Low-cost ubiquitous spectrum sensing and characterization

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In the face of a wireless network capacity crunch, governments, industry and academia are exploring new techniques to deliver wireless communications through highly-efficient utilization of radio spectrum. A new paradigm called Dynamic Spectrum Access (DSA) brings hope for efficient reuse of underutilized radio bands. A key challenge in DSA networks is the need for accurate characterization of spectrum occupancy. Although the latter has been an active area of innovation a plethora of research questions still remain unanswered. *How much spectrum is really available in the wide range of 30MHz to 6GHz? What are the inherent properties of primary transmitters?* and *What is the potential benefit of DSA operation in these bands?*.

To answer these questions there is a need of a system for ubiquitous spectrum sensing and characterization across time, frequency and space. Existing such systems use mid- to high-end spectrum sensors, whose cost is prohibitive to large-scale deployments. As a result these systems provide a limited view on spectrum occupancy. Recent work by Nika et. al [1] explores the feasibility of low-cost spectrum sensors that use $20 RTL-SDR radios in combination with a smartphone or laptop for crowd-sourced spectrum monitoring. Other work by Zhang et. al [2] designs a system that makes use of utility vehicles equipped with high-end radio sensors to collect spectrum scans while periodically traversing a fixed trajectory.

Our work proposes a combined system design and spectrum scan analysis methodology that provides: (i) low-cost ubiquitous sensing and (ii) per-transmitter characterization of spectrum occupancy. Similar to Zhang et. al [2] we envision the use of a vehicular platform for spectrum scan collection. Each vehicle will be equipped with our custom sensor that will collect traces continuously as the vehicle traverses the city grid. These traces will be ultimately offloaded to a central server for storage and characterization. Our key contributions are twofold. We design and implement a wide-band spectrum scanner that costs $150-$400 and covers the full frequency range from 32MHz to 1.7GHz[1]. We also design novel techniques for characterization of spectrum occupancy from mobile spectrum measurements.

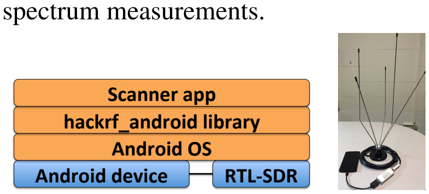

Figure 1: Sensor implementation. (a) hardware/software stack and (b) sensor.

Sensor design. Our sensor uses an RTL-SDR dongle with a wide-band multi-polarized antenna. It has a RTL2832U tuner with frequency range of 24-1766 MHz and sampling rate of 2.4 MHz. We experiment with two host Android devices: a tablet (Nexus 7 with 2GB RAM and 1.5GHz Qualcom Snapdragon S4) and a phone (Nexus 5 with 2GB RAM and 2.26GHz Qualcomm Snapdragon 800). We use Dennis Mantz's hackrf_android library[2] to create our scanner application, which will collect and store the traces.

Challenges. There are two immediate challenges that arise with our design. The first one is related to the feasibility of trace collection by our sensor. Of particular concern are power consumption and storage limitations that will determine whether we can perform continuous sensing. The second challenge is to understand the fidelity of traces collected by a low-cost mobile sensor as compared to their stationary counterparts. We are particularly interested in quantifying the extent to which dynamic (in time and frequency) transmitters can be characterized via intermittent measurements.

References

[1] A. Nika et. al. Towards commoditized real-time spectrum monitoring. HotWireless '14, Maui, Hawaii, USA, 2014.

[2] T. Zhang et. al. A vehicle-based measurement framework for enhancing whitespace spectrum databases. MobiCom '14, Maui, Hawaii, USA.

[1] Depending on the RTL-SDR radio this range can be up to 2.2GHz

[2] `github.com/demantz/hackrf_android`