Martlet

A Scientific Work-Flow Language for Abstracted Parallisation

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- About climate*prediction*.net
- Example problem
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- Extending use through JIT Compilers
- Conclusion

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Introducing climate*prediction*.net

Use distributed computing to:

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Use distributed computing to:

- improve the parametrisation of climate models both future and present

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Use distributed computing to:

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- generate a huge set of analysable perturbed climate model runs as a resource for scientists.

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Introducing climate*prediction*.net

Use distributed computing to:

- improve the parametrisation of climate models both future and present
- generate a huge set of analysable perturbed climate model runs as a resource for scientists.

The framework to achive this is currently built on top of the Berkeley Open Infrastructure for Network Computing (BOINC)

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Achived so far

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Achived so far

- Over 62,250 machines running models

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- Over 62,250 machines running models
- Over 180,000 full climate models run

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Achived so far

- Over 62,250 machines running models
- Over 180,000 full climate models run
- Totalling over 17,100,000 years modelled

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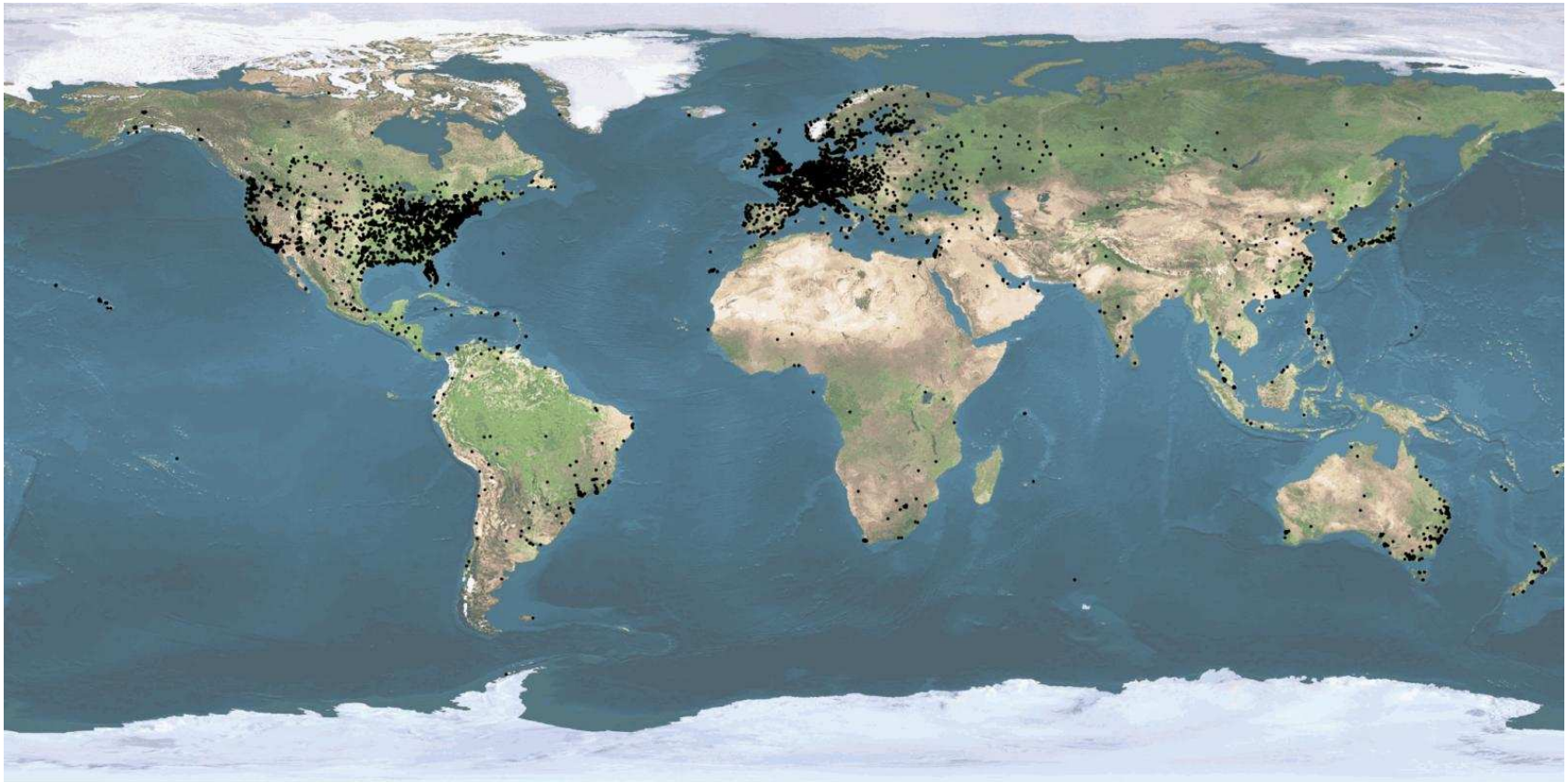
Map of Users



