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Next Generation Simulation and Optimization Platform for Forest Management and Analysis

Antti Mäkinen

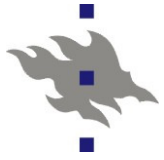
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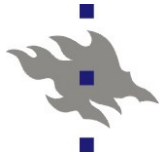
Background - The SIMO project

- "SIMulation and Optimization for the next generation planning system"
- Collaborative research project between University of Helsinki, and Finland's forest planning organisations
- 3-year project, running until 10/2007
- The goal of the project: Design and produce a set of open source components for a next generation forest planning system



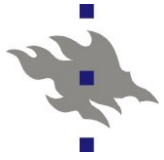
Background - The SIMO project

- Is there a need for a new forest planning system?
- Current planning systems in Finland 1) utilize only limited set of models 2) operate only with particular data sets
- Technical developments offer new data sources
- Objectives in forest planning have diversified
- Utilizing new data sources and conducting new types of analyses is difficult, or even impossible in many cases



Requirements for the platform

- FLEXIBILITY: support for various kinds data sets and models
- ADAPTABILITY: support for planning problems of different scales and types
- EXTENDABILITY: support for possible future needs



Fulfilling the requirements – platform design overview

■ Data

- Flexible, non-fixed data model – can be defined to fit different data sets

■ Models

- Separate model libraries – new models are easily implemented

■ Simulation logic

- Separated from the application logic – description of the simulation and the planning task

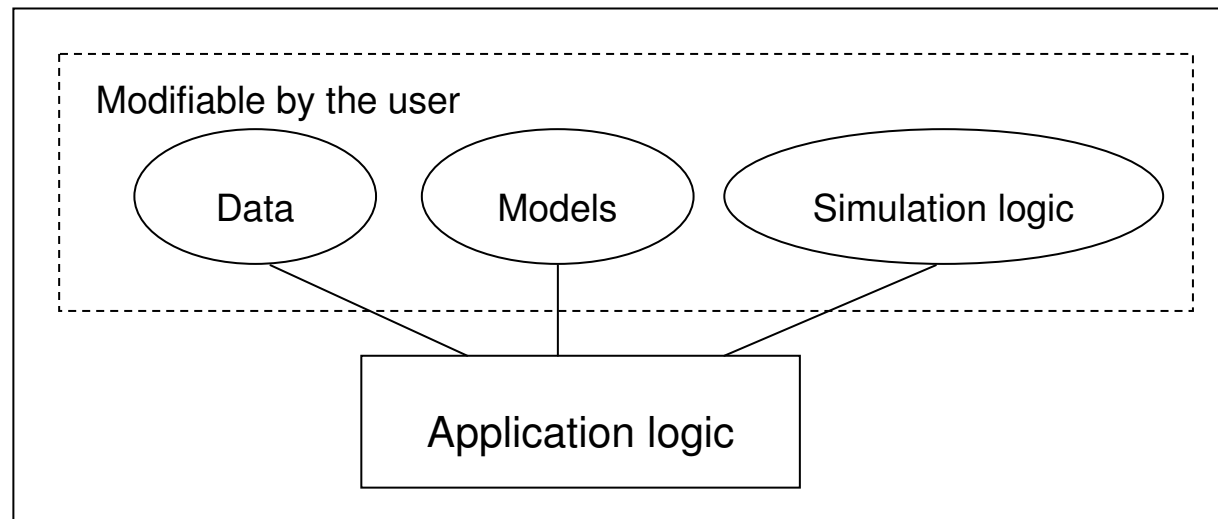
■ Application logic

- Well documented set of software modules – easy to implement into existing forest information system



