

# Software Architectures for Distributed Environmental Modeling

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# Outline

- Background
  - iEMSs OGC MoU: standardisation in the field of distributed environmental modelling
- Current developments
  - OSGIS 2011, FOSS4G, MODSIM, iEMSs, ...
  - also this conference...
- Future
  - iEMSs 2012 session and workshop proposal

# CLIME modelling workbench

CLIME catchment modelling - Mozilla Firefox

File Edit View History Bookmarks Tools Help

URL not shown

Dear Ari Jolma, welcome to the [CLIME catchment modelling workspace](#). [Archives](#) of the Catchment Modelling email list, [CLIME homepage](#)

GWLF
  Parameters
  Georeferencing
  Options
  Filetool
  Editor
  Show only my projects

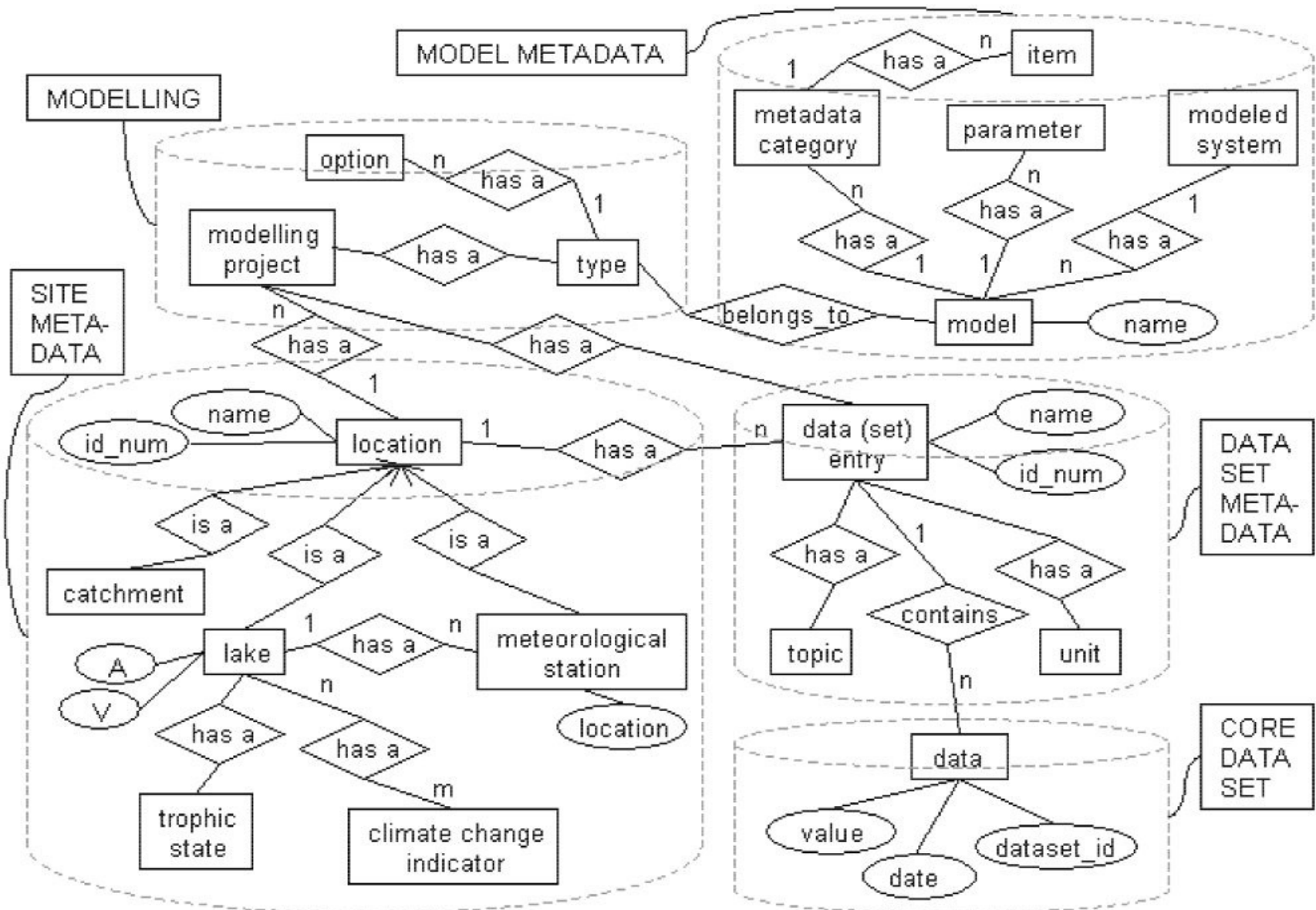
### The interactive table for GWLF modelling

Rows are 'modelling project' objects. Editing is allowed only to the owners. Everybody can add new objects. Use the [CLIME metadata editor](#).

