Beast II 101: Part 2

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was: Common errors

2. `Operator` **calls** `input.get()` **instead of** `input.get(this)`.
When an `Operator` does a proposal, it should change a `StateNode`. This `StateNode` needs to be one of its inputs. So, to get the `StateNode` normally a call to `input.get()` would give the value. However, for the `State` to know that a `StateNode` changes, the method `input.get(this);` should be called.
Note that this only applies to the `proposal()` method, not to `initAndValidate()` (though it does not hurt in the latter) since only in `proposal()` a `StateNode` should be changed.

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Note that this only applies to the `proposal()` method, not to `initAndValidate()` (though it does not hurt in the latter) since only in `proposal()` a `StateNode` should be changed.

You can happily get all you like and set what you like on StateNodes that are in the State

was: Common errors

3. **Shadow a `StateNode` in a `CalculationNode`.**
It is tempting to use a pattern like this:

```
public Input<RealParamater> m_p = new Input<>...;
    private RealParameter m_pShadow;

    public void initAndValidate() {
        m_pShadow = m_p.get();
    }

    double calculateSomethingOld() {
        // uses non-current value
        return m_pShadow.getValue() * 2.0;
    }

    double calculateSomethingNew() {
        // uses current value
        return m_p.get().getValue() * 2.0;
    }
```

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3. **Shadow a `StateNode` in a `CalculationNode`.**

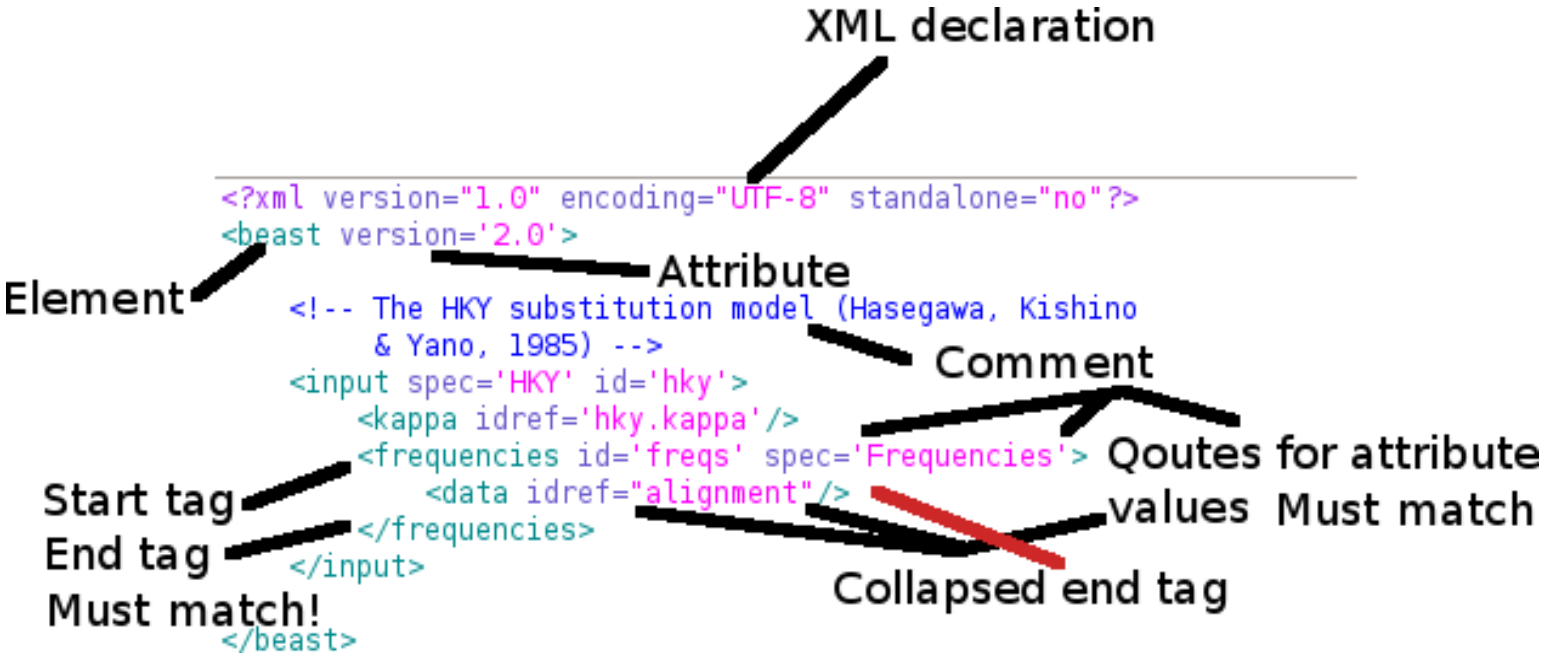
It is tempting to use a pattern like this:

```
public Input<RealParamater> m_p = new Input<>...;
    private RealParameter m_pShadow;

    public void initAndValidate() {
        m_pShadow = m_p.get();
    }

    double calculateSomethingOld() {
        // uses non-current value
        return m_pShadow.getValue() * 2.0;
    }

    double calculateSomethingNew() {
        // uses current value
        return m_p.get().getValue() * 2.0;
    }
```

