Introduction to Hardware Signal Injections

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Uses of Hardware Signal Injections

Complete end-to-end test of detector and analysis

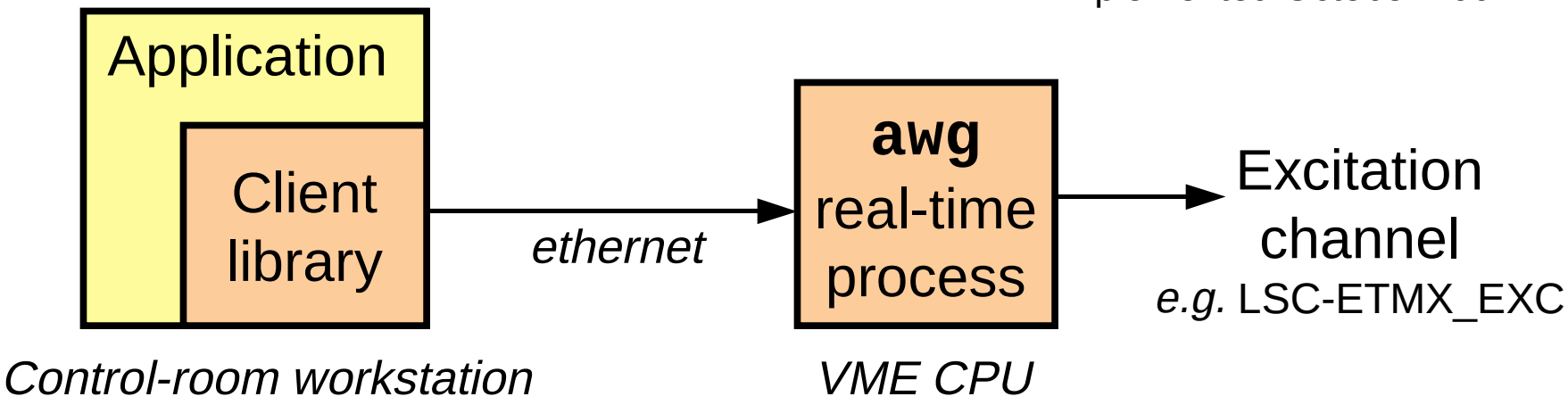
- Verify that detector does not distort signal in unexpected ways
- Verify that search algorithm can detect signals !
- Check that correct parameters are recovered
  - Checks both calibration and search algorithm

Study coupling of GW signal into auxiliary channels

- To evaluate “safety” of veto conditions

Signal Injection Architecture

Implemented October 2001



Application passes waveform data to client library

Also specifies starting time for injection

Client library sends data to awg in 1-second chunks

Several seconds of buffering

awg adds a data value to digital controller every 1/16384 sec

Synchronized with GPS clock

Client Library

a.k.a. "SIStr" library *(Signal Injection Stream)*

Simple application interface

- Open stream (specify channel and starting time)
- Append waveform data to stream
  - Pass any number of data values at a time
  - Make as many "append" calls as necessary
- Close stream (sends all data, then releases excitation channel)

Library handles buffering and data transmission timing

- Application just has to provide data as fast as it can
- Arbitrarily long waveforms can be sent

Limitations

Waveform data must account for transfer function of actuator

i.e. weight desired displacement by f^2

Can't inject arbitrarily large signals

Limited by dynamic range of actuator

Dewhitening affects available dynamic range as a function of frequency

Can't have two processes injecting into same excitation point

e.g. can't have calibration lines and simulated astrophysical waveform both going into LSC-ETMX_EXC

Client Programs

`awgstream`

Reads waveform data from an ASCII file

Can specify start time and an overall scale factor

`multiawgstream`

Injects a sequence of waveforms at specified times

Others could be written

Could calculate waveform on the fly

Injecting Multiple Waveforms: multiawgstream

- client software for injecting multiple waveforms in series
- uses SIStr library by P. Shawhan and D. Sigg
- user can run multiple multiawgstream clients to inject into multiple channels simultaneously (e.g., inject simultaneuosly into H1/H2:LSC-ETMX_EXC, H1/H2:LSC-ETMY_EXC)
- typing "multiawgstream" by itself will give usage

From a control room machine, type:

multiawgstream <channel> <rate> <configfile> <scale> <gpstime> [-q] [-d]

Need configuration file! Example:

```
# Hanford S2 burst configuration file for H1:LSC-ETMX_EXC
# Specify waveform data files and aliases

wffile   /mypath/wfsg100Q9.dat   wfsg100Q9
wffile   /mypath/wfsg235Q9.dat   wfsg235Q9
wffile   /mypath/wfsg361Q9.dat   wfsg361Q9
wffile   /mypath/wfsg554Q9.dat   wfsg554Q9
wffile   /mypath/wfsg850Q9.dat   wfsg850Q9

# Specify signal aliases, scale factors, and time offsets

wfsg100Q9       0.5353    21.0000
wfsg100Q9       1.5604    41.0000
wfsg235Q9       1.1372    61.0000
wfsg361Q9       3.3150    81.0000
wfsg554Q9       9.6635   101.0000
wfsg850Q9      28.1701   121.0000
wfsg850Q9      40.4747   141.0000
wfsg850Q9     100.5366   161.0000
```

Injections During S1

Correlated noise (for stochastic group)

- Two sets of files injected simultaneously into L1+H2, with a few amplitudes
- One set of files simultaneously injected into H1+H2 (one amplitude)

Inspiral chirps

- Into ETMX_EXC in some cases, DARM_CTRL_EXC in others
- Two inspiral waveforms, various amplitudes

Burst waveforms

- “Sine-Gaussians” (various frequencies) injected into L1+H2

Shortcomings (due to limited time)

- Calibration lines were not present at time of injections
- Limited number of waveforms were injected
- Injections were not done systematically into all interferometers

Injections Before S2

Tried to do things more systematically than for S1

- Time for injections was allocated as part of the run plan
- Try to cover all interferometers (but susceptible to locking problems)
- Keep calibration lines going during injections
  - Took a while to shake down how to do this
  - Most successful approach: leave calibration lines on ETMX, inject waveforms into ETMY

Correlated (stochastic) noise

- A few sets of files, a few amplitudes
- H1+H2 (no calibration lines)
- H1+L1 (calibration lines on ETMX, but with odd amplitudes)

Injections Before S2

Inspirals

- Several different waveforms, including some high-mass ones
- Injected into ETMX, ETMX–ETMY, ETMX+ETMY
- Some very loud into ETMX
- Had calibration lines on DARM

Bursts

- Sine-Gaussians at various frequencies
- Lots of different polarizations and amplitudes
- Some loud, though limited by dynamic range of actuation (at least at some frequencies)
- Had calibration lines on DARM_CTRL

Injections During S2

“Intra-run” injection sequence

- 18 inspirals + 24 bursts, injected into ETMY
- 30-minute sequence, done several times so far

Plan for a night of additional studies near end of S2 run

- Night of April 9-10
- Will need to set priorities and make plan in next ~2 weeks