PITT | SWANSON ENGINEERING
ELECTRICAL & COMPUTER

Senior Design Expo • Spring 2015

Wireless Networking using Software Defined Radio

Cody Houck and Nathan Hachten

Introduction

- Telecommunications is one of the fastest growing industries of today, requiring engineers to implement new standards more efficiently.
- Software defined radio is a technology that replaces traditional analog radio front-ends with programmable hardware controlled through a software interface.
- Modern service providers are moving towards software radio in order to keep up with the data needs of their customers while keeping sustainability at the forefront of their design.

Problem Statement

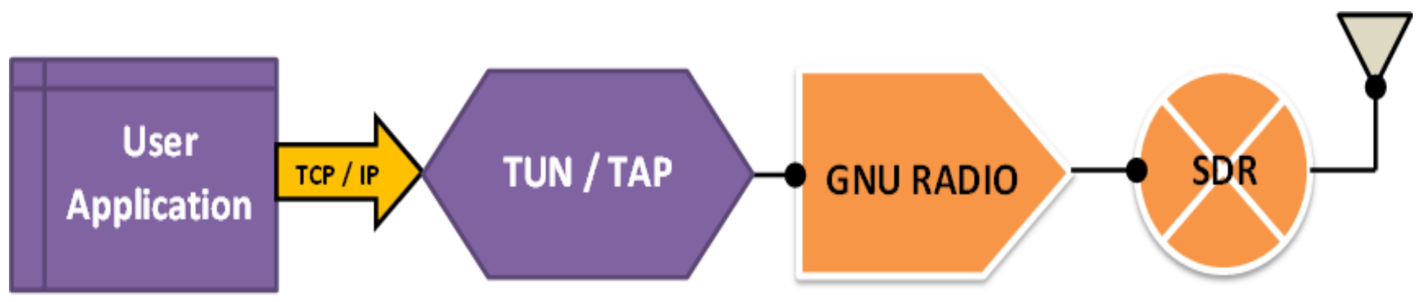
- Our product is a showcase of how software defined radio can be used to replace traditional networks that require specialized hardware for intercommunication.
- Operates at ~2 Mbps to provide speeds comparable to modern residential wireless systems when environment is stable; falls back to GMSK when it is poor.
- System can be used for basic networking needs such as wireless routing.

Design Approach

Physical/RF
- GNU Radio SDR Platform
- OFDM w/ QPSK with fallback to GMSK
- Reed-Solomon Forward-Error-Correction

Network
- TCP/IP
- Virtual networking through TUN/TAP

Figure 1 - Standard wireless router (left) and SDR (right)
Figure 2 - TUN/TAP as intermediary Data Link and Network layers



Experiments and Testing

- System was benchmarked by sending data in the form of packets across the channel at a set bit rate and measuring the uncorrected packet loss.
- The range was changed throughout the testing to see how distance, scattering, and gain affected the error rate.
- Ping response times measured and averaged.