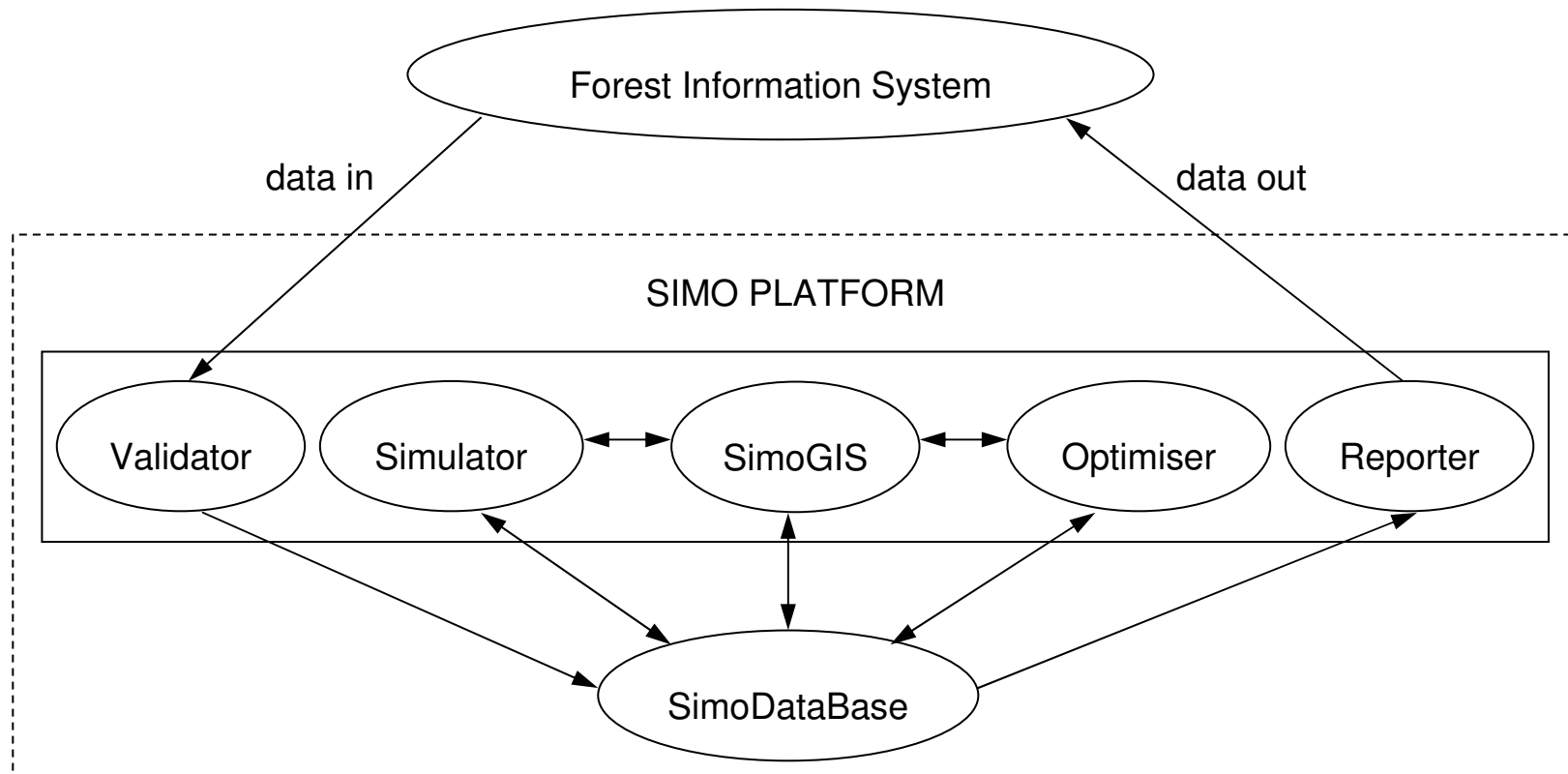
Fulfilling the requirements – platform design overview

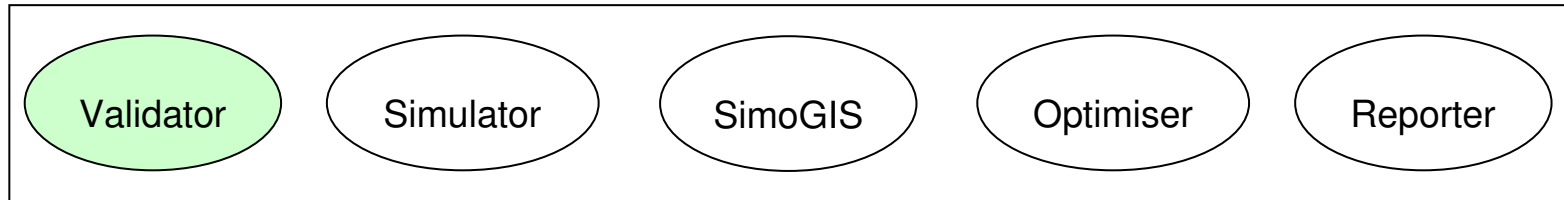
- Data content, models and simulation logic can be modified for different applications
- Application logic is hard-coded, users need not touch that