Users on all seven continents

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Returned Runs

Returned runs create a data set that is:

- too big to return to a single location
- trivially partitioned

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Returned Runs

Returned runs create a data set that is:

- to big to return to a single location
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Because of this we:

- ensure that individual runs are not split
- use many donated computers to store returned runs

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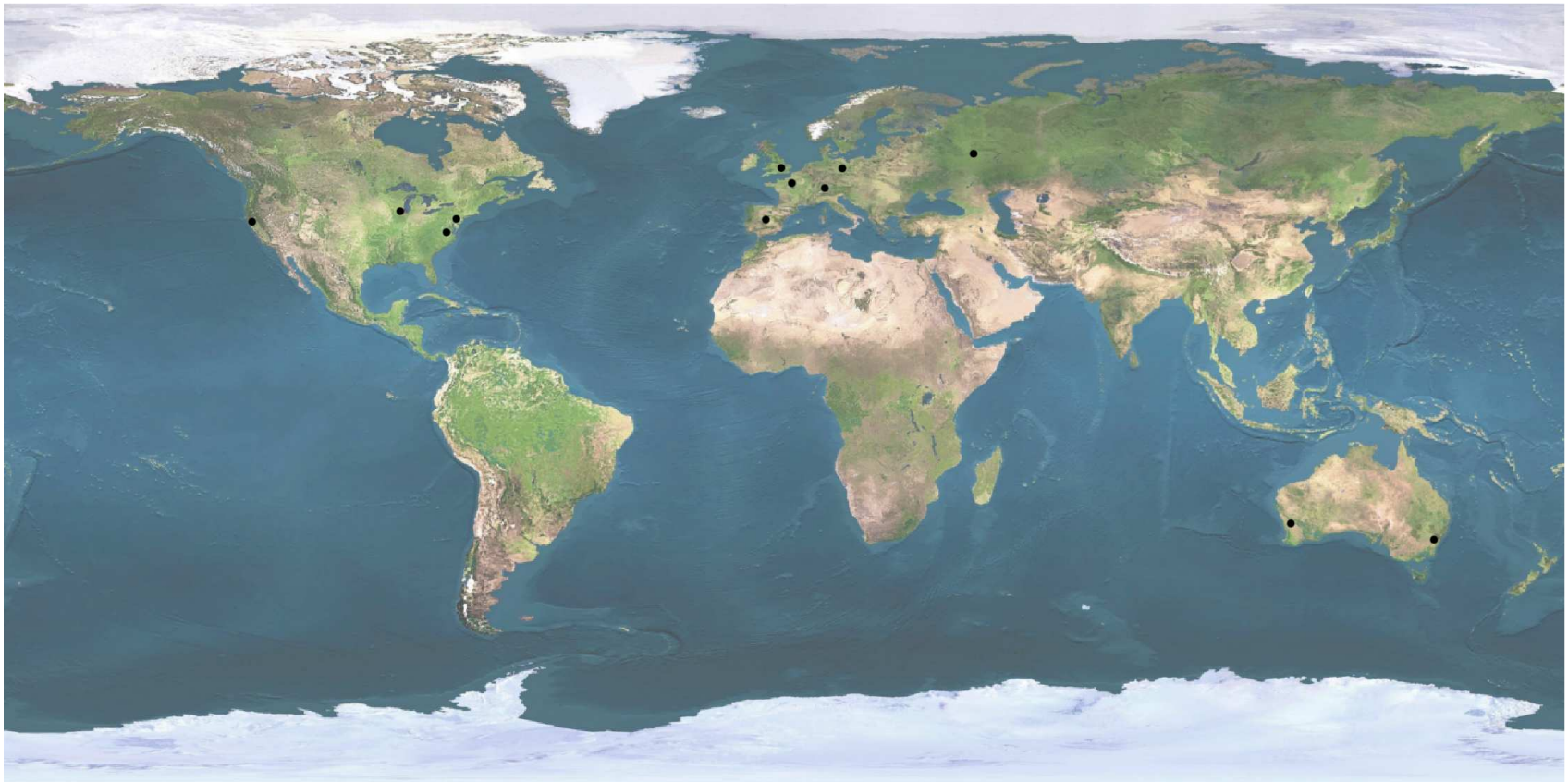
Example problem



