Towards an Operational Semantics of Biological Diversity: Integrating Structure and Function in a Web-accessible knowledge base.

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A semantic framework and simulation toolkit to describe, store and use generic knowledge models, encompassing structural knowledge (data, such as timeseries, GIS coverages) and functional knowledge (dynamic models of various scope, scale, and paradigm).

rationale

provide an unified, object-oriented description framework for interoperable, paradigm-neutral model component (modules)

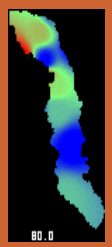
describe different aspects of the world (such as space or time) independently from the modules, and make modules capable of "adopting" them, thus being exposed to change

a web-based virtual machine creates and initializes objects from specifications, create the world as a semantically mediated view of what the modules have adopted, define correct relationships between modules and operations to make them transparent to each other, and carry on the change actions that the generated world implies.

Compatible representation of structural and functional knowledge

Bibliographic information
parameters and constants
timeseries data
spatial coverages
....

NP params
---
1 23 44 44
2 12 12 33
3 11 22 33



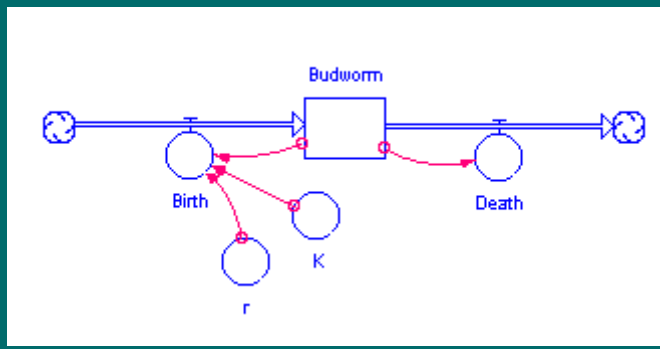
Land use priorities

Forest 0.83
Urban 0.44
Agriculture 0.12

```
<?xml 1.0>
<raster name="temperature">
  <dspace dimensions="2"  unit="m"/>
     <resolution>100</resolution>
     <projection>UTM</projection>
     <extent>
          <longitude>12'23.33</longitude>
          <latitude>32'123.2<latitude>
     </extent>
  <content href="elevation.e00"
           format="arc"/>
</raster>
```

Process models
agent models
optimizers
interfaces to GIS and statistical software

$$\frac{dB(t)}{dt} = rB(1 \quad \frac{B}{K}) \quad \frac{B^2}{1f\ B^2}$$



DOMAINS:

declare the representational model for an aspect of the world as seen by a module

expose a module to an aspect of the world, such as space or time, and extend its semantic space with related operators and functions.

Allows semantic mediation between modules, taking care of issues such as units, scale, and representational paradigm.

TIME generates spontaneous change in the form of actions, propagated to all objects according to their view of time.

Other domains "contextualize" change actions, possibly replicating or aggregating change according to a module's view.

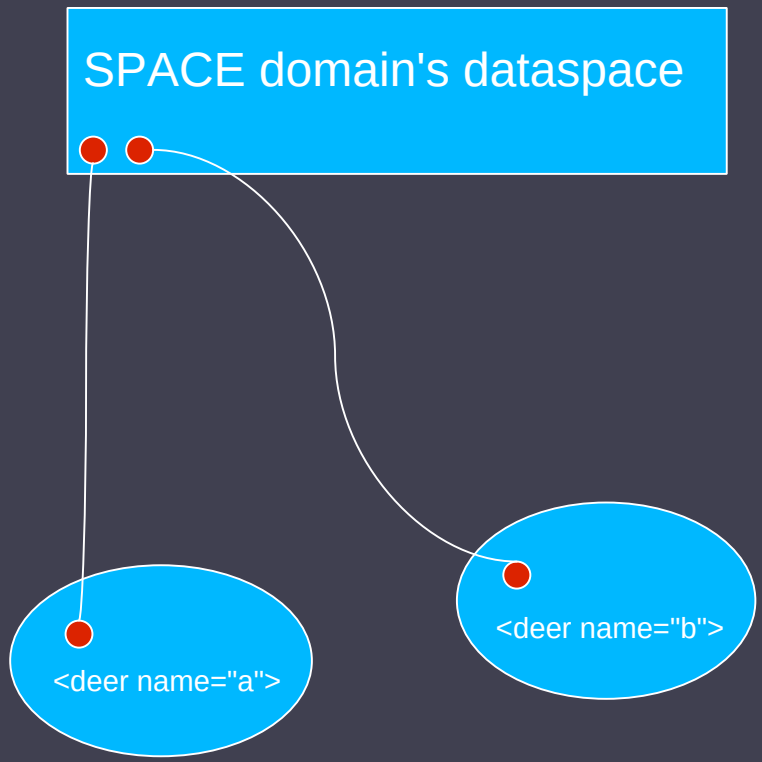
```
<mapseries name="temperature">
    <time start="2000-1-1" end="2000-1-2"
          step="1" unit="hour"/>
    <grid lat=".." long=".." projection="UTM"
          dims="2" resolution="10" unit="m"
          xExtent="1403" yExtent="880"/>
    <content href="http://site/arcmaps/*.dat" />
</mapseries>
```

Domains provide modules with "awareness" of domain-related conditions, in the appropriate "language" (units, resolution, representation) for each module to understand.

When another module's *state* is referenced by another module's behavior, the state is read in the *context* of the inquiring module.

Modules answer "messages": messages not understood are routed to the adopted domains, so adopting domains provides "eyes" for the modules' behavior to use.

Domains can mediate compatible representations (e.g. gridded (raster) or polygon-based (vector) space).



Domainized references

```
closestDeer := [self nearest [self classPath]];
  if (closestDeer != nil) {
      foodAtHisPlace := food{closestDeer:space};
      if (food < foodAtHisPlace) {
         [behavior swap peaceful aggressive];
         [self move [closestDeer space]];
      }
  }
```

Domains assess, enforce and allow compatibility of "world views" between modules

CLASSIFICATION domains

link module states to classifier objects (e.g. References, methods of measurement, economic value...)

propagate polimorphism through model structure. Classification objects can be accessed and used.

SPACE domain

checks compatibility of geographical location

interpolates and aggregates information at different spatial scales

scaling algorithms are user-controlled and extensible

TIME domain

automatically interpolates missing data handles different time units

interpolates over fine time scales

aggregates over coarse time scales

interpolation and aggregation algorithms are user-controlled and extendible

A polymorphic repository interface supports relational distributed databases, URL-based access (HTTP, SOAP and XP-COM interfaces). Data models for databases are automatically maintained from the installed XML object grammars.

Our prototype system will include the IUCN red list of threatened species with fully characterized spatial, temporal and 'ecological' domains, plus a number of biodiversity process models.

Views over the repository use the domain concept to translate ecological concepts (e.g. Species-area relationship) that the database user can discover dynamically with no need for preexisting conceptualization.

Models can be dynamically constructed, modified, run and stored through the web-based virtual machine. Open source software allows local storage and use of all data and models.