You can happily shadow anything you like

What is XML?

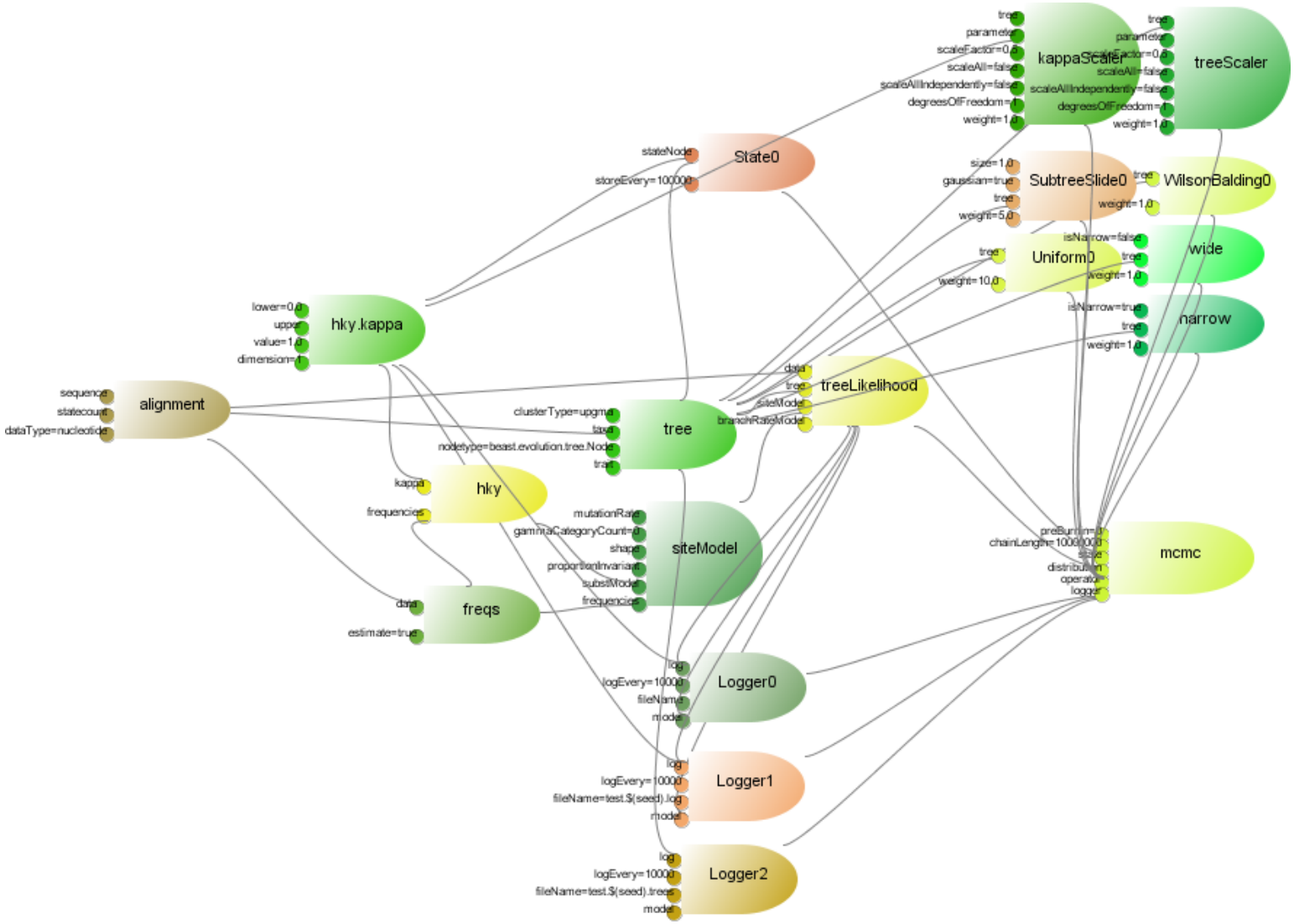
"The Extensible Markup Language (XML) is a simple text-based format for representing structured information"