Locations of upload servers

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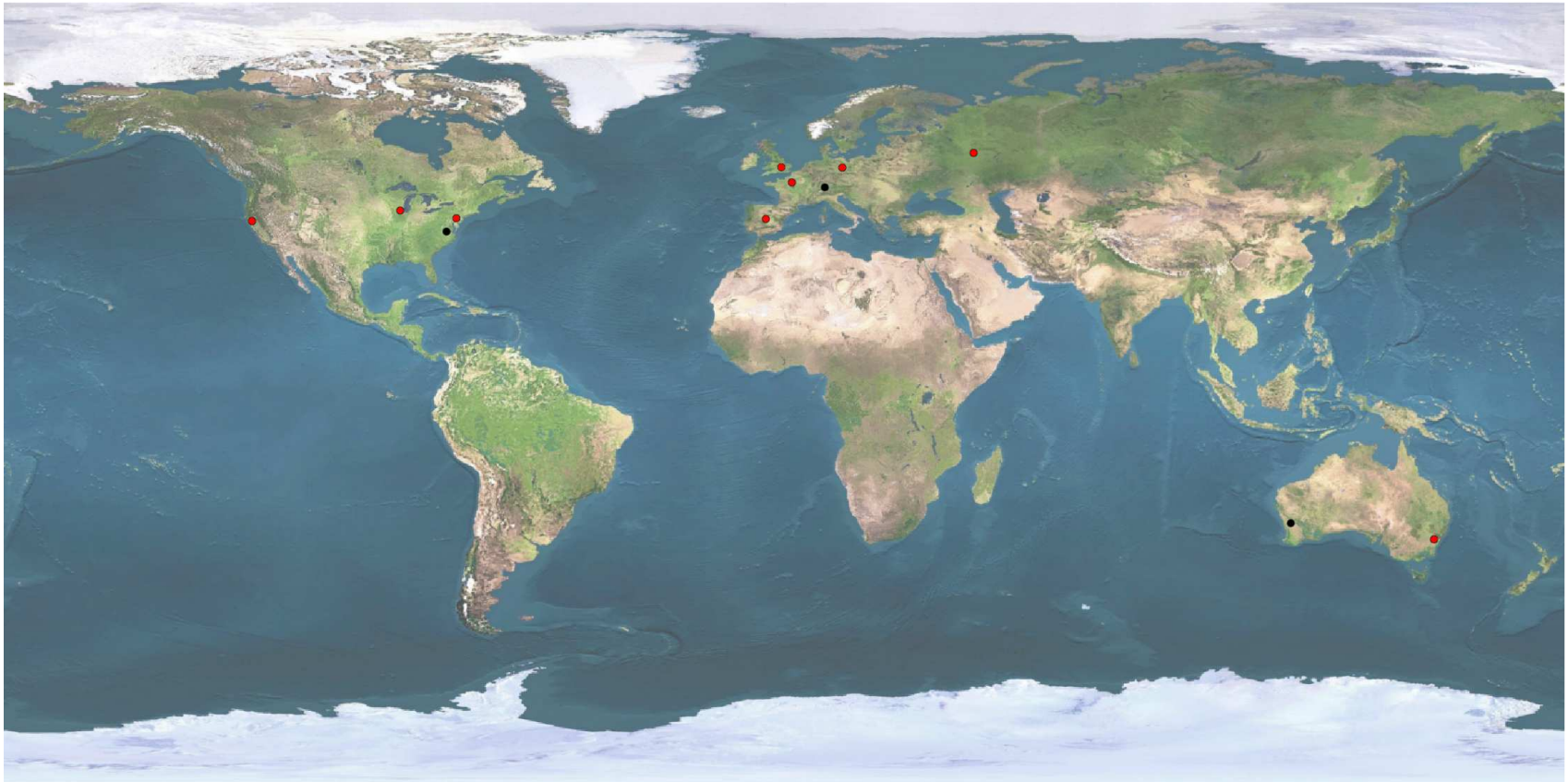
Example problem



