LSC Astrophysical Source Identification and Signatures sub-group teleconference

Minutes taken by J. T. Whelan whelan@oates.utb.edu

2001 November 21 16:30-17:30 GMT

Participants

UWM  B. Allen, A. Wiseman, P. Brady, D. Brown, S. Koranda

UNC  C. Evans

PSU  J. Whelan (visiting from UTB)

Caltech  M. Vallisneri, A. Buonanno, Y. Chen, K. Thorne, P. Shawhan, S. Anderson, T. Creighton, A. Lazzarini

AEI  S. Berukov, A. Sintes, C. Cutler

Birmingham  A. Vecchio

Northwestern  V. Kalogera, P. Charlton

MIT  J. Sylvestre

1 Julien Sylvestre: Porting time-frequency cluster code [tfclusters] to the Condor (grid) environment

J. Sylvestre described a recent implementation of his tfclusters LAL package using the Condor distributed computing system. The motivation was to develop a flexible way to do numerical simulations that was easy and quick.
The calculations were to measure the false alarm and detection rates for the algorithm as a function of threshold, by analyzing simulated noise with and without injected signals. The criterion was to calculate the value of the 90% confidence limit to an accuracy of 1% (so width/rate$\sim$1%). This requires an amount of data such that (rate)$\times$(time)$\sim 10^5$, which for a rate of 1/hr means several years of data. So it was desirable to generate noise on the fly and thus save on file I/O.

The test was run by executables linked to the LAL library, invoked by a scheduler which estimates a rate based on the results, and submits new jobs to the Condor system if necessary. Coding up this implementation took a few hours. Fourteen years’ worth (3TB) of data was analyzed in a couple of days, using $\sim$200 hours of CPU time. A limiting factor was the overhead in submitting many short jobs; the ratio of overhead to CPU time was about 50 to 1. This can be submitting longer jobs. J. Sylvestre said that the length of a typical job was around 30 sec–30 min, and B. Allen observed that submitting jobs of about an hour in length was probably a good figure, and that this may be limited by Condor only accepting about 1GB of data at a time.

2 Curt Cutler: Validation of Barycenter Timing Code [LALBarycenter]

C. Cutler described a test of the LALBarycenter routine done by R. Dupuis which compared the results of the LAL routine with that of the TEMPO package for 300 points on the sky at intervals of 20 minutes over the course of 4 years. The residuals (shown in Figure 1) are $\lesssim 3–4$ $\mu$sec.

The test did reveal one bug: a declination of exactly $\pm 90^\circ$ causes a problem when the code takes the tangent of the declination angle.

The yearly modulation seen in Figure 1 is most likely because correction for the Einstein delay was taken out of the LAL code to speed its operation. This difference in the time delay is due to the varying gravitational redshift as the Earth moves through its elliptical orbit, primarily because of the varying distance from the sun, but also because of the distance from Jupiter and Saturn. Accounting for this effect would probably reduce the residuals from several $\mu$sec to around 1 $\mu$sec.

C. Cutler said “tiny cosmetic improvements” have been made to the code since R. Dupuis ran the test, and everything should be checked into the repository within around a week.

The tests are run by a script, so the whole thing can be re-run with each new check-in of the code, to make sure everything still works. C. Cutler said the test routines run by LAL “make check” are pretty trivial; they verify the error conditions and look at a few test cases.
Figure 1: A figure that Rejean Dupuis made, showing how LALBarycenter routine differs from TEMPO for a large range of times and sky positions for GEO 600. The comparison is for 312 points on the sky in 1998, 1999, 2000, and 2001. The positions are for declination of $\pm 89^\circ$, $\pm 75^\circ$, $\pm 60^\circ$, $\pm 45^\circ$, $\pm 30^\circ$, $\pm 15^\circ$, and $0^\circ$; and right ascension from 0 to 24 in steps of 2 hours.
with valid data. B. Allen pointed out that even a few dozen tests for different sky positions and times would likely be enough to catch errors in the code.

The range of dates for which the LAL routines will work is a function of the length of the ephemeris files included with LAL; C. Cutler proposes including 10 years for now.

B. Allen suggested that once this package is in a stable state, it might be a good idea to re-run the test script on other platforms and make sure the code is as accurate there as well. (TEMPO, which is written in an old version of FORTRAN, is fairly platform-dependent.)

3 Peter Shawhan: Two Items

3.1 Injecting astrophysical signals into LIGO hardware

P. Shawhan described the tools available for hardware signal injection, i.e., physically moving the mirrors at a site to mimic a gravitational wave signal which can then be looked for in the resulting data stream. This is done via the Global Diagnostic System (GDS) which can inject signals into several channels using the coil driver etc. This process had been limited by the memory and CPU power of the processor driving the GDS, but this has been solved with a system to divide prepared signals into one-second chunks, which are synced by GPS time. There is a command-line interface called `awgstream` which reads a series of data points from an ASCII file, allows the user to specify a channel, scaling, and start time, and produces the one-second data chunks, which can be fed into the GDS with a several-second buffer.

One subtlety in producing the input data is that `awgstream` doesn’t take into account the transfer function of the hardware component used to perform the signal injection, so this must be built into the input data. (A. Lazzarini wondered if this led to dynamic range problems, since producing mirror-shaking data amounted to reverse whitening of one’s inputs.) The data must also be sampled at the rate of the channel into which they’re to be injected.

P. Shawhan also noted that having this injection implemented via a library allowed signals to be calculated on the fly, and that the synchronization capabilities mean that signals can be injected in a coördinated way into multiple interferometers. This will probably not be tested in the E6 run this month, but may be in the E7 run in December. (It was pointed out that while it’s not essential to have an engineering run going on when this is tested, you’d like to at least know that the IFO was in lock.)