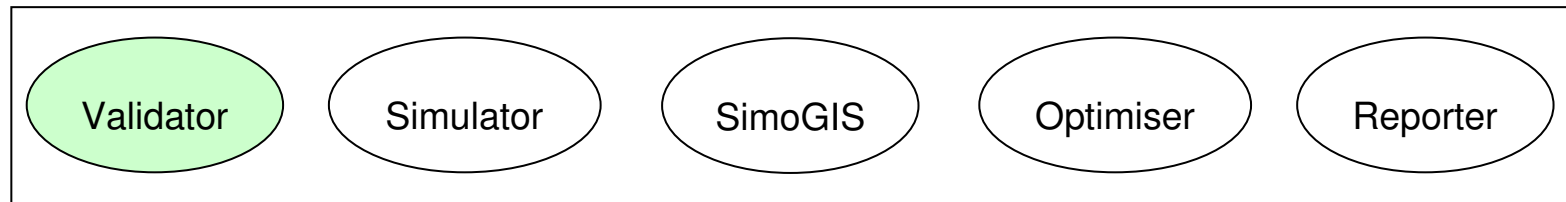


Technical solutions - platform components in detail



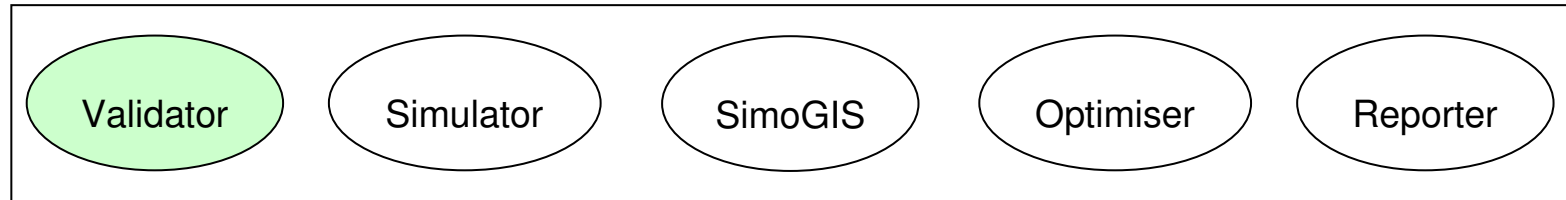


- Validates the structure of input data, model definitions, simulation logic files and other XML format input files
- Makes sure that a common "vocabulary" is used in all input files, vocabulary defined in the metadata
- Validating the content of data or simulation is more difficult, but under development



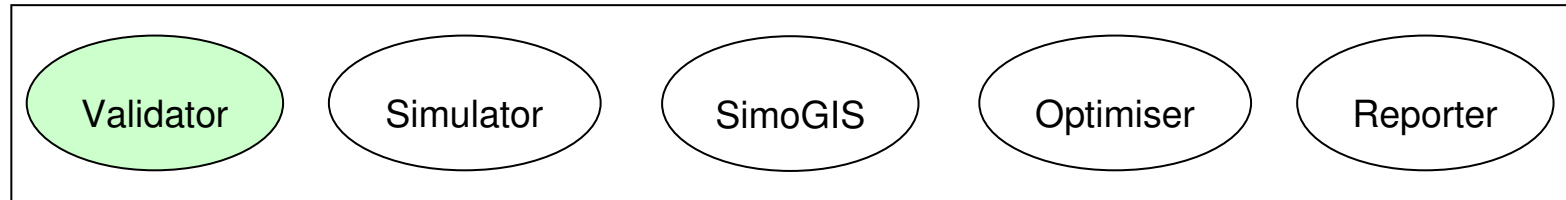
■ What XML?

```
<data>
  <object level="stand" id="123456">
    <attributes>
      <attr>
        <variable>AREA</variable>
        <value>1.608</value>
      </attr>
    </attributes>
    <subobjects>
      <object level="tree">
        <attributes>
          <attr>
            <variable>species</variable>
            <value>1</value>
          </attr>
          <attr>
            <variable>height</variable>
            <value>15.5</value>
          </attr>
        </attributes>
      </object>
    </subobjects>
  </object>
</data>
```