Upload severs holding revent data to query X

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Example problem

$$y_0 = \sum_{i=0}^{n_1-1} x_i$$
$$z_0 = n_1$$
$$y_1 = \sum_{i=n_1}^{n_2-1} x_i$$
$$z_1 = n_2 - n_1$$
$$\vdots$$
$$y_{a-1} = \sum_{i=n_{a-1}}^{n_a-1} x_i$$
$$z_{a-1} = n_a - n_{a-1}$$

$$\overline{x} = \frac{\sum_{i=0}^{a-1} y_i}{\sum_{i=0}^{a-1} z_i}$$

Using existing workflow languages would require the user to know the value of a at the time they write the workflow, and to update the workflow when the value of a changes.

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Returned Runs

As analysis is typically data intensive, this means most direct analysis of the data needs to occur locally to the upload servers. This requires that an interface is provided to:

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- Hide the complexity of the distribution

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Returned Runs

As analysis is typically data intensive, this means most direct analysis of the data needs to occur locally to the upload servers. This requires that an interface is provided to:

- Prevent users running their own binaries
- Hide the complexity of the distribution
- Hide the internal state from the user

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Functional Programming

A function for reversing a list

```
reverse :: [a] -> [a]
reverse [] = []
reverse (x:xs) = reverse xs ++ [x]
```

Note the separation between the base case and the inductive case

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Introducing Martlet

```
define{
   uri1 = baseFunction:system:http://cpdn.net:8080/Martlet;
}

proc(A,B){

   Y = new dismatrix(A);
   Z = new disinteger(A);
   ZTotal = new integer(B);

   map{
      matrixSum:uri1(A,Y);
      matrixCardinality:uri1(A,Z);
   }
```

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Introducing Martlet

```
   tree((YL,YR)\Y -> B, (ZL,ZR)\Z -> ZTotal){
      matrixSumToVector:uri1(YL,YR,B);
      integerSum:uri1(ZL,ZR,ZTotal);
   }

   matrixDivide:uri1(B,Z_Total,B);
}
```

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Introducing Martlet

- Two classes of data structure
  - Local data
  - Distributed data

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Introducing Martlet

- Two classes of data structure
  - Local data
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- Two types of statement
  - Normal statements
  - Expandable statements

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- Both functions and data structures are referenced by URIs

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- Two classes of data structure
  - Local data
  - Distributed data
- Two types of statement
  - Normal statements
  - Expandable statements
- Both functions and data structures are referenced by URIs
- Functions are first class values

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Data Structures

```
define{
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proc(A,B){
   Y = new dismatrix(A);
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Local Data Structures

```
define{
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   map{
      matrixSum:uri1(A,Y);
      matrixCardinality:uri1(A,Z);
   }
```

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Local Data Structures

Local data structure

- Exists only in a single location
- Can be acted on directly

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Distributed Data Structures