It’s planned to test hardware signal injection during the E6 run, perhaps only in one arm. The signal can be injected into one mirror, or into the differential arm control system, which would cause both mirrors to move. P. Shawhan was not sure if different channels could be excited simultaneously.

A. Wiseman asked if this is documented somewhere, and P. Shawhan replied not yet.
The code itself is not integrated into the LDAS software index; to find it, you need to know where it is. The best way to get started using it is to contact P. Shawhan or D. Sigg. P. Shawhan said he would be sending around more information on this.

3.2 Generating Simulated FRAME Data with LIGO Tools

P. Shawhan has added a new item to the LIGOtools FAQ: “How can I create a frame file with simulated data”. Briefly, the answer is that there are C Library functions as well as higher level tools in the form of the Fbe command-line interface and the mkframe Matlab library.

Fbe has been used by D. Brown and was also used to create simulated data for the burst-stochastic MDC. J. Whelan is sending P. Shawhan the information on TCL scripts which are in the burst-stochastic MDC repository.

A. Wiseman pointed out the connection between this item and number 1, that the barriers to large-scale testing of LIGO data analysis have been removed.

4 Alessandra Buonanno: Waveforms for binary black hole inspiral/merger and precessing binary inspiral

A. Buonanno reported on work that she, Y. Chen, and M. Vallisneri have been doing, along with D. Chernoff, on a scheme for producing robust waveforms for detecting binary back hole inspirals in the mass range 10–20 $M_\odot$, for which there should be 20-100 gravitational wave cycles in the LIGO band. The two problems to be dealt with are

1. Most of the gravitational wave signal seen by LIGO comes from the regime where post-Newtonian methods fail

2. As yet unmodelled spin effects will significantly affect the waveform

The goal is to provide a template basis optimized for detecting inspirals, which would not be suitable for parameter extraction.

The work is divided into two steps:

4.1 Without spin effects

There are three main families of post-Newtonian expansions: Taylor approximants, Padé approximants, and effective-one-body solutions. The last two show better convergence, but
this has only been checked in the test mass limit. One of these bases may be close to the true waveform, but not close enough to make a detection.

One strategy is to build an “effective basis” which includes all three families, and hopefully passes close to the real signal as well. The basis being considered is, in the frequency domain, a polynomial in $f$, whose coefficients are chosen to maximize the overlap with waveforms from each family.

Another strategy is to understand how the three methods differ from each other, as described by T. Damour, B. Iyer, and B. Sathyaprakash. The three types of waveforms can each be parametrized in terms of the reduced mass $\mu$ and total mass $M$ of the binary system by the mass ratio $\eta = \mu/M$ along with $\mu$. The physically meaningful parameter space has $0 \leq \eta \leq 1/4$; however, if the Padé approximants are extended into the unphysical region $\eta > 1/4$, they pass close to the Taylor and effective-one-body waveforms, so perhaps using Padé waveforms with a full range of $\eta$ values allows one to cover the full template space. The maximum overlap between Padé and other waveforms allowing this full range of $\eta$ values is much higher than the local maximum achieved by limiting $\eta$ to the physical range. Finally, A. Buonanno noted that since the innermost stable circular orbit was inside the LIGO band, the plunge part of the waveforms is important, and may be treated as an extension of the inspiral, which is done in the effective one body approach.

4.2 With spin

A. Buonanno mentioned two techniques to deal with the issue of spin: the adiabatic limit as described by G. Schäfer and the Hamiltonian method of T. Damour and G. Schäfer.

4.3 Discussion

B. Allen asked whether these template waveforms would also be suitable for setting upper limits. The problem is that one can basically only make statements about the existence of signals with a certain waveform, not about astrophysical systems. P. Brady said there would be a difficult task estimating the systematic bias involved. K. Thorne said that we really don’t know what happens at the end of the inspiral phase, so for the initial search we’ll have to “fish” for a signal using the best possible set of templates. C. Cutler asked how many templates were involved; the answer was about 3000 not including spin effects (for LIGO-I sensitivity).

K. Thorne asked when the expected delivery date was, A. Buonanno asked when they’d be needed by, and P. Brady said the sooner, the better.
5 Going over the LAL Bug reports

The group went over the open bug reports at http://www.lsc-group.phys.uwm.edu/lal/bugs.html, sorted by responsible party:

- A. Wiseman said he’d resolve the LALdoc problems by the next ASIS meeting
- J. Whelan explained that bugs belonging to S. Bose had been addressed during the latter’s recent visit to Brownsville; the citation bug had been fixed but not yet checked into the repository, while the handling of units would be temporarily fixed in an inflexible way while the more general way was implemented. The net effect is that the two bug reports will soon be replaced with a change request.
- D. Brown explained that his two non-analyzed bugs are still being worked on.
- P. Brady will get to his docbugs soon.
- C. Cutler and J. Sylvestre had already fixed their code, but not yet closed the bug reports.
- E. Daw is busy with other things, so his docbugs will likely be around for a while.
- B. Allen will talk to B. Sathyaprakash about his bugs later this week.
- B. Allen will look at his bug report to J. Whelan which is currently in “feedback” state.

A. Wiseman said that there will be no release of LAL to support E6, since the development is proceeding at too quick a pace, but the next version will be released in December to support E7.

6 Other Business

6.1 Next ASIS Meeting

Because the second Tuesday of next month (December 11) falls two days before the start of GWDAW, it was decided to hold the next telecon one week earlier, at 16:30 GMT on Tuesday, December 4.

6.2 New ASIS Secretary

B. Allen announced that J. Whelan is taking over as ASIS secretary as of this meeting.