Reserved characters in attribute values: " (") ’ (') < (<) > (>) & (&) e.g. x="""

XML

Let's put this model into XML



First the hky-scale operator

Beast 2 Reserved XML attributes

`name`, `spec`, `id`, `idref`

- XML element `input` can be used for every plugin.
- Specify `name` to match with input name.
- Specify `spec` to identity Plugin.
- XML id/idref mechanism to reuse Plugins.
- XML attributes for primitives (Integer, Double, Boolean, String).

```
<input name='operator' id='kappaScaler'
    spec='beast.evolution.operators.ScaleOperator'
    scaleFactor='0.5' weight='1'>
    <input name='parameter' idref='hky.kappa'/>
</input>
```

XML rule: namespaces

Top level `beast` element can be used to define namespaces in the usual Java fashion.

```
<beast namespace="beast.core:beast.evolution.operators">
```

This allows shortening of spec-values:

```
<input name='operator' id='kappaScaler'
    spec='beast.evolution.operators.ScaleOperator'
    scaleFactor='0.5' weight='1'>
    <input name='parameter' idref='hky.kappa'/>
</input>
```

becomes

```
<input name='operator' id='kappaScaler' spec='ScaleOperator'
    scaleFactor='0.5' weight='1'>
    <input name='parameter' idref='hky.kappa'/>
</input>
```

XML rule: input/name

Input elements with name attributes equal the name's value as element name

```
<input name='xyz'></input>  == <xyz></xyz>
```

so

```
<input name='operator' id='kappaScaler' spec='ScaleOperator'
    scaleFactor='0.5' weight='1'>
    <input name='parameter' idref='hky.kappa'/>
</input>
```

equals

```
<operator id='kappaScaler' spec='ScaleOperator'
    scaleFactor='0.5' weight='1'>
    <parameter idref='hky.kappa'/>
</operator>
```

XML rules: idref

If idref is only attribute in element, an attribute with element name and before the idref.

```
<name idref="some-id"/> == name='@some-id'
```

So

```
<operator id='kappaScaler' spec='ScaleOperator'
    scaleFactor='0.5' weight='1'>
    <parameter idref='hky.kappa'/>
</operator>
```

equals

```
<operator id='kappaScaler' spec='ScaleOperator'
    scaleFactor="0.5" weight="1" parameter="@hky.kappa"/>
```

Beast 2 Reserved XML elements


```
<beast version='2.0' namespace='x.y.z:a.b.c' >
<map name='xyz' >x.y.z.Class </map>
element <xyz> is expanded to
<input name='xyz' spec='x.y.z.Class'>

<input >

<run > spec must be beast.core.Runnable
<distribution > spec must be beast.core.Distribution
<operator > spec must be beast.core.Operator
<logger >      spec=beast.core.Logger
<data >        spec=beast.evolution.alignment.Alignment
<sequence >    spec=beast.evolution.alignment.Sequence
<state >       spec=beast.core.State
<parameter >   spec=beast.core.parameter.RealParameter
<tree >        spec=beast.evolution.tree.Tree

<plate > mainly for Beauti templates
```

XML: example

```
<input name='substModel' id="hky" spec="HKY">
    <input name='kappa' idref="hky.kappa" >
    <input name='frequencies' id="freqs" spec="Frequencies">
           <input name='data' idref="alignment"/>
    </input>
</input>
```

```
<input spec="TreeLikelihood">
    <input name='data' idref='alignment'/>
    <input name='tree' idref='tree'/>
    <input name='siteModel' spec="SiteModel">
        <input name='substModel' idref='hky'/>
    </input>
</input>
```

Assuming `namespace='beast.evolution.sitemodel: beast.evolution.substitutionmodel: beast.evolution.likelihood'`

Compress inputs

Input elements with name attributes equal the name's value as element name

```
<input name='xyz'></input>  == <xyz></xyz>
```