```
define{
   uri1 = baseFunction:system:http://cpdn.net:8080/Martlet;
}

proc(A,B){
   Y = new dismatrix(A);
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   map{
      matrixSum:uri1(A,Y);
      matrixCardinality:uri1(A,Z);
   }
```

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Distributed Data Structures

Distributed data structure

- Abstractly, a list of local data structures
- Can be split across many locations
- Can be acted on only in conjunction with an expandable statement

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Statements

Normal statements

- Sequential composition
- Asynchronous composition
- If-else
- While
- Temporary Variables
- Process calls

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Statements

Expandable statements

- Map
- Foldr
- Foldl
- Tree

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Map

```
define{
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   map{
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```

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Map

Haskell definition

```
map f [] = []
map f (x:xs) = (f x):(map f xs)
```

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Map

Haskell definition

```
map f [] = []
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Example Martlet code

```
map{
    f1(A);
    f2(A,B);
}
```

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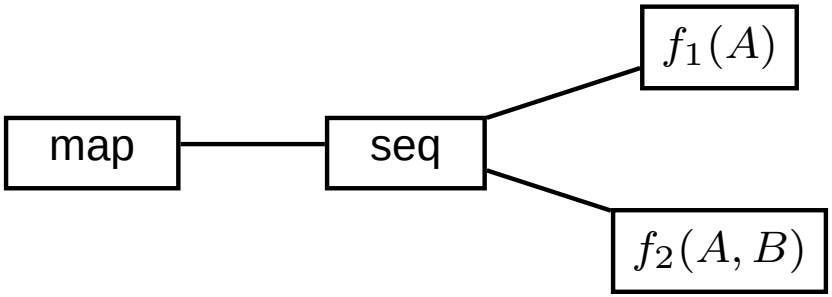
Map

The unexpanded abstract syntax tree



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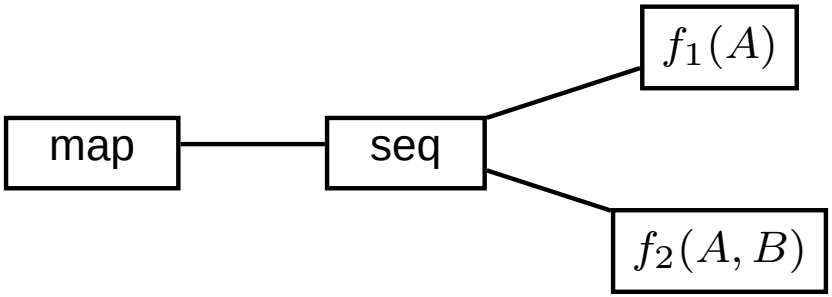

Concrete input data

$$A = [A_1, A_2, A_3]$$

$$B = [B_1, B_2, B_3]$$

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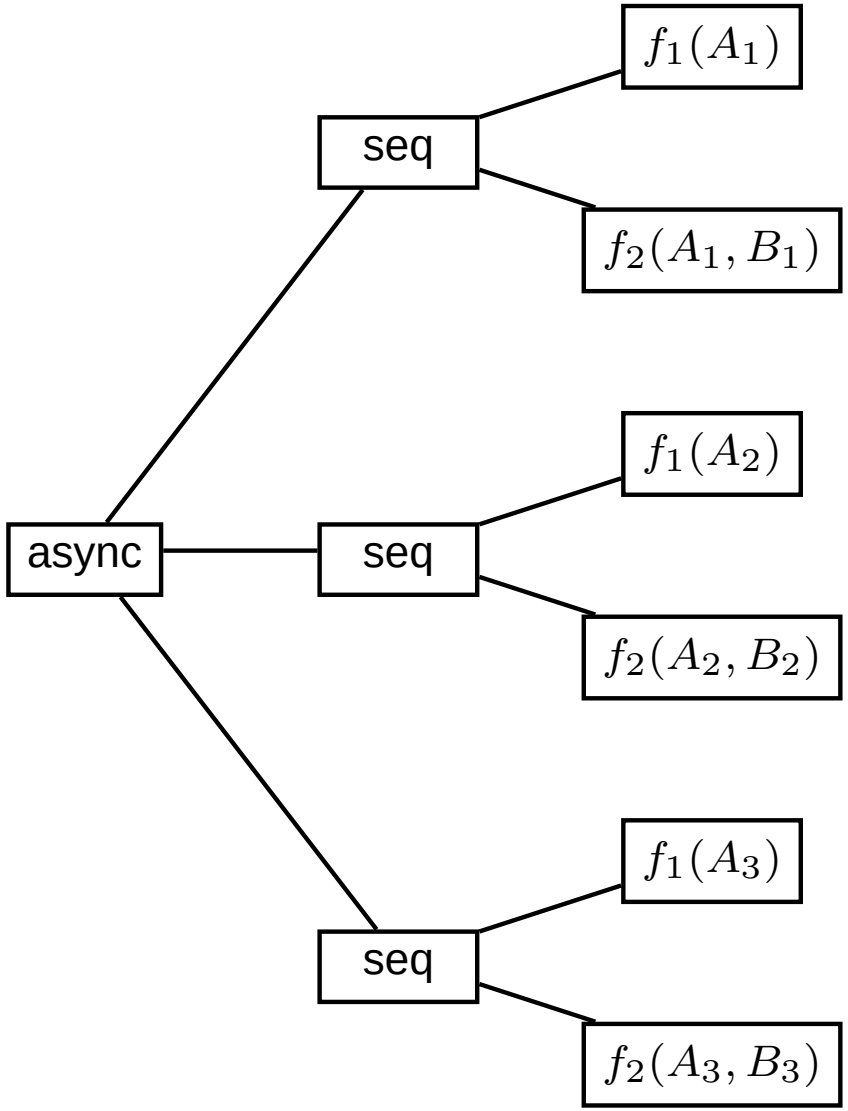
Map



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Tree