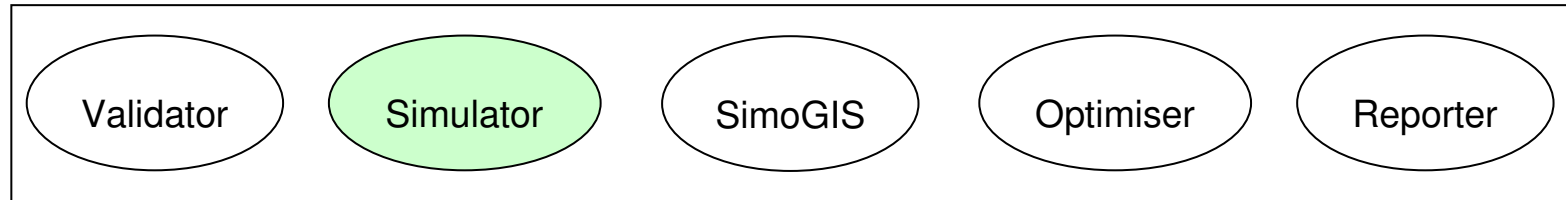
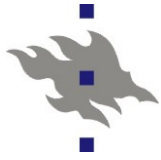
■ What XML?

```
<model_chains xmlns="http://atititude.mmvar.helsinki.fi/simo" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation="http://atititude.mmvar.helsinki.fi/simo http://atititude.mmvar.helsinki.fi/simo/Model_chain.xsd">
  <chain_group name="forestry operations on MT">
    <model_chain name="Thinnings" evaluate_at="comp_unit" output="on">
    <model_chain name="Update Stratum after thinning" evaluate_at="stratum" output="on">
    <model_chain name="Update comp_unit after thinning" evaluate_at="comp_unit" output="on">
    <model_chain name="Final harvests" evaluate_at="comp_unit" output="on">
      <task name="Ready for clearcut?">
      <task name="update passed_regen_level">
      <branching_group name="Final_harvest">
        <branch_task name="clearcut the stand">
          <condition>
          <task name="clearcut">
            <model output="on">
              <name>clearcut</name>
              <operation>
                <cost_table>timber_prices</cost_table>
              </operation>
            </model>
          </task>
          <task name="zero REGENERABLE comp_unit">
        </branch_task>
        <!--<branch_task name="5 year delayed clearcut">
      </branching_group>
    </model_chain>
    <model_chain name="Update comp_unit after clearcut" evaluate_at="comp_unit" output="on">
  </chain_group>
</model_chains>
```

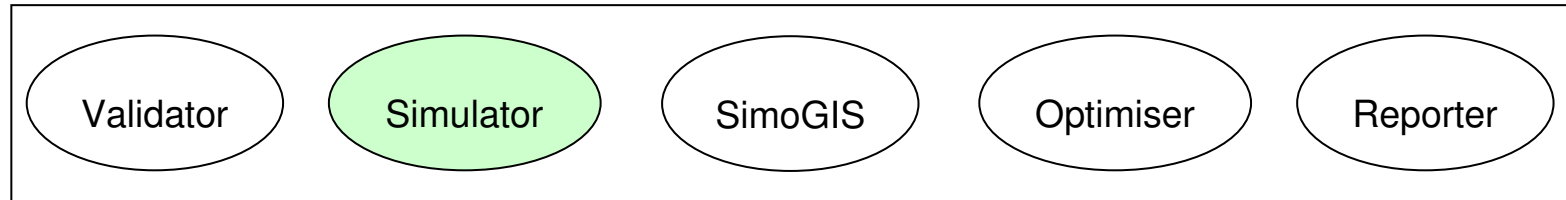


■ What XML?

```
<operation>
  <name>clearcut</name>
  <implemented_at>OperationLibrary.dll</implemented_at>
  <implemented_in>C</implemented_in>
  <type>model</type>
  <description>First implementation of a clearcut model.</description>
  <data>
    <variables>
      <variable>
      </variable>
    </variables>
  </data>
  <results>
    <result>
    </result>
  </results>
</operation>
```

