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A conceptual data model and modelling language for fields and agents

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Introduction

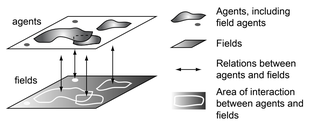
Environmental systems are heterogeneous because they consist of fields and agents (see the figure at right).

Integration of these fields and agents would be helpful for modelling. However, existing modelling frameworks concentrate on either agent-based or field-based modelling and are often low-level programming frameworks.

A concept is lacking that integrates fields and agents in a way that is easy to use for modelers who are not software engineers.

Research aim

We develop a *conceptual data model* that represents fields and agents uniformly. We show how the data model can be used in a *high-level modelling language* based on the ideas of map algebra.



Approach

- Integration of fields and agents at a high conceptual level
  - Domain analysis
- Design of data types
  - Data types are based on conceptual data model
- Design of high-level operations based on the ideas of *map algebra.*
  - *Result = phenomenon + phenomenon* where *phenomenon* represents agent or field data types.

Related Research

EGU Poster A.448 De Jong, K, M. de Bakker, D. Karssenberg. 2016. A physical data model for fields and agents.

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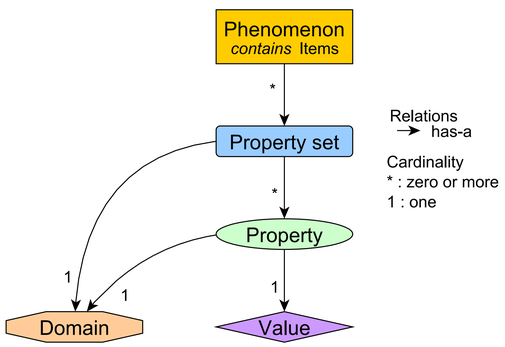
Conceptual Data Model



The ***phenomenon*** is the thing that is modelled, which can be any real world thing, for example trees. A *phenomenon* usually consists of several *items*, e.g. single trees.

The ***domain*** is the spatiotemporal location and/or extent for which the *items* in the *phenomenon* are defined. Multiple different *domains* can coexist for a given *phenomenon*. For example a *domain* describing the extent of the trees and a *domain* describing the stem locations.

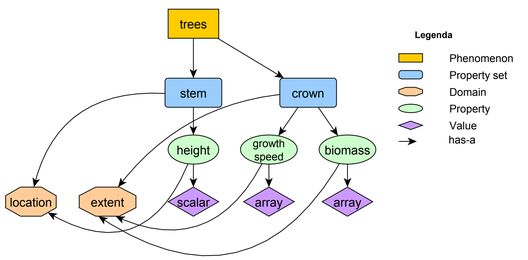
The same goes for the ***property***, which is an attribute of the thing that is being modeled. A *property* has a ***value***, which is possibly discretized, for example the biomass over the tree crown extent.

Properties sharing the same *domain* are grouped into a ***property set***.

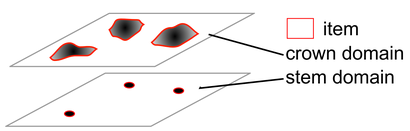
Conceptual Data Model example

This example shows how agent and field attributes can be combined.

The *Phenomenon* **trees** contains several tree *items.* Each of these *items* have the properties **height, growth speed** and **biomass.** Since **growth speed** and **biomass** share the spatial *domain* of trees, namely the **extent** of the tree crown, these properties are in the same *property set* **crown**.

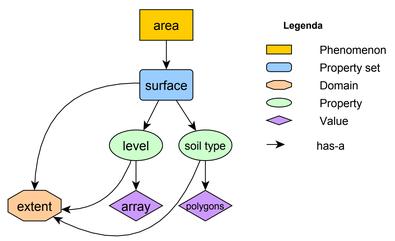


The figure below shows the two *domains*, consisting of the **extent** and the location of three *items.* Also the **biomass,** which varies over space, of these three *items* is shown.

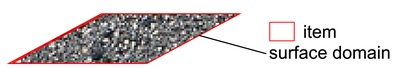


Example

We can, for instance, also represent a Digital Elevation Map, which is a typical example of a field.



The figure below shows the domain of the area. Now, the *phenomenon* consists of one *item,* so there is also one *item* in the *domain*, which is a bounding box. Also the **surface level** *property* is shown.



Modelling Language

We add the elevation from the DEM *phenomenon* to the *height* of the trees

```
trees.stem.heightAboveSea = trees.stem.height + area.surface.level
```

This operation adds the elevation from the DEM (at the locations of the trees) to the height of the trees.

Another example that uses both field and agent is trees fallen as a result of a storm and consecutively moved downslope over a steep hillslope. We create a slope map from the DEM

```
area.surface.aspect = aspect(area.surface.level)
```

Then we move the trees by 5 meters using the aspect map (see figure below)

```
trees.stem = move(trees.stem, area.surface.aspect, <distance>)
```

The location of the *items* in the original *domain* of trees.stem is overwritten by the new location.