```
    tree((YL,YR)\Y -> B, (ZL,ZR)\Z -> ZTotal){
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Tree

Haskell definition

```
tree f [x] = x
tree f (x:y:ys) =
  f (tree f xs') (tree f ys')
     where (xs',ys') = split (x:y:ys)
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Example Martlet code

```
tree((XL,XR)\X -> A){
   f(A,XL,XR);
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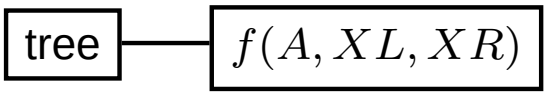

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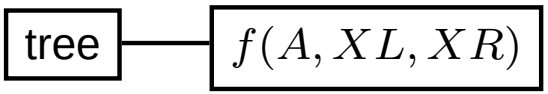

Concrete input data

$$X = [X_1, X_2, X_3, X_4, X_5]$$

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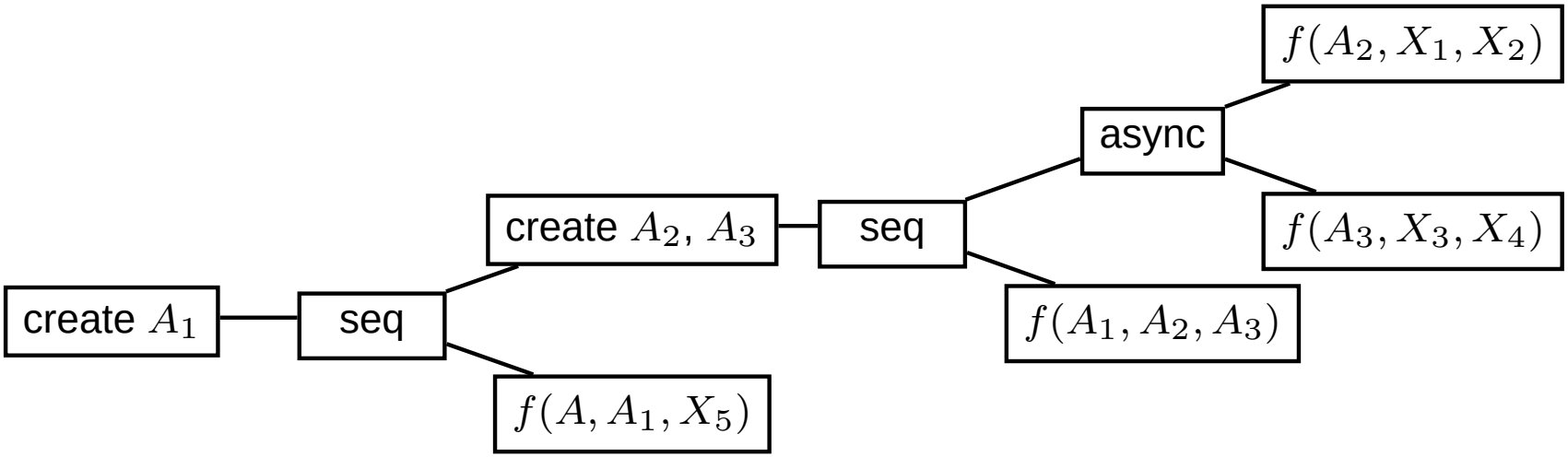
Expanded concrete syntax tree



