Time-critical gravitational wave searches

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Overview

- Current model for distribution of the search – advantages and disadvantages
- Another model – idea of a low latency search
- Algorithm for load balancing the different jobs
- Current status
- Future developments

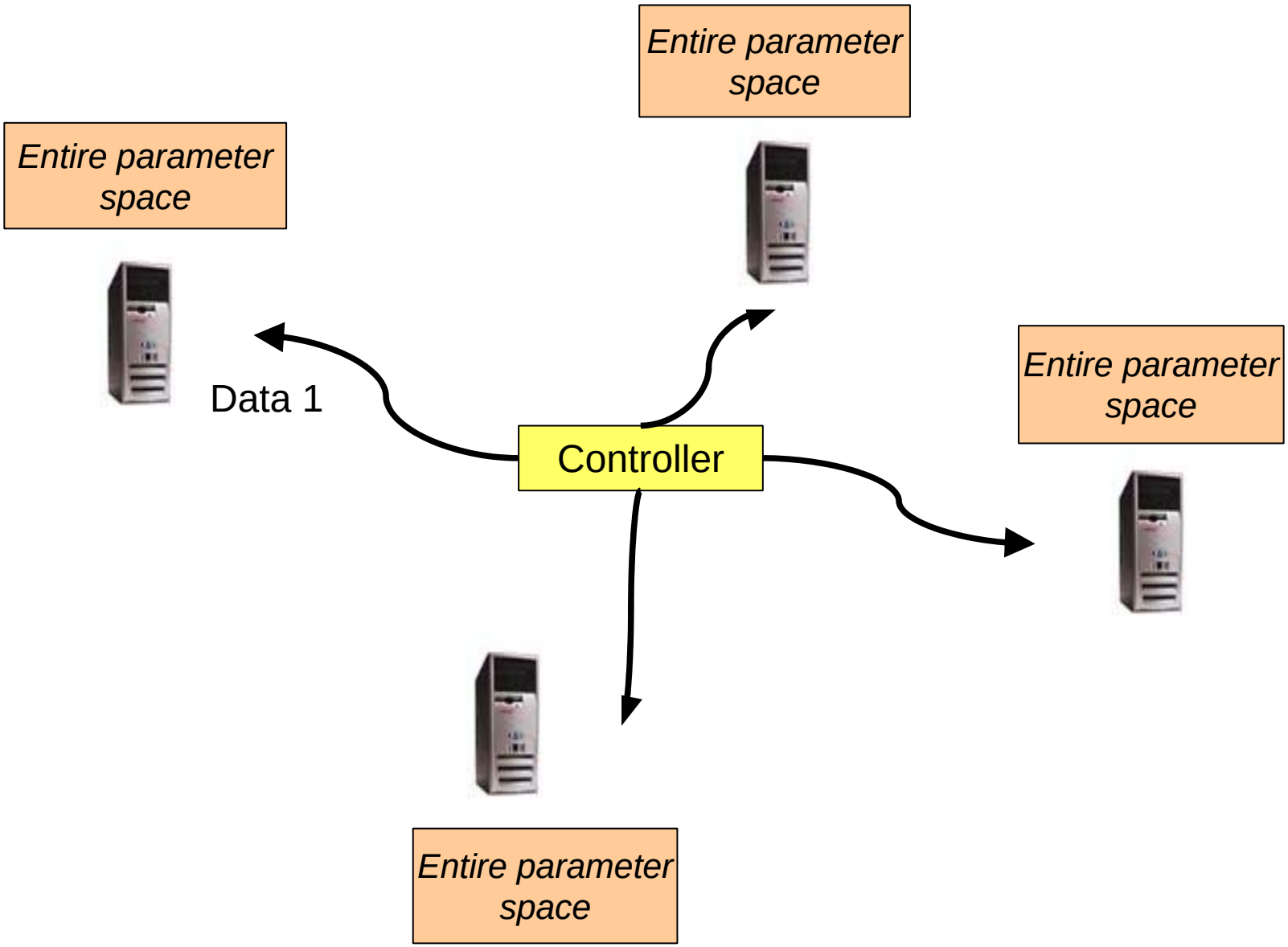
Search we wish to perform

- Search LIGO/GEO data for gravitational wave signals from inspiralling compact binary systems
- Matched filtering – correlation of data with templates defined within search space
- Non-spinning case – 4 search parameters (t_a, phi_a, m_1, m_2)
- Spinning case – 12 search parameters (as above plus spins, orientation of orbit)

