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ABSTRACT

The popularity of cloud-assisted database-driven cognitive radio network (CRN) has increased significantly due to three main reasons; reduced sensing uncertainties (caused by the use of spectrum scanning and sensing techniques), FCC mandated use of a database for storing and utilizing idle channels, and leveraging cloud computing platform to process big data generated by wideband sensing and analyzing. In database-driven CRN, secondary users periodically query the database to find idle channels for opportunistic communications where secondary users use their geolocation (with the help of Global Positioning System - GPS) to find idle channels for given location and time. Use of GPS makes the overall CRN vulnerable where malicious users falsify their geolocations through GPS spoofing to find more channels. The other main drawback of GPS is estimation error while finding location of users and idle bands. Due to this there will be probability of misdetection and false alarm which will have its effect on overall performance and efficiency of the system. In this paper, the authors present a three-stage mechanism for detecting GPS spoofing attacks using angle of arrival, received signal strength and time of arrival. They also evaluate the probability of misdetection and probability of false alarm in this system while detecting location of secondary users. The authors evaluate the performance of the proposed approach using numerical results.

KEYWORDS
Cognitive Radio Networks, Dynamic Spectrum Access, False Alarm, Geolocation Database, GPS Spoofing, Misdetection, MUSIC, RSSI

1. INTRODUCTION

The static spectrum allocation policy was opted to decrease interference and improve the security for licensed users (Haykin, 2005) (Akyildiz, Lee, Vuran, & Mohanty, Sept. 2006). This method of allocation not only led to the underutilization of licensed bands, but also increased congestion in unlicensed bands (FCC Spectrum Policy Task, 2002). Cognitive radio is a smart radio technology that is capable of addressing these issues without harming the primary users (PUs). In cognitive radio, secondary users (SUs) can use the licensed bands in the absence of PUs and hop to the next available channel if the PUs reappear (Rawat, Song, & Shetty, Dynamic Spectrum Access for...
Wireless Networks, 2015). In order to utilize licensed bands effectively and to not interfere with PUs, the spectrum scanning and geolocation database are most widely used techniques to find the idle channels. Spectrum scanning is associated with some delay as the user has to scan the entire spectrum to find available channels (Akyildiz, Lo, & Balakrishnan, Cooperative spectrum sensing in cognitive radio networks: A survey, 2011). On the other hand, geolocation database can minimize delay and uncertainties as the idle channel information in the database is continuously being updated by sensors at various locations. Additionally, the FCC also necessitated the usage of geolocation databases for storing idle channels along with their locations for given time (Rawat, Shetty, & Raza, Geolocation-aware resource management in cloud computing-based cognitive radio networks, 2014).

Following the FCC mandated rules, SUs use GPS for reporting exact locations comprising of longitude and latitude coordinates to the geolocation database and get the available channels in that location. Allocation of suitable channels to SUs rely on the error-free location reported by the GPS. One of the major drawbacks of GPS is its vulnerability to various kinds of attacks (Jafarnia-Jahromi, Broumandan, Nielsen, & Lachapelle, 2012) (Tippenhauer, Pöpper, Rasmussen, & Capkun, 2011). Location falsification attacks on GPS are the prime focus in cognitive radio networks (CRN) as this attack will not only affect legitimate SUs but will also have its impact on the PUs.

The second drawback of using GPS is that the angle estimation is associated with some measurement errors (Radio, 2016). This measurement error can lead to a difference between the location reported to the database and the actual location, thereby, increasing the probability of misdetection and false alarm in the system. The probability of misdetection (PMD) and the probability of false alarm (PFA) are important in cognitive radio networks as the performance and efficiency of the system can be analyzed using these factors.

The main contributions of this paper are as follows:

- We present the location falsification attacks and three state detection approach for location falsification attacks using angle of arrival, time of arrival and received signal strength;
- We evaluate the proposed mechanism using numerical results obtained from simulation and experiments;
- We investigate probability of false alarm and probability of misdetection and evaluate the effect of these factors on dynamic spectrum access in CRN.

Recent works related to detection and mitigation of GPS spoofing were discussed in (Jafarnia-Jahromi, Broumandan, Nielsen, & Lachapelle, 2012) (Balabadrapatruni, 2012) (Dhope, 2010). Authors in (Jafarnia-Jahromi, Broumandan, Nielsen, & Lachapelle, 2012) have presented GPS spoofing mitigation techniques. In (Balabadrapatruni, 2012) (Dhope, 2010) different methods are presented that can be used for determining the angle of arrival in antenna arrays including MUSIC, Bartlett, and ESPIRIT. The probability of misdetection and probability of false alarm scenarios are significant in spectrum sensing. None of those approaches use three stage verification approach for detecting falsified location using angle of arrival, time of arrival and received signal strength which is the subject matter of this paper.

2. SYSTEM MODEL

Figure 1 represents the system model considered in this paper for cloud-assisted database-driven opportunistic spectrum access for SUs in CRN. The system model is inspired from storm model for dynamic spectrum access proposed in (Rawat, Shetty, & Raza, Secure Radio Resource Management
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