FLORIDA POLYTECHNIC UNIVERSITY

MASTER'S THESIS

Security, Control, and Visualization of a Cognitive Radio Mesh Network

Author:
John MCCORMACK

Supervisor:
Dr. Ryan INTEGLIA

A thesis submitted in fulfillment of the requirements for the degree of Masters of Engineering

in the

College of Engineering

January 24, 2016

Declaration of Authorship

I, John MCCORMACK, declare that this thesis titled, "Security, Control, and Visualization of a Cognitive Radio Mesh Network" and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

Signed:

Date:

"Thanks to my solid academic training, today I can write hundreds of words on virtually any topic without possessing a shred of information, which is how I got a good job in journalism."

Dave Barry

FLORIDA POLYTECHNIC UNIVERSITY

Abstract

Dr. Ryan Integlia
College of Engineering

Masters of Engineering

Security, Control, and Visualization of a Cognitive Radio Mesh Network

by John MCCORMACK

The system presented is that of a cognitive radio mesh network testbed. The testbed is made up of Ettus Research USRP Software Defined Radios. The mesh network is created using the batman-adv mesh network protocol. The system is capable of running tests on various cognitive radio functions including frequency hoping. Also presented is a visualization and control system implemented in Unity3D. This tool allows for unique visualization of the network in addition to providing means for human in the loop cyber physical systems. Finally, a novel security scheme is presented that serves as a first step towards cryptographic wireless transmission protocols over the cognitive radio mesh network.

Acknowledgements

I would like to thank Dr. Ryan Integlia for all of his support throughout this process. I would also like to acknolwedge Joseph Prine, Bradley Trowbrdige, and R. Cody Maden for all of their hardwork.

Contents

List of Figures

List of Tables

List of Abbreviations

LAH **L**ist **A**bbreviations **H**ere
WSF **W**hat (it) **S**tands **F**or

Physical Constants

Speed of Light $\quad c_0 = 2.997\,924\,58 \times 10^8\,\mathrm{m\,s^{-1}}$ (exact)

List of Symbols

a	distance	m
P	power	W ($\mathrm{J\,s^{-1}}$)
ω	angular frequency	rad

To my parents, Joe and Kathy McCormack for supporting me in all my endeavors.

Chapter 1

Introduction

1.1 SDN In Unity as a Mesh Network with Actuation and Feedback

1.2 Human Machine Interaction

1.3 Trends Towards Software Defined Environment

1.4 Encryption in SDR and Mesh Environments

Chapter 2

Literature Review

2.1 SDR Fundamentals

2.2 GNU Radio and MATLAB

2.2.1 GNU Radio

2.2.2 MATLAB

2.2.3 Hardware in the Loop Simulation

2.2.4 RFNoc

2.3 SDN Fundamentals

2.4 Network Concepts

2.4.1 What is a Networ

2.4.2 Mesh Network

2.4.3 WSNs

Origin in Dust Networks

Fog Computing

2.4.4 Mesh Extension into SDR

2.4.5 SDR Mesh Extension into AR/HMI

2.4.6 What is a network protocol

OSI Model

Common Protocols

Batman

OLSRD

2.5 Gaming Development Engines

2.5.1 Unity 3D

2.5.2 Unreal

2.5.3 Open Source Alternatives

2.6 Gamification and Serious Games

Chapter 3

Methodology

3.1 Design

3.1.1 SDR

3.1.2 SDR Network/SDN

3.1.3 Intelligence and Automatic Decision Making Components

Sensors

HMI

Network

Application: Security

3.1.4 Sensor Integration

Groups of Sensors

Imagers

Audio

LIDAR

3.1.5 Human Machine Interfaces

User Data

3.1.6 Augmented Reality

3.2 Fabrication and Build Process

3.2.1 SDR

3.2.2 SDR Networks and SDN

3.2.3 Intelligence

Sensors

HMI

Network

Application:Security

3.2.4 Sensor Integration

Groups of Sensors

Chapter 4

Findings

4.1 Results

4.2 Data Analysis

4.3 Hardware in the Loop Simulation

4.4 Assumptions

4.5 Discussion of Error

Chapter 5

Discussion

5.1 Constraints and Limitations

5.2 SDR/SDN In Unity

5.3 SDR/SDN Controllability and Feedback

5.4 SDR Network

5.5 Cognitive Networks

5.6 Software Defined Environment

5.7 Human Machine Interaction

5.8 Applications

5.8.1 SDR Network AR

5.8.2 Security

5.8.3 Gaming and Crowdsourcing

Chapter 6

Conclusion

6.1 Summary

6.2 Conclusion

6.3 Recommendation

6.4 Future Work

Appendix A

Appendix Title Here

Write your Appendix content here.