Applying to the example

```
<substModel id="hky" spec="HKY">
    <kappa idref="hky.kappa" >
    <frequencies id="freqs" spec="Frequencies">
           <data idref="alignment"/>
    </frequencies>
</substModel>


<distribution spec="TreeLikelihood">
    <data idref='alignment'/>
    <tree idref='tree'/>
    <siteModel spec="SiteModel">
        <substModel idref='hky'/>
    </siteModel>
</distribution>
```

Compress idrefs

if idref is only attribute in element, an attribute with element name and before the idref.

```
<name idref="some-id"/> == name='@some-id'
```

Applying to the example

```
<substModel id="hky" spec="HKY" kappa="@hky.kappa" >
    <frequencies id="freqs" spec="Frequencies"
        data="@alignment"/>
</substModel>

<distribution data="@alignment" spec="TreeLikelihood"
    tree="@tree">
    <siteModel spec="SiteModel" substModel='@hky'/>
</distribution>
```

Note: you still can use any of the previous versions! These are just short-cuts.

Resolving input name

- specified in name attribute

```
<input name="xyz" >
```

- if not, use element name

```
<xyz value="3" >
```

- if input, use ’value’ when there is text content, but no element content

```
<input>3</input>
```

Resolving input value

- if idref is specified, use the referred object

```
<xyz idref="other" > or xyz='@other'
```

- specified in value attribute

```
<xyz value="3" >
```

- if not, use value of (non-reserved) attribute

```
<input xyz="3" >
```

- if not, use text content when there is text content, but no element content

```
<input>3</input>
```

```xml
<run chainLength="10000000" id="mcmc" preBurnin="0" spec="MCMC">
    <state>
        <parameter id="hky.kappa" name="stateNode" value="1.0"/>
        <tree id="tree" name="stateNode" spec="beast.util.ClusterTree">
            <taxa idref="alignment"/>
        </tree>
    </state>

    <distribution id="likelihood" spec="TreeLikelihood" tree="@tree" data="@alignment">
        <siteModel spec="SiteModel">
            <substModel id="hky" kappa="@hky.kappa" spec="HKY">
                <frequencies spec="Frequencies" data="@alignment" estimate="true"/>
            </substModel>
        </siteModel>
    </distribution>

    <operator id='kappaScaler' spec='ScaleOperator' scaleFactor="0.5" weight="1" parameter="@hky.kappa"/>
    <operator id='treeScaler' spec='ScaleOperator' scaleFactor="0.5" weight="1" tree="@tree"/>
    <operator spec='Uniform' weight="10" tree="@tree"/>
    <operator spec='SubtreeSlide' weight="5" gaussian="true" size="1.0" tree="@tree"/>
    <operator id='narrow' spec='Exchange' isNarrow='true' weight="1" tree="@tree"/>
    <operator id='wide' spec='Exchange' isNarrow='false' weight="1" tree="@tree"/>
    <operator spec='WilsonBalding' weight="1" tree="@tree"/>

    <logger logEvery="10000" fileName="test.$(seed).log">
        <model idref='likelihood'/>
        <log idref="likelihood"/>
        <log idref='hky.kappa'/>
        <log spec='beast.evolution.tree.TreeHeightLogger' tree='@tree'/>
    </logger>
    <logger logEvery="10000" fileName="test.$(seed).trees" log='@tree'/>
    <logger logEvery="10000">
        <model idref='likelihood'/>
        <log idref="likelihood"/>
        <ESS spec='ESS' name='log' arg="@likelihood"/>
        <log idref='hky.kappa'/>
        <ESS spec='ESS' name='log' arg="@hky.kappa"/>
    </logger>
</run>
```

XML

XMLParser produces semi sensible parser error messages:

```
Error 124 parsing the xml input file

This plugin (treeLikelihood) has no input with
name xxx. Choose one of these inputs: data,tree,
siteModel,branchRateModel,useAmbiguities

Error detected about here:
  <beast>
      <run id='mcmc' spec='MCMC'>
          <distribution id='posterior' spec='CompoundDistribution'>
              <distribution id='treeLikelihood' spec='TreeLikelihood'>
```

and

```
Error 122 parsing the xml input file

Cannot create class: CompoundDistibution. Class could not be found.
Did you mean beast.core.util.CompoundDistribution?

Error detected about here:
  <beast>
      <run id='mcmc' spec='MCMC'>
          <distribution id='posterior' spec='CompoundDistibution'>
```

Add-ons

A Beast 2 add-on is a library based on Beast 2

Why add-ons:

- Making work easier citable
- Making the core easier to learn – it's a lot smaller / cleaner
- Separating out stable / experimental code / dead code
- ...