Figure 3 - SDR connected to it's corresponding processing station

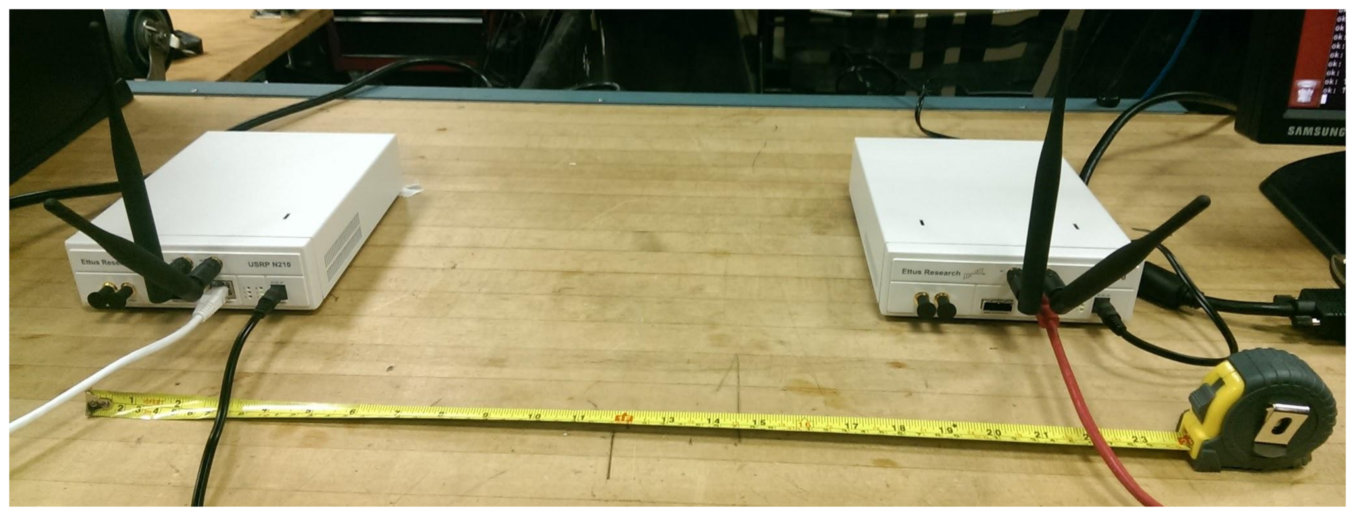


Figure 4 - Testbed for range and speed benchmarking

Results

OFDM		
Constellation Mapping	***Uncoded Packet Loss [%]***	***Ping Response Time [ms]***
BPSK	0.31	55
QPSK	11.37	64
16QAM	35.72	112
GMSK		
Modulation Index	***Uncoded Packet Loss***	***Ping Response Time***
1/2	0.00	42

- Ping response times less than 50 ms.
- ~10 dB improvement in packet loss when operating at 2 Mbps as opposed to 500 Kbps.
- Distance over 100 cm affects packet loss significantly.

Data Analysis

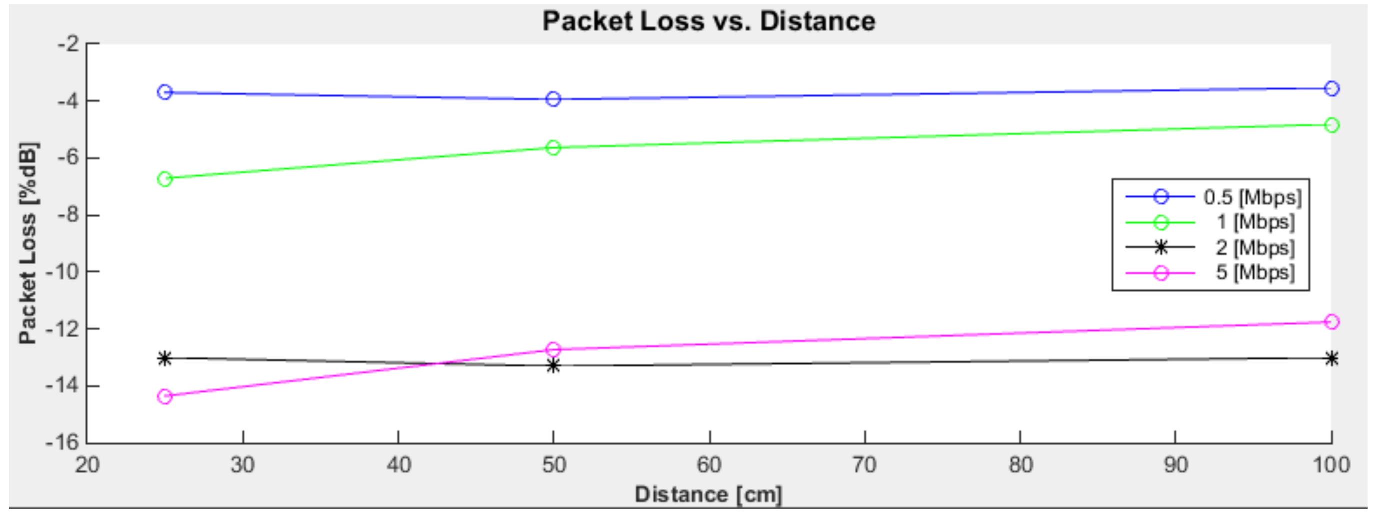


Figure 5 - Packet loss versus distance of tested bit rates

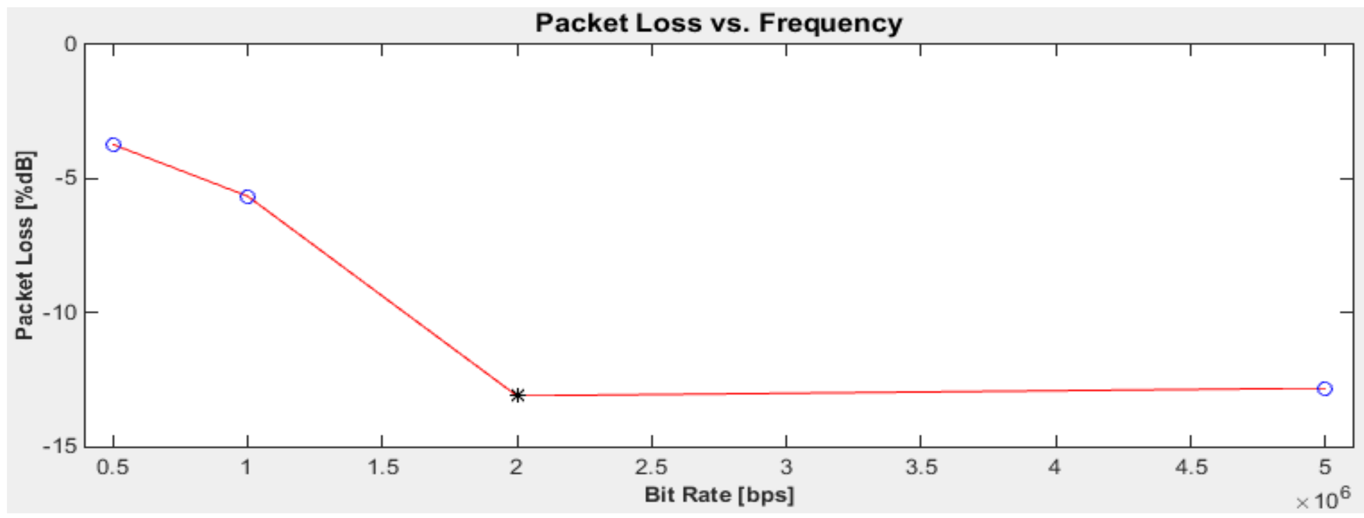


Figure 6 - Packet loss versus tested bit rates

Sustainability

Environmental
- Software defined radio can be dynamically changed without replacing hardware, thus producing less waste.

Social
- Mitigates user downtime as the network can be reconfigured without taking the system offline, improving customer safety and satisfaction.
- Can be reconfigured remotely, reducing the amount of time spent in the field providing maintenance.

Economic
- Allows for the same hardware to be used across all standards, removing the overlap of systems and eliminating the cost of having multiple hardware components.

Conclusions

- Code should adaptively control how the modulation is performed; should switch QAM levels before switching to GMSK.
- Multiple antennas (MIMO) would provide more diversity gain, improving the performance of the system.

Acknowledgements

We would like to say thank you to Dr. Steve Jacobs and Dr. Jack Lange for the advice throughout our project, Rich Colwell and James Doty for donating equipment and lab space, and also to our sponsors for donating the software defined radio equipment. We hope you enjoyed the project as much as we did!

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Introduction

- Telecommunications is a huge industry
- Software defined radio (SDR) has programmable hardware controlled with software
- Modern service providers are moving towards SDR in order to provide sustainable communication

Problem Statement

- IP addressable network connectivty using SDR for physical layer
- Implement wireless peer-to-peer network with SDR
- Operates at ~2 Mbps

Design Approach

Physical/RF

- GNU Radio SDR Platform
- OFDM w/ QPSK with fallback to GMSK
- Reed-Solomon Forward-Error-Correction

Figure 1 - Wireless router (left) and SDR (right)

Network

- TCP/IP
- TUN/TAP

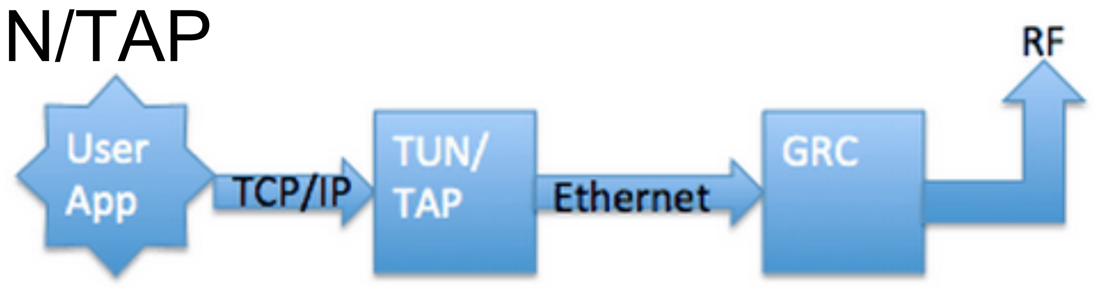

Figure 2 - TUN/TAP as intermediary Data Link and Network layers

Experiments and Testing

- Measure packet loss
- The range was varied to test how distance, scattering, and gain affected the error rate.
- Ping time

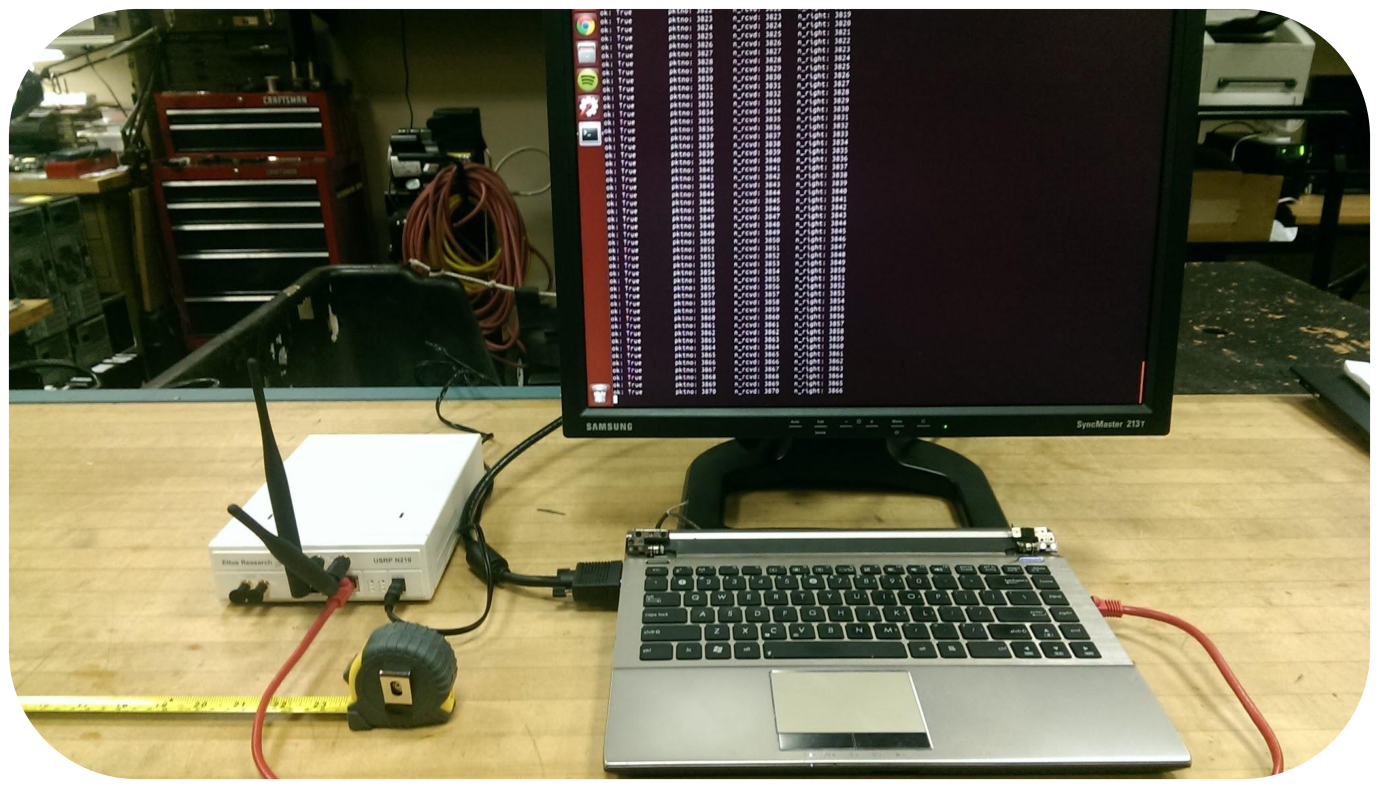

Figure 3 - Testbed for range and speed benchmarking

Results

- Ping response time of ~ 50ms
- ~10 dB improvement in packet loss when operating at 2 Mbps as opposed to 500 Kbps.
- Distance over 100 cm affects packet loss significantly when using constant TX/RX gain value of 10 dB.

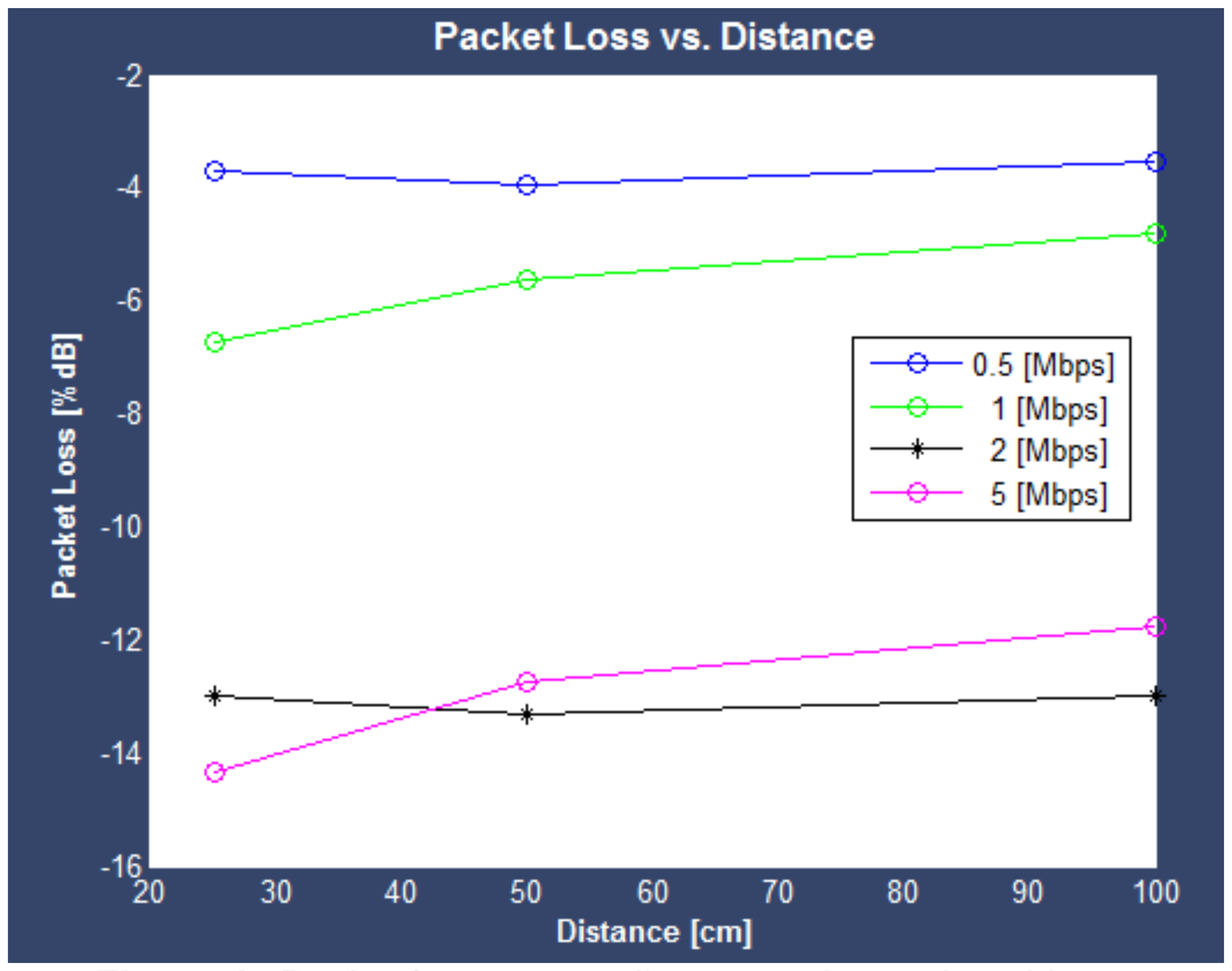

Figure 4 - Packet loss versus distance using various bit rates

Data Analysis

Sustainability

Environmental

- Fewer parts -> less waste

Social

- Software upgrade -> less dowtime -> better user experience

Economic

- Less hardware -> cheaper

Conclusions

- Code should adaptively control how the modulation is performed; this was outside the time frame of this project.
- Multiple antennas (MIMO) would provide more diversity gain, improving the performance of the system.
- Need a more powerful TX/RX to use higher-level QAM constellations (i.e. 16QAM).

Acknowledgements

We would like to say thank you to Dr. Steve Jacobs and Dr. Jack Lange for the advice throughout our project and taking the time out of their schedules to help us. We hope you enjoyed it as much as we did!