Current model for distribution

- Structure mainly in use for distribution (except online search) is a data-parallel model
- Each slave node receives different chunk of data
- Each node searches the entire parameter space for its chunk of data

Illustration of distribution model



Advantages and disadvantages of this distribution model

Advantages

- *Simple to achieve – start up multiple identical jobs with different data*
- *When a job finishes, start another with a different set of data*
- *Simple but effective!*

Disadvantages

- *Results not received until jobs have processed the entire parameter space!*
- *Thus, first set of results obtained after time taken for 1 node to process chunk of data*
- *Introduces a large latency in the analysis*

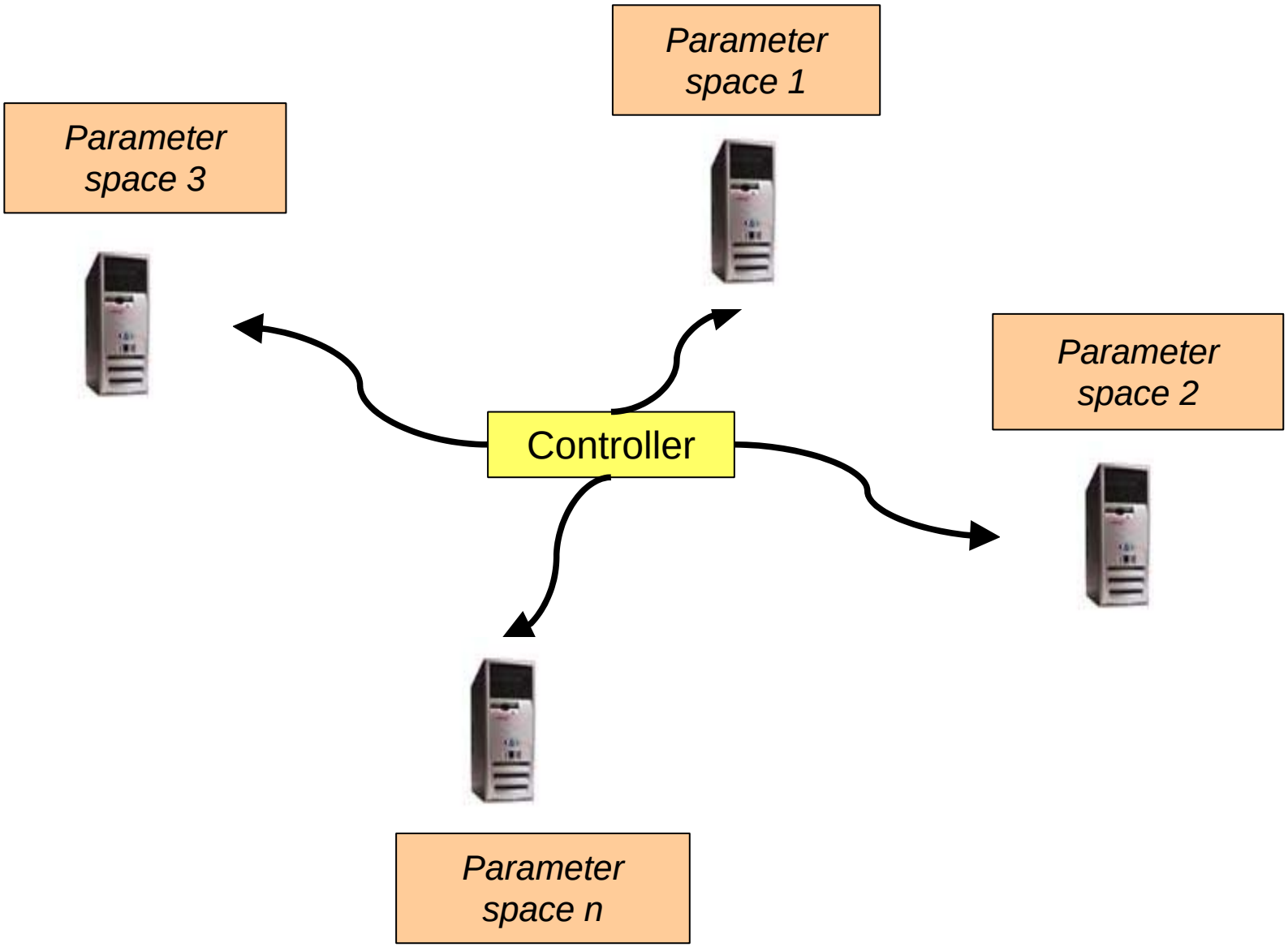
Is latency a problem?