Add-ons

- SnAP - multi-species coalescent for SNP and AFLP data `http://code.google.com/p/snap-mcmc/`
- beastii - utilities, Peter Will's AARS substitution model `http://code.google.com/p/beastii/`
- Subst-BMA - Bayes model averaging over subst. models `http://code.google.com/p/subst-bma/`
- EBSP/*BEAST - Joseph's thesis work
- Experimental phylogeography
- David Welch's Prevalence/SI-likelihood
- Sibon's MCMC monitoring thing
- ...

What makes an Add-on

- A jar file that contains the code
- A jar file with the source
- Example XML files
- Documentation
- A Beauti 2 template

Recommended directory structure:

`myAddOn/../beast2`	Beast 2 files
`myAddOn/src`	source files
`myAddOn/examples`	XML examples
`myAddOn/build`	class files
`myAddOn/build/dist`	jar files
`myAddOn/lib`	libraries used (if any)
`myAddOn/doc`	documentation
`myAddOn/templates`	Beauti templates (optional)

Setting up an Add-on

Checkout Beast 2 code, available at
`http://code.google.com/p/beast2`

Setting up an add-on in Intellij, basic steps

- Make a project containing Beast 2
- Create new module, e.g. called MyAddOn
- Create module dependency of MyAddOn on Beast 2

see SDK documentation for more details.

Setting up an add-on in Eclipse, basic steps

- Make a project containing Beast 2
- Create new project, e.g. called MyAddOn
- Add beast 2 to the Java build path of MyAddOn

see SDK documentation for more details.

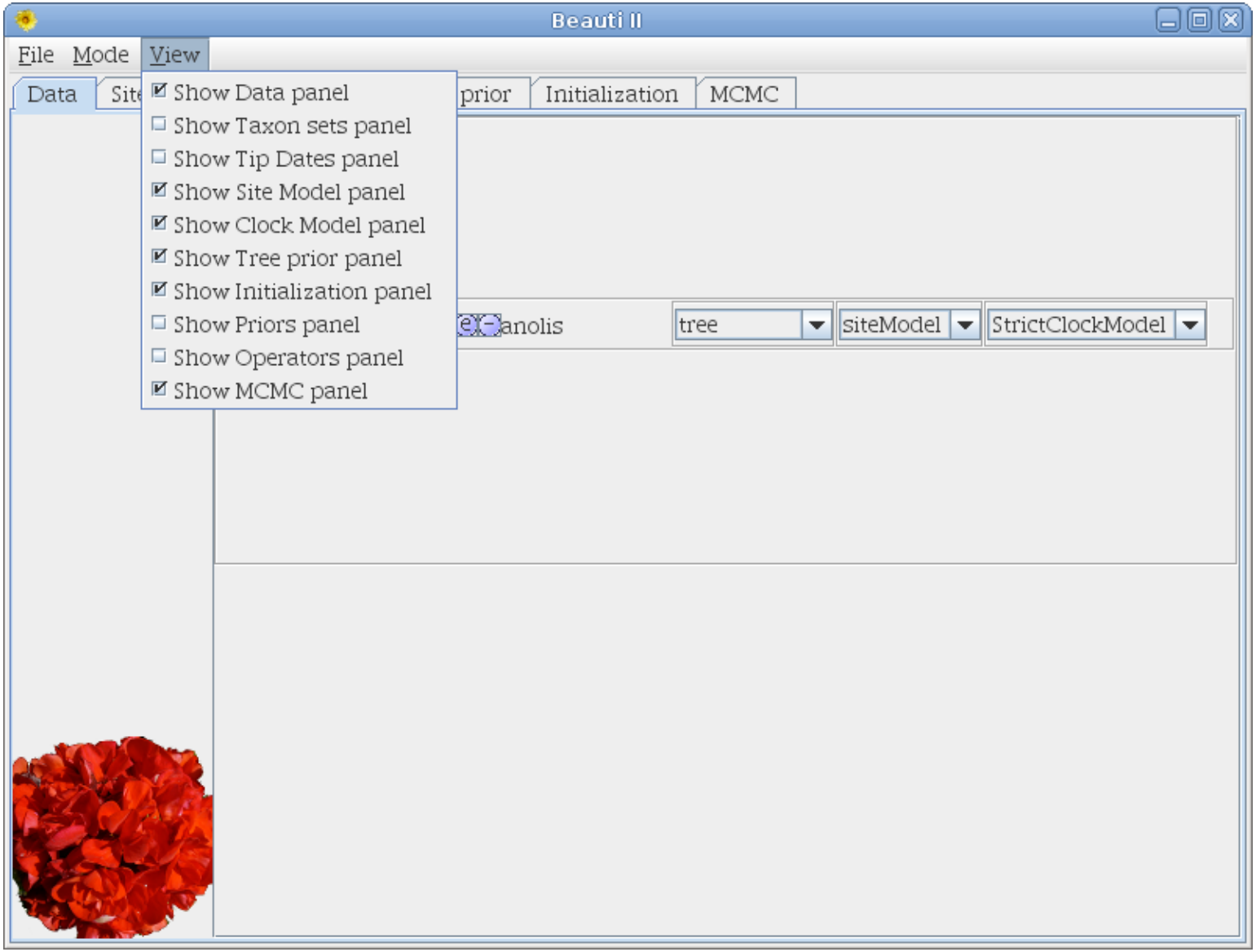
Setting up an add-on in Hudson (for automatic regression testing): ask Walter