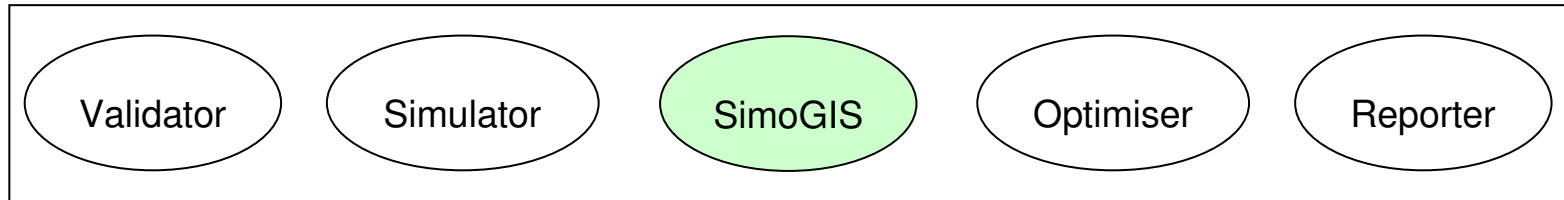


- Common metadata for the data, simulation logic and the models connects the XML files with the application logic to create a simulator
- Simulator processes the data according to the simulation logic
- Currently a simulator with treewise models and a simulator with standwise models for Finland's conditions have been implemented in SIMO

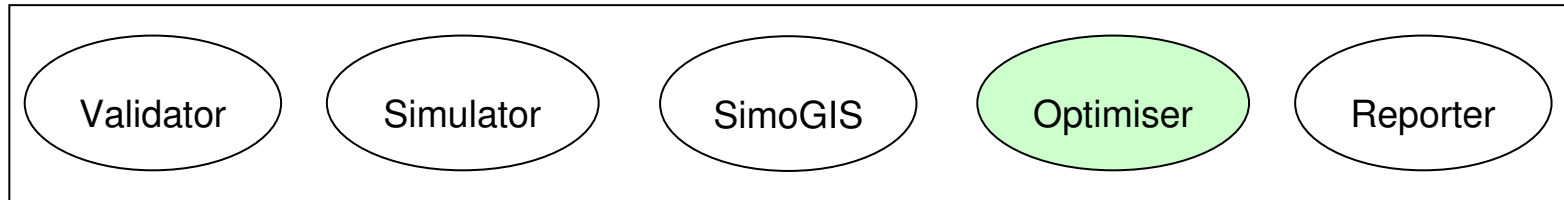


- Want to simulate some new phenomena? Implement the needed models into a model library, define the simulation logic and start simulating!

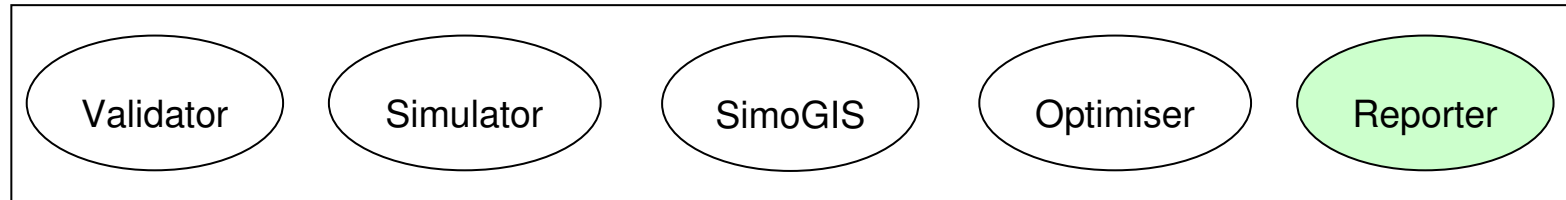
- Simulator implementation:
 - Software modules programmed in Python
 - Simulation logic and models are described in XML (eXtended Markup Language), structures of xml documents in SIMO schemas
 - Models can be implemented in C, C++, Fortran or Python