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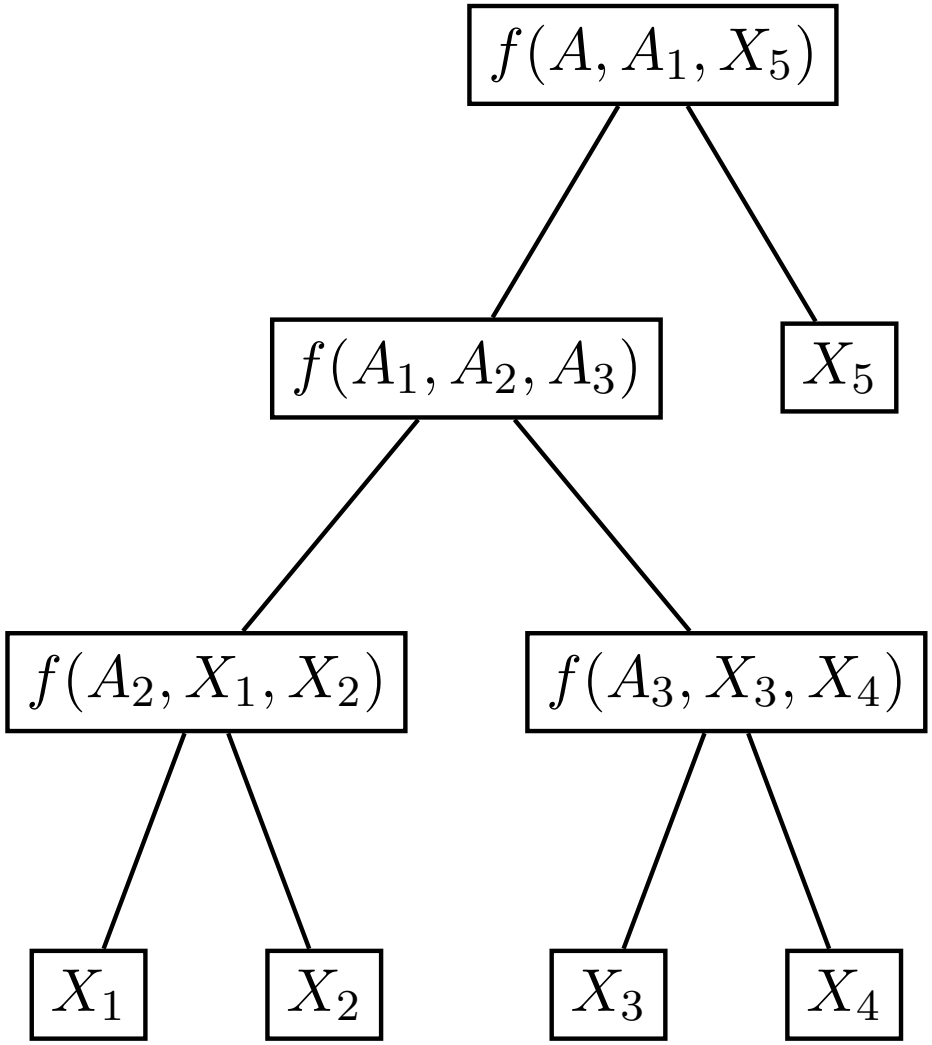