- Not in some cases – e.g. It could get you 100 hours of results in 100 hours
- However, it could take 100 hours to get *any results!!*
- *If results are needed quickly, this is not satisfactory*

Another model – low latency search

- In this case jobs are distributed in a data-serial, parameter space-parallel manner
- Each node searches the same chunk of data, but a different area of the parameter space
- In this way results can be obtained in real time (provided enough nodes...)

Illustration of distribution model



Low-latency distribution

- Each node has same data, but different areas of the parameter space – how do we split the parameter space?
- For certain searches, some areas of parameter space 'more equal' than others
- For heterogeneous resources, different nodes may perform differently
- Need a means of balancing the splitting such that each node takes about the same time to process the data

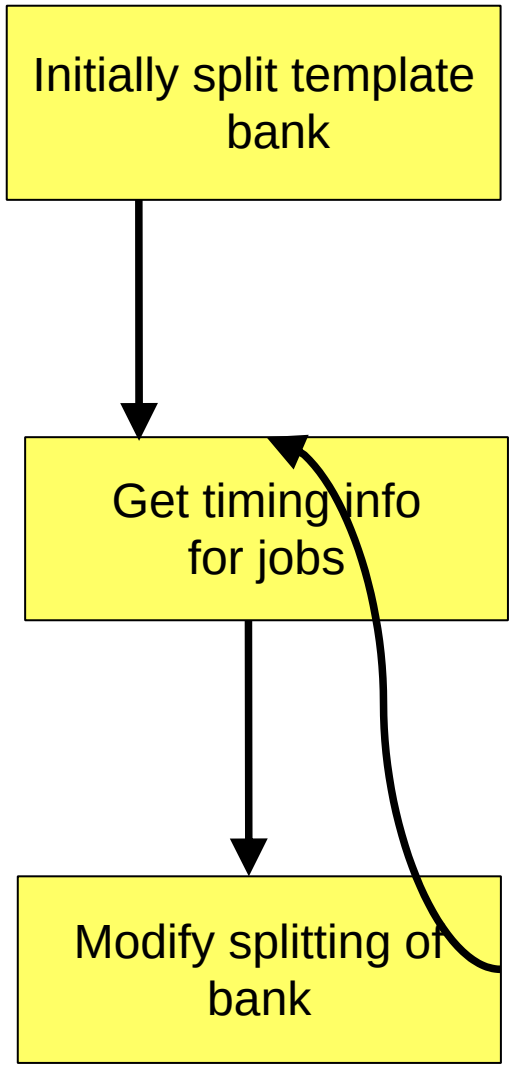
Low latency distribution

Step-wise load-balancing algorithm

A simple model: -

- *Initially split the parameter space naively (i.e. each node gets same number of templates)*
- *Use the timing information of this data chunk to determine the splitting for the next*
- *The splitting of subsequent runs will be determined by timings obtained from previous runs*

Illustration of model



Mechanism for balancing the load

- Get timing information for the previous run for the nodes T_n
- Work out the average time per template for the node, $t_n = T_n / n_n$, where n_n is the no . of templates for node n for previous run.
- For next run, if N_{tot} is total no. of templates for distribution,

