that uses the ESP8266-E12 chip is used. Being an Arduino compatible WiFi-ready device, it's perfectly suited for this purpose due to its low power consumption, connectivity and price. A customized firmware was written and loaded into the node in order to capture the readings provided by the RF sensor. The node transmit the captured data wirelessly to its assigned hub, using the MQTT protocol over a WiFi network.

For the sensor hubs, a Raspberry Pi with WiFi capabilities is used, plugged into a wired Ethernet network that provides it with access to the cloud. It is configured to serve as a WiFi Access Point (AP) for the nodes, and it also runs *Mosquitto*, an Open-Source MQTT broker service. Additionally, each sensor hub runs a custom Python script, which forwards each piece of data received to a remote Cloud Service using the MQTT protocol over TCP/IP.

The programs used in the sensor node and hub are available as Open-Source projects in GitHub.

Cloud Service, Android App & SMS Alerts

For the cloud service to which the capture data will be sent and centralized in, Amazon's AWS IoT platform is used. This particular service allows us to make use of an extensible Rules Engine that can react to specific data measurements, and a Device Shadow that allows us to interface our rules and database(NoSQL, DynamoDB) with a mobile application by using device states.

An android application was developed to connect directly to the cloud service using MQTT over Secure WebSockets. When connected, the application polls the latest state from the device shadow every 5 seconds, which shows RF measurement readings in dBm (as captured by the sensor node) as well as error messages.

By using the AWS IoT platform, we are also able to notify users via SMS if RF measurements exceed a predefined threshold.

Results

IoT as a platform is a suitable tool for prototyping solutions to real-world existing problems, which then can be tested and implemented due to the availability of technologies, components, services and applications.

Sources

- [1]http://spectrum.ieee.org/telecom/wireless/electronic-noise-is-drowning-out-the-internet-of-things
- [2]http://www.qsl.net/va3iul/Homebrew_RF_Circuit_Design_Ideas/LED_RF_Power_meter.gif

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