Distributing Add-ons

- Create Add-on files containing add-on classes only
- Put on a web-site
- Download to $BEAST_HOME/beastlib
- It will be picked up from there when running BeastMCMC or Beauti

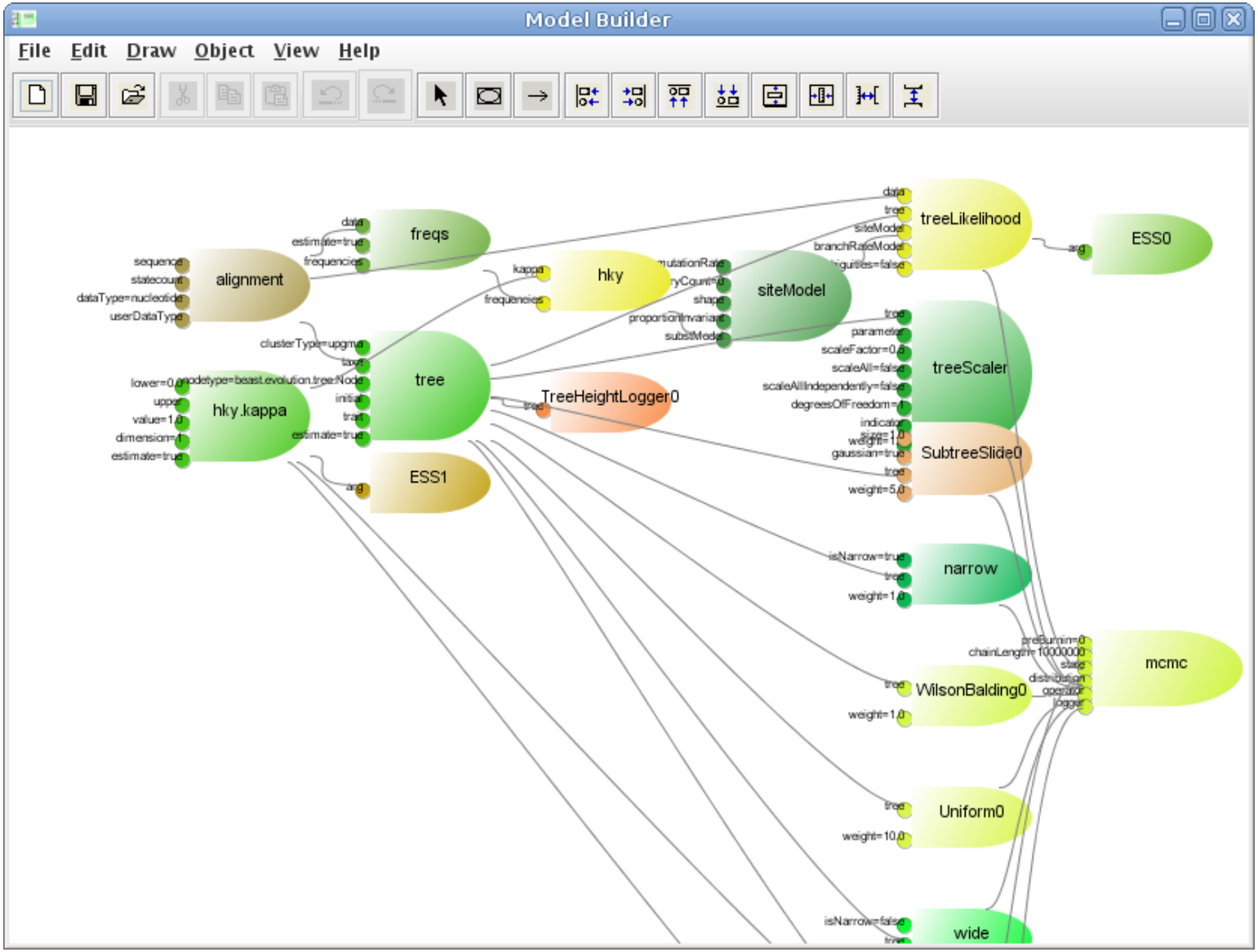
Future work: automate this process, provide catalogue, GUI, etc.

Beauti 2: replacement of Beauti 1



More about Beauti in Part III

Model builder: GUI for graphical manipulation of Plugins



In development...

Spreadsheet: calculates partial results on the fly

Beast II Calculator

File Edit Window Help

AlArabiya

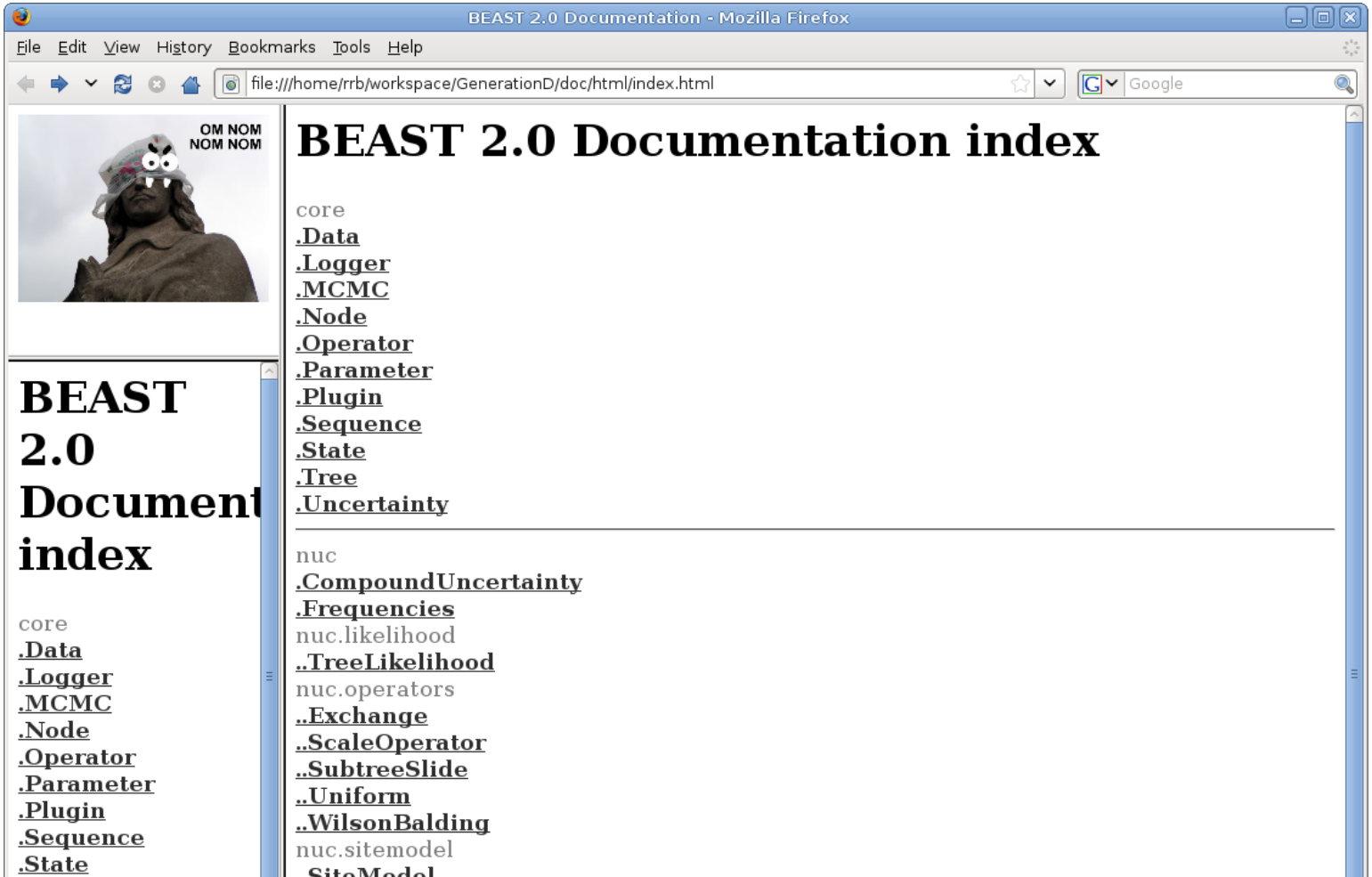
	A	B	C
1	State	State([$B2,$B3],100000)	
2	hky.kappa	RealParameter(0.0,null,2.0,1,true)	4.0
3	tree	ClusterTree(upgma,$B5,beast.evolution.tree.Node,null,null,true)	0.107031...
4			
5	alignment	Alignment([$B6,$B7,$B8,$B9,$B10,$B11],null,nucleotide)	
6	Sequence	Sequence(4,human, AGAAATATGTCTGATAAAAGAGTTACT...	
7	Sequence	Sequence(4,chimp, AGAAATATGTCTGATAAAAGAATTACTT...	
8	Sequence	Sequence(4,bonobo, AGAAATATGTCTGATAAAAGAATTACT...	
9	Sequence	Sequence(4,gorilla, AGAAATATGTCTGATAAAAGAGTTACTT...	
10	Sequence	Sequence(4,orangutan, AGAAATATGTCTGACAAAAGAGTTA...	
11	Sequence	Sequence(4,siamang, AGAAATACGTCTGACGAAAGAGTTAC...	
12			
13	treeLikelihood	TreeLikelihood($B5,$B3,$B14,null,false)	-1986.84...
14	siteModel	SiteModel(null,0,null,null,$B15)	
15	hky	HKY($B2,$B16)	
16	freqs	Frequencies($B5,true,null)	
17			
18	kappaScaler	ScaleOperator(null,$B2,0.5,false,false,1,1.0)	
19	treeScaler	ScaleOperator($B3,null,0.5,false,false,1,1.0)	
20	Uniform	Uniform($B3,10.0)	
21	SubtreeSlide	SubtreeSlide(1.0,true,$B3,5.0)	
22	narrow	Exchange(true,$B3,1.0)	33
23	wide	Exchange(false,$B3,1.0)	66.0
24	WilsonBalding	WilsonBalding($B3,1.0)	
25			
26	Logger	Logger([$B13,$B27,$B2,$B28],10000,null,$B13,autodetect)	
27	ESS	ESS($B13)	
28	ESS	ESS($B2)	
29			
30	Logger	Logger([$B13,$B2,$B31],10000,test.$(seed).log,$B13,autodetect)	
31	TreeHeightLog...	TreeHeightLogger($B3)	
32			
33	Logger	Logger([$B3],10000,test.$(seed).trees,null,autodetect)	
34	mcmc	MCMC(0,10000000,$B1,$B13,[$B18,$B19,$B20,$B21,$B22,$B2...	
35			
36			

In development...

Documentation

XML documentation provided through

- @Description annotation on plug in
- Tooltip text on inputs
- getCitation method
- Input validation rules



Other

o Sequence generator, for simulation studies

o Sequence with XML merging through Beauti, handy for scripting

o XMLParser to beautify XML

BEAST 2.0


```
~> java beast.app.BeastMCMC

Usage: BeastMCMC [options] <Beast.xml>
where <Beast.xml> the name of a file specifying a Beast run
and the following options are allowed:
-resume : read state that was stored at the end of the last run from file
and append log file
-overwrite : overwrite existing log files (if any). By default, existing
-seed [<int>|random] : sets random number seed (default 127), or picks a
-threads <int> : sets number of threads (default 1)
-beastlib <path> : Colon separated list of directories. All jar files in
```