WCN Project on Local Packet Detection in SDR Based IoT Gateways

Team 3

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I. Aim

The aim of this project is to get a systems level understanding of how wireless signals are detected in real-world wireless paradigms. This is achieved by implementing a local packet detection on a low cost SDR based IoT gateway platform.

II. Introduction

Software Defined Radios (SDRs) are devices that can be tuned to retrieve wireless signals from a particular frequency band; the idea of its invention aiming at shifting the processing paradigms of wireless signals to software rather than hardware. This provides SDRs the flexibility to retrieve any wireless signal arriving at a particular frequency, irrespective of its technology, modulation scheme, bandwidth etc.

SDRs can hence act as universal gateways operating across technologies. Past works have developed smart home gateways using the expensive USRP radio with GNU radio support to effectively decode the packets in 2.4GHz ISM bands. This implementation however failed to cope up with the latency requirements of Wi-Fi and incurred significant cost (thousands of dollars). In contrast, focusing on low-power IoT technologies that can be implemented on cheap programmable radios like RTL-SDRs provide cost based benefits with the additional advantage of scalability with the help of a cloud based backhaul.

An architecture with an inexpensive RTL-SDR, connected to a low-cost hardware board like Raspberry Pi, provided with an ethernet based cloud backhaul can hence work as a

cheap, universal IoT gateway. However, even for IoT technologies which transmit with a smaller bandwidth of the order of tens to hundreds of kilohertz, retrieving all bit streams without sample loss is highly challenging. While a naive receiver would simply upload all received bit streams to the cloud, this poses immense strain on backhaul bandwidth, which is often a commodity cable backhaul at most homes.

This can be resolved by implementing a local wireless packet detection in real-time at the Raspberry Pi. This implies that rather than transmitting the entire reception over cloud backhaul, the Pi performs a signal detection locally, identifying and transmitting only the actual signal over the ethernet backhaul in real-time.

Packet detection can be performed using two methods. One is a typical energy based detection where the entire signal stream is monitored against varying power levels. The points where the power is higher is considered to be signal while the rest is discarded as noise. The more efficient method which shows better noise resilience is correlation based approach. Here the entire signal is correlated with the preamble of the wireless packet to identify the signal position (Correlation is simply the sum of products of the signal with its preamble).

III. First Deliverables

Here, the students are expected to get familiar with the devices and understand the packet detection algorithms explained above.

A. Implementation

Implement a basic signal file retrieval over the RTL-SDR and send it to your laptop (the cloud) over the RPi ethernet interface. Implement a C-code that can perform energy-based detection on the file retrieved. Find the preamble of the transmitted signal and implement a correlation based detection in C.

B. Outcomes expected

Show the performance of the two algorithms across varying levels of transmit power from the transmitter device. Compare the efficiency of the detection algorithms in terms of error in detection.

IV. Second Deliverables

Next task is to implement energy detection based algorithm in real time.

A. Implementation

Local detection in the bit stream received by the RTL-SDR requires modifying the driver code to process it at buffer level rather than saving it as file. The modified code should be optimized to work in the RPi (Remember that RPi is a memory constrained device).

B. Outcomes expected

Show the efficiency of the energy based local detection in real time. This can be done with respect to demonstrating the sample loss while implementing the algorithm.

V. Third Deliverables

Next task is to implement correlation based algorithm in real time.

A. Implementation

Local detection in the bit stream based on correlation requires modifying the RTL-SDR driver code to do processing at buffer level like in the previous case. Remember that correlation by itself and students need to come up with some strategy that can ensure that correlation operation works in real time with minimal sample loss. As in the previous case this code should also be as optimized as possible to work in the RPi .

B. Outcomes expected

Show the efficiency of the correlation based local detection in real time. This can be done with respect to demonstrating the sample loss while implementing the correlation based algorithm. The performance of this should be compared with the previous energy based strategy in terms of samples lost.

VI. Marks Distribution

The project will be evaluated for 100 Marks, reduced to 40 Marks. Distribution of 40 Marks is as follows:

1) Weekly meeting & interactions: 4 Marks
2) First phase: 8 Marks
3) Second phase: 12 Marks
4) Third phase: 12 Marks
5) Final seminar and demo: 4 marks

VII. References

1) https://www.imore.com/how-get-started-using-raspberry-pi -for RPi setup
2) https://www.youtube.com/watch?v=1pr319FvOwI -for RTL-SDR setup on RPi
3) https://www.rtl-sdr.com/tag/command-line/ - for rtl-sdr commands
4) Nagaraj, Sumeeth, et al. "Differential preamble detection in packet-based wireless networks." IEEE Transactions on Wireless Communications 8.2 (2009): 599-607.