FLORIDA POLYTECHNIC UNIVERSITY

MASTER'S THESIS

ARCAM-NET: A Software Defined Radio Network Testbed

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- I have acknowledged all main sources of help.
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Abstract

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ARCAM-NET: A Software Defined Radio Network Testbed

by John MCCORMACK

ARCAM-Net is a Software Defined Radio Network (SDRN) testbed and platform. Nearly every component except the Software Defined Radios (SDRs) themselves are open source components. The goal of ARCAM-Net is to establish a low cost platform that can be quickly implemented by anyone interested in experimenting with SDRNs. This document presents the network itself and also acts as a manual for working with ARCAM's first implementation.

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List of Abbreviations

SDR	**S**oftware **D**efined **R**adio
SDRN	**S**oftware **D**efined **R**adio **N**etwork
CR	**C**ognitive **R**adio
CRN	**C**ognitive **R**adio **N**etwork
CRAHN	**C**ognitive **R**adio **A**d-**H**oc **N**etwork
BATMAN	**B**etter **A**pproach **T**o **Mobile** **A**d-hoc **N**etworking
ALFRED	**A**lmighty **L**ightweight **F**act **R**emote **E**xchange **D**aemon
GMSK	**G**aussian **M**inimum-**Shift** **K**eying
OFDM	**O**rthoganal **F**requency **D**ivision **M**ultiplexing
WAN	**W**ide **A**rea **N**etwork
LAN	**L**ocal **A**rea **N**etwork
ISP	**I**neternet **S**ervice **P**rovider
FCC OSI ISM	

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

Chapter 1

Introduction

1.1 Mesh Networks

In a traditional Wide Area Network (WAN), a user is able to connect to the internet through an Internet Service Provide (ISP). The user will almost always pay the ISP in exchange for the ability to connect to the rest of the internet. This is considered a centralized way to connect to the internet, where the users all connect through a few central points in the ISP's infrastructure. An alternative to this type of networking is multi-hop, ad-hoc, mesh networking. Mesh networks are decentralized networks. This means there is no single point of failure.

In an ad-hoc network, each radio is able to communicate directly to any other radio within its transmission range. There is no need to connect to a central router. Ad-hoc networks are defined at the physical layer (PHY), or layer 1 in the Open Systems Interconnect (OSI) model. Mesh routing takes place as part of layer 2 or 3 of the OSI model depending on the routing protocol chosen. A mesh network builds upon an adhoc network by allowing radios to retransmit any packets they receive. This allows two radios to communicate over a larger distance by leveraging other radios located inbetween the sender and receiver.

In simple mesh networking protocols, any packet sent may flood through the network to every other radio. However, with more advanced protocols an algorithm is used to ensure that a packet follows a direct path from sender and receiver and only uses a hop if necessary. The distributed nature of a mesh network creates many unique features. The decentralized nature of a mesh network prevents issues related to single points of failure. If a node goes down, the network can reconfigure and find a new path to the target.

1.2 Software Defined Radio Networks

Software Defined Radios (SDRs) are radio communication systems that utilize software to process radio frequency information in place of traditional hardware. A radio frequency frontend is able to capture and transmit signals, while the actual processing of the signal is taken care of by a digital system like general purpose processor on a traditional computer. This allows for a single piece of hardware to replace the need for multiple types of radios.

A typical cell phone can have a bluetooth, wifi, gps, and cellular radio all in a very small package. In the future, these systems could be replaced by a single SDR. SDRs are capable of using both digital and analog transmission protocols. They can use general purpose processors, digital signal processors, or FPGAs to process the RF information. Analog to Digital Converters (ADCs) are used to receive data from the antenna while Digital to Analog Converters (DACs) are used to transmit the processed signals.

As the name suggests, a Software Defined Radio Network (SDRN) is a network made up of SDRs. The networks can operate on a nearly infinite combination of center frequencies, amplitudes, bandwidths, and protocols. The flexibility of an SDRN is limited by the physical hardware capabilities of the SDR, the computation speed of the processing unit, and regulations from governing bodies like the Federal Communications Commission (FCC). Still, the flexibility of recofigurable radios leads to opportunities for advancing communications infrastructure beyond traditional protocols.

1.3 Trends Towards Cognitive Radio Environments

Cognitive Radio Networks (CRNs) are systems of SDRs that are capable of utilizing artifical intelligence and machine learning to dynamically alter transmission patterns in real time. These decisions can be made by a central server that oversees all nodes on the network, but modern systems strive to make each node capable of independent decisions.

Cognitive Radio Adhoc Networks (CRAHNS) combine software defined radios to form mesh networks. Cognitive features of the radios can allow them to change transmission parameters in accordance with link quality to ensure packets are routed properly in the mesh network. The CRs could make small changes, like increasing or decreasing their gains, in order to continue to transmit to moving nodes. They could also make larger changes, like switching entire protocols, to adapt to the needs of the network in near real time.

Beyond ensuring good throughput in a network, CRNs also solve a major issue facing the wireless world. Frequency spectrum is a finite resource, and the available bandwidth is being quickly used up. CRNs can utilize frequency hopping to share frequency resources with traditional wireless communication systems. A CRN can begin its operation on a specified band. If a traditional transmitter, usually called the primary user (PU), begins to operate on that frequency then the CRN will “hop” by switching to a different frequency and continuing operation.

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