Catchment	Owner	Area	Channel Flow Coeff	Deep GW Cap	Melt Coeff	Precip Correct Factor	Recess Coeff	Slow Recess Coeff	Soil Water Cap
<a href="#">Arbogaån</a>	Karen Moore	3802							
<a href="#">Arbogaån (all sub-catchments combined)</a>	Karen Moore	3378			0.22	0.93	0.02		7.27
<a href="#">Káfalla</a>	Karen Moore	413			0.36	0.93	0.02		5.87
<a href="#">Fellingsbro</a>	Karen Moore	298			0.22	0.99	0.03		12.6
<a href="#">Dalkarlvshyttan</a>	Karen Moore	1183			0.21	0.91	0.02		4.76
<a href="#">Hammarby</a>	Karen Moore	891			0.24	0.89	0.03		6.82
<a href="#">Rällsjälven</a>	Karen Moore	298			0.19	0.96	0.02		9.17
<a href="#">Kringlan</a>	Karen Moore	295			0.21	0.93	0.06		12.15
<a href="#">Hedströmmen</a>	Karen Moore	1058							
<a href="#">Dömsta</a>	Karen Moore	998			0.41	0.94	0.02		8.48
<a href="#">Bernshammar</a>	Karen Moore	595			0.31	0.91	0.02		5.72
<a href="#">Köpingsån</a>	Karen Moore	284							
<a href="#">Odensvibron</a>	Karen Moore	110			0.17	0.98	0.04		12.98
<a href="#">Kolbäcksån</a>	Karen Moore	3093							
<a href="#">Hallstahammar</a>	Karen Moore	2849			0.14	0.86	0.02		3.99
<a href="#">West Branch Delaware River</a>	Don Pierson	912			0.45	1	0.1		10.9
<a href="#">Lough Leane basin</a>	Eleanor Jennings								
<a href="#">Flesk</a>	Eleanor Jennings	332	0.42	6.81	0.45	0.89	0.1	0.0155	25
<a href="#">Deenagh</a>	Eleanor Jennings	31	0.467	16.08	0.45	0.75	0.033	0.0037	25
<a href="#">Long Range</a>	Eleanor Jennings	130	0.25	8.41	0.29	1.27	0.089	0.0207	20
<a href="#">Haarajoki</a>	Marko Järvinen	54.6							
<a href="#">Mustajoki</a>	Marko Järvinen	76.8							
<a href="#">Pääjärvi drainage basin</a>	Marko Järvinen	212							
<a href="#">Trout Beck</a>	Pam Naden	11.46	0.625	5.46	0.335	0.975	0.148	0.0054	20
<a href="#">Piburger See drainage basin</a>	Ulrike Nickus	1.6	0.145	3.206	0.15	1.155	0.01	0.011	10
			$\mu=0.381$ $\sigma=0.188$ n=5	$\mu=7.993$ $\sigma=4.907$ n=5	$\mu=0.283$ $\sigma=0.109$ n=17	$\mu=0.957$ $\sigma=0.114$ n=17	$\mu=0.046$ $\sigma=0.040$ n=17	$\mu=0.011$ $\sigma=0.007$ n=5	$\mu=11.806$ $\sigma=6.778$ n=17

Update data Done

# CLIME database



# Middleware, Enterprise Application Integration

- Alonso et al, 2004: Web Services
- Resource management layer / Application logic layer
- Middleware offers programming abstractions that hide complexities of building distributed applications (in the resource management layer)
  - use remote services, authentication, naming, multi-threading, logging, transactions, asynchronicity, persistent objects, messaging, ...
- EAI is a generalization of the middleware idea, which includes application logic layer

- Consortium created for standardization efforts
- Geospatial data as services
  - National and international SDIs (Spatial Data Infrastructures): use OGC standards → much interest (software, data services)
  - WMS has time parameter, WFS can use it as a property
- Processing services
  - Emerging area, initial services are basic geospatial methods
- Sensor web enablement
  - Model as a Sensor?
    - SUDPLAN paper in this conference
    - (My experience: HYDROSYS project, GSN software, linking of models with GSN)
- Domain working groups
  - iEMSs and OGC MoU, Earth Sciences WG – environmental modeling

# Other things open

- Open standards
- Open data
  - Data that is free for use and building on
  - Sometimes elementary data items, often real-time
  - Also voluntary data – the complementary use of different types of data
  - Open for processing chains that complement the data
- Free and open source software
  - Software that is free to use and build on
  - Low threshold for use through standards and openness

# Linking models to data, with each other and into systems

- Bai and Fitch, MODSIM 2009: Data services with *enterprise service bus*; *Web service* interface for models; also Theisselmann et al, workflows, same conference
- Granell et al, EM&S 2010: *Service-oriented* applications for (of and from) models
- HarmonIT, Orchestra, SoDa: Linking models, data services, service chaining
- FP7 UncertWeb: creating an uncertainty-enabled *Model Web* (FOSS4G)
- FP7 EuroGEOSS: workflows to create new products from existing (interoperable) data and model (services) (OSGIS 2011 paper)
- Using models as a part of distributed environmental information systems is state-of-the-art
  - for example the case of Baltic Sea oil spill situation picture system – the use of oil spill simulation model Seatrack Web (developed by SMHI)

# The case of model development and evaluation

- Jakeman et al, 2006: Ten iterative steps in development and evaluation; and other such modelling workflows
- Steps are knowledge-intensive and explorative
  - thus need for generic tools, and
  - flexible data services
- But the *workflow* itself could be supported (actually the modelling team)
  - Working through the workflow would create a database of the modelling (which could then be published)
  - Requires ontologies / object-oriented databases for conceptualization and other tasks

# Collaboration

- iemhub.org "online community resource for those involved in the development, evaluation, and application of environmental models"
  - tool repository, but no collaborative development in the sense of versioning systems
- community modeling, an older idea
  - for example the chesapeake community modeling program
- social networking, distributed by default

# IBAM

- Integrated Bayesian risk analysis of ecosystem management in the Gulf of Finland
- Included in the project a test/tool development for collaborative development of Bayesian networks
  - subversion repository for networks
    - a bit geeky perhaps...
  - store/load models into/from a relational database
  - software for Bayesian networks: good FOSS solutions lacking → server side solution for those without workstation licences

# Bits and pieces of distributed IS architectures

- Concepts
  - Service, Event, Task, Message
- Roles
  - Subscriber, Event handