

scln


An Onion Router for Microcontrollers

Joseph Colosimo


6.858 Final Project

December 13, 2011


Testing a Cellphone

fig/cellmodel1.pdf

Testing a Cellphone

fig/cellmodel2.pdf


Testing a Cellphone

fig/cellmodel3.pdf

“Live” Testing


fig/chanmodel1.pdf

“Live” Testing

fig/chanmodel1.pdf


- ▶ Difficult to access data from radio towers

“Live” Testing

fig/chanmodel2.pdf


- ▶ Difficult to access data from radio towers

“Live” Testing

 `fig/chanmodel2.pdf`

- ▶ Difficult to access data from radio towers
- ▶ Cellphone may not be built yet

“Live” Testing

 `fig/chanmodel3.pdf`

- ▶ Difficult to access data from radio towers
- ▶ Cellphone may not be built yet

“Live” Testing

fig/chanmodel3.pdf


- ▶ Difficult to access data from radio towers
- ▶ Cellphone may not be built yet
- ▶ Hard to test specific environments

“Live” Testing

fig/chanmodel4.pdf


- ▶ Difficult to access data from radio towers
- ▶ Cellphone may not be built yet
- ▶ Hard to test specific environments

Simulation

sim1.pdf


- ▶ Accurate mathematical models exist
- ▶ No end-to-end capability testing

Simulation


fig/sim2.pdf

- ▶ Accurate mathematical models exist
- ▶ No end-to-end capability testing


The Tradeoff

tradeoff1.pdf


The Tradeoff

fig/tradeoff2.pdf


The Tradeoff — Best of Both Worlds?

fig/tradeoff3.pdf


The Tradeoff — Best of Both Worlds?

fig/tradeoff4.pdf

The Tradeoff — Best of Both Worlds?

fig/chanmodel4.pdf

The Tradeoff — Best of Both Worlds?


fig/chanmodel-chanem.pdf

Commercial Channel Emulators

- ▶ Highly accurate channel emulators are available for purchase


Commercial Channel Emulators

- ▶ Highly accurate channel emulators are available for purchase
- ▶ Designed for commercial networks

fig/planes1.pdf


Commercial Channel Emulators

- ▶ Highly accurate channel emulators are available for purchase
- ▶ Designed for commercial networks


fig/planes2.pdf

Commercial Channel Emulators


- ▶ Highly accurate channel emulators are available for purchase
- ▶ Designed for commercial networks
- ▶ Airborne networks use very different environmental models

 `fig/planes3.pdf`


Environment Flexibility

fig/modules1.pdf


Environment Flexibility

modules2.pdf

Environment Flexibility

modules3.pdf

Environment Flexibility


modules4.pdf

Preliminary Work

- ▶ Researched and chose a reasonable type of hardware to use for the project

Preliminary Work

- ▶ Researched and chose a reasonable type of hardware to use for the project
- ▶ FPGAs are capable of performing streaming math very fast

fig/fpgaboard.pdf

Preliminary Work

- ▶ Researched and chose a reasonable type of hardware to use for the project
- ▶ FPGAs are capable of performing streaming math very fast
- ▶ Need to convert analog waveform to digital, modify it, and then convert it back

`fig/fpgaboard.pdf`


Preliminary Work

- ▶ Researched and chose a reasonable type of hardware to use for the project
- ▶ FPGAs are capable of performing streaming math very fast
- ▶ Need to convert analog waveform to digital, modify it, and then convert it back
- ▶ High speed ADCs and DACs available as an addon board

`fig/fmcboard1.pdf`

Preliminary Work


- ▶ Researched and chose a reasonable type of hardware to use for the project
- ▶ FPGAs are capable of performing streaming math very fast
- ▶ Need to convert analog waveform to digital, modify it, and then convert it back
- ▶ High speed ADCs and DACs available as an addon board

fig/fmcboard2.pdf


Preliminary Work

- ▶ Researched and chose a reasonable type of hardware to use for the project
- ▶ FPGAs are capable of performing streaming math very fast
- ▶ Need to convert analog waveform to digital, modify it, and then convert it back
- ▶ High speed ADCs and DACs available as an add-on board
- ▶ Began work on interfacing the two boards

Architecture

 `fig/chanmodel-chanem.pdf`


Architecture

fig/arch1.pdf

Architecture

fig/arch2.pdf


Architecture

 fig/arch3.pdf

Pre-processing: interpret data from ADC, convert to common stream format, downconvert

Post-processing: upconvert, convert to DAC's format

Architecture

arch4.pdf

Emulation: emulate selected environment (operate on streaming format)

Implementation Plan

Timeframe	Tasks
Summer 2011	Purchased required hardware, created development environment, began work on interfacing FPGA with ADCs and DACs
January 2012	(4 weeks)
Week 3	Re-acquire hardware, continue interface work
Week 4	Create demonstration showing data traveling from one side of chanem to the other
Summer 2012	(10 weeks)
Week 4	Design and test digital upconverter, downconverter
Week 8	Design computer interface and associated documentation
Week 10	Create full demonstration showing conversion of signal
Fall 2012	(16 weeks)
	Devoted to research and implementation of proprietary emulation algorithms. Goal: 3-week research–implement–test cycles

Potential Pitfalls and Questions

- ▶ ADC/DAC troubles: lack of documentation, developer support

Potential Pitfalls and Questions

- ▶ ADC/DAC troubles: lack of documentation, developer support
⇒ Lincoln “gurus” — large network of FPGA specialists

Potential Pitfalls and Questions

- ▶ ADC/DAC troubles: lack of documentation, developer support
⇒ Lincoln “gurus” — large network of FPGA specialists
- ▶ Insufficiently powerful hardware

Potential Pitfalls and Questions

- ▶ ADC/DAC troubles: lack of documentation, developer support
⇒ Lincoln “gurus” — large network of FPGA specialists
- ▶ Insufficiently powerful hardware
⇒ More advanced in-house hardware available for use

Potential Pitfalls and Questions

- ▶ ADC/DAC troubles: lack of documentation, developer support
⇒ Lincoln “gurus” — large network of FPGA specialists
- ▶ Insufficiently powerful hardware
⇒ More advanced in-house hardware available for use
- ▶ Do mathematical models even exist?

Potential Pitfalls and Questions

- ▶ ADC/DAC troubles: lack of documentation, developer support
⇒ Lincoln “gurus” — large network of FPGA specialists
- ▶ Insufficiently powerful hardware
⇒ More advanced in-house hardware available for use
- ▶ Do mathematical models even exist?
⇒ Several phenomena have been documented; approximate models should be possible

chanem in Summary

- ▶ Channel emulation is an important way to test a network algorithm in real-time

chanem in Summary

- ▶ Channel emulation is an important way to test a network algorithm in real-time
- ▶ chanem specifically aims to focus on providing emulation for under-researched airborne network environments

chanem in Summary

- ▶ Channel emulation is an important way to test a network algorithm in real-time
- ▶ chanem specifically aims to focus on providing emulation for under-researched airborne network environments
- ▶ The proposed implementation provides a clear path for the implementation of chanem on hardware and the research and application of mathematical models for airborne environments.