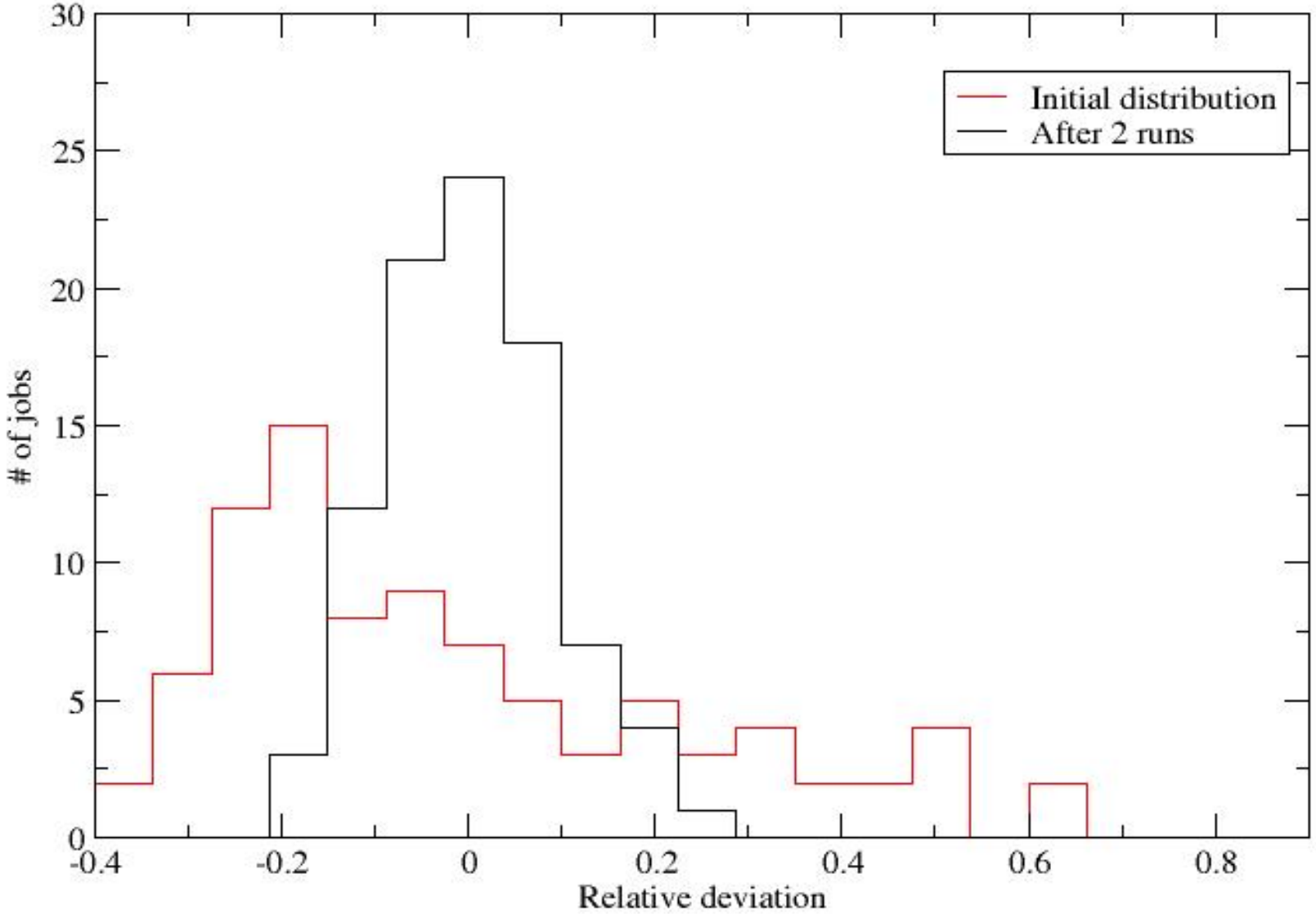
Status of implementation

- Implemented as a set of Python classes/ scripts
- Runs under Condor
- Requires no modification of LAL inspiral search codes
- In event of job failure/delay, 'march ahead regardless'

Performance test

- Inspiral search run on S3 playground data for L1 using PadeT1 templates
- Parameter space 3-20M_{sun} – around 300 templates
- Run on 30 nodes on (temperamental) explorer cluster at Cardiff

Performance test



Future development

- Improvement of the march-ahead step-wise algorithm
  - Instead of using timing info for previous run, use Gaussian weighted average of many
  - Re-implement in a more robust manner
- Development of a new dynamically load-balanced algorithm
  - Slave nodes request templates off controller when idle. When templates are all used, supply the new data
  - May require modification of inspiral code
  - How to implement??