It is still worth teaching digital communications to undergraduates.
The “Conventional” Digicomm Class

- Theory-only
- Smattering of topics, focusing mostly on aspects that lend themselves to elegant theory
- Students learn certain aspects really well but have big gaps in their understanding
- Today’s students want to build stuff, and that is totally reasonable
Digicomm Makes a Great Lab Course!

[I don’t mean a pure lab course with no theory: rather a course that blends theory and hands-on design.]

• Conveys the value of information theory over ad-hoc experimentation

• Very satisfying when your comm. system works.

• But labs require space, equipment, specialized expertise, etc.

  • So move to the cloud ...
CommCloud: Current Version
CommCloud: Current Version

- A Mac Mini with external USB audio hardware
- Send it a .wav file, and it plays the .wav file through passive filters and sends you a .wav back, consisting of what the receiver hears.
Last login: Tue Aug 15 13:54:28 on ttys008
erie ~ 1 > cd demo
erie ~/demo 2 > ls -l
total 1040
-rw-r--r-- 1 abw35 staff 529244 Aug 15 12:47 impulse.wav
erie ~/demo 3 > ccplay impulse.wav impulse_out.wav
WAV File OK
Connecting to server ...
received response.
File played on audio0 at 44100Hz, file recorded on UR22 at 44100Hz using 24 bits per sample, sleep1=0.500, sleep2=0.500. MD5:
907562793e45108e6657b294adf33c5f
impulse_out.wav saved
erie ~/demo 4 > ls -l
total 2328
-rw-r--r-- 1 abw35 staff 529244 Aug 15 12:47 impulse.wav
-rw-r--r-- 1 abw35 staff 655400 Aug 15 13:54 impulse_out.wav
erie ~/demo 5 >
Last login: Tue Aug 15 13:54:28 on ttys008
erie ~ 1 > cd demo
erie ~/demo 2 > ls -l
total 1040
-rw-r--r-- 1 abw35 staff 529244 Aug 15 12:47 impulse.wav
erie ~/demo 3 > ccplay impulse.wav impulse_out.wav
WAV File OK
Connecting to server ...
received response.
File played on audio0 at 44100Hz, file recorded on UR22 at 44100Hz
using 24 bits per sample, sleep1=0.500, sleep2=0.500. MD5: 907562793e45108e6657b294adf33c5f
impulse_out.wav saved
erie ~/demo 4 > ls -l
total 2328
-rw-r--r-- 1 abw35 staff 529244 Aug 15 12:47 impulse.wav
-rw-r--r-- 1 abw35 staff 655400 Aug 15 13:54 impulse_out.wav
erie ~/demo 5 >

Anyone can use the channel anywhere.
A Sample Transcript

Last login: Tue Aug 15 13:54:28 on ttys008
erie ~ 1 > cd demo
erie ~/demo 2 > ls -l
  total 1040
  -rw-r--r--  1 abw35  staff  529244 Aug 15 12:47 impulse.wav
erie ~/demo 3 > ccplay impulse.wav impulse_out.wav
WAV File OK
Connecting to server ...
received response.
File played on audio0 at 44100Hz, file recorded on UR22 at 44100Hz using 24 bits per sample, sleep1=0.500, sleep2=0.500. MD5: 907562793e45108e6657b294adf33c5f
impulse_out.wav saved
erie ~/demo 4 > ls -l
  total 2328
  -rw-r--r--  1 abw35  staff  529244 Aug 15 12:47 impulse.wav
  -rw-r--r--  1 abw35  staff  655400 Aug 15 13:54 impulse_out.wav
erie ~/demo 5 >

Minimal learning curve.
ccplay

erie ~/demo 5 > ccplay -h
          [--channel CHANNEL] [--rate RATE] [--depth DEPTH]
          wav_input wav_output

Apply remote analog channel to a given .wav file

positional arguments:
  wav_input             an input .wav file to be sent through the remote channel
  wav_output            the name of the file you would like the output .wav file to be saved as

optional arguments:
  -h, --help            show this help message and exit
  --version             show program's version number and exit
  --prepause PREPAUSE   a time (in seconds) to pause while recording before the file is played
  --postpause POSTPAUSE a time (in seconds) to pause while recording after the file is played
  --channel CHANNEL     a channel specifier; options are 'audio0' and 'audio1'; if none is specified then a channel with the shortest queue will be used
  --rate RATE           sampling rate, in Hz, at which to record the output .wav file; options are 8000, 44100, 96000, and 192000; if not specified, the sampling rate of the input .wav file is used
  --depth DEPTH         resolution, in bits-per-sample, at which to record the output .wav file; options are 8, 16, 24; if not specified, the depth of the input .wav file is used
Measured Impulse Response
Expanding CommCloud

• Possible Extensions
  • USRP radios in progress
  • Wireless between buildings
  • Underwater channels (MITRE)
  • User accounts
  • Web access

• Vision: Open-access tool for research & teaching at under-resourced institutions, hobbyists, etc., with a light learning curve.
Moving Forward

• We have found this useful at Cornell:
  • Students build OFDM systems for the CommCloud channel: requires contending with noise, ISI, channel uncertainty, frame synchronization, clock skew & quantization effects.

• Would others find this useful?
  • Should we advertise, commit to maintaining, make more user friendly (web interface)?

• If yes, would the BoG endorse & fund? (maybe as a “new initiative?”)