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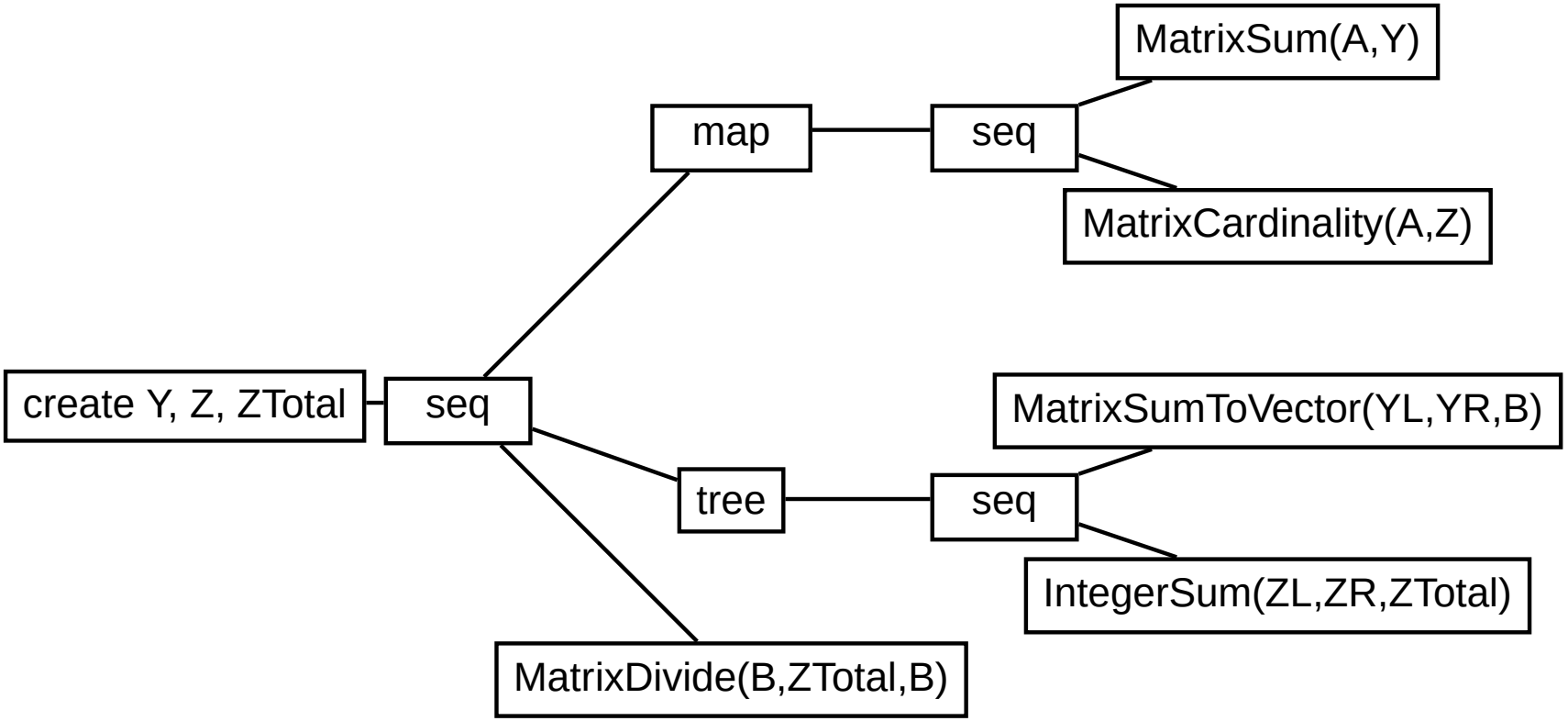

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JIT Compliers

- Produce XML to represent the concrete syntax tree
- Use a JIT compiler to convert this to the workflow language of your choice
- Execute on existing resources
- Store returned results

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Conclusions

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- Solution to a new style of problem

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- Can be used to build on existing resources with relative ease and without affecting their existing functionality

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More information please email

`Daniel.Goodman@comlab.ox.ac.uk`

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