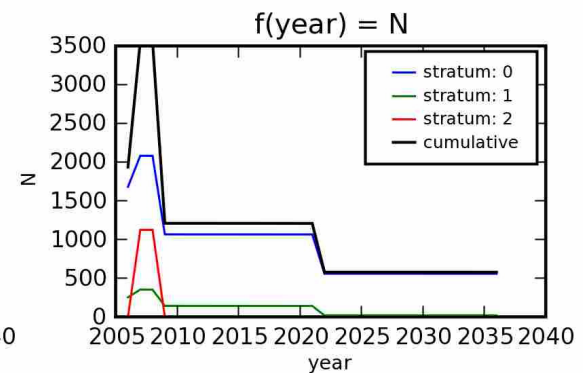
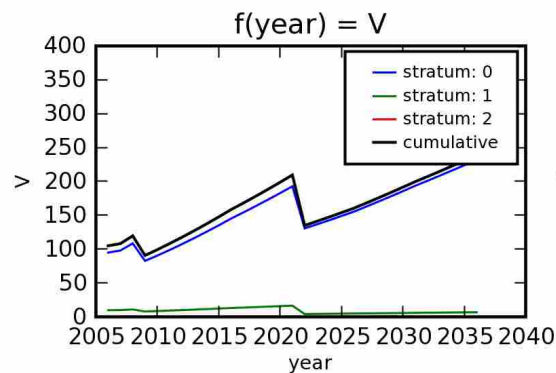
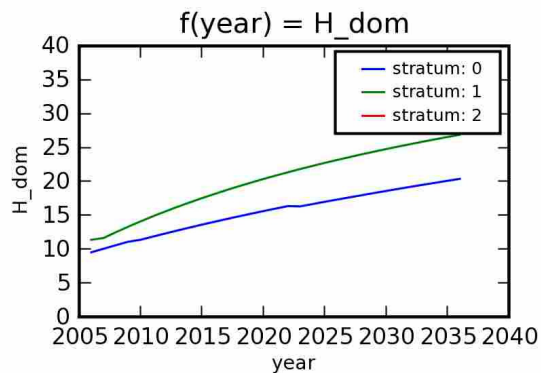
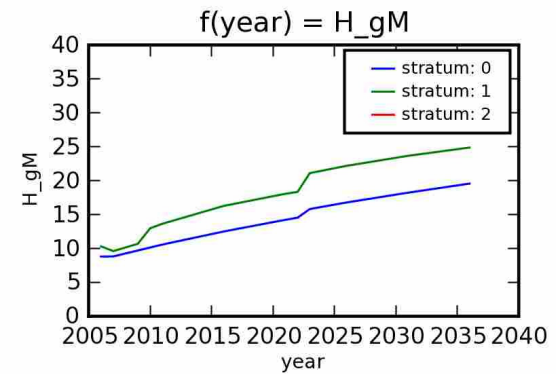
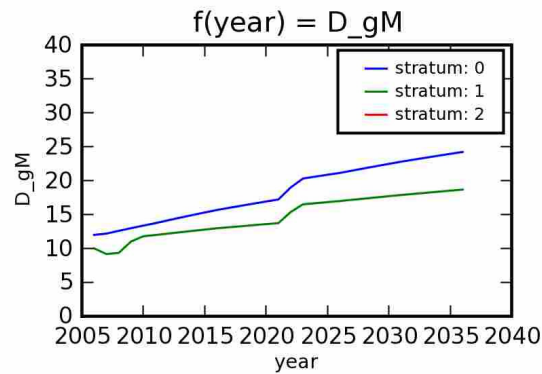
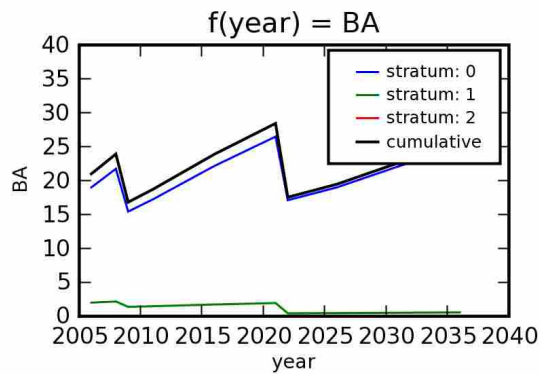
- Handles the spatiality in the simulations and optimisation: neighbourhood operations, splitting and union of objects
- Data exchange format GML (Geography Markup Language), XML standard for geographic information
- Development in early stage...



- Development about to begin
- Will include linear programming and metaheuristic methods



- Generates output from the simulation/optimisation results, currently outputs XML, text and simple graphs





And finally

- Can be easily integrated into existing systems, no user interface within this project
- All the components will be distributed as open source at the project website
- More information:

<http://www.mm.helsinki.fi/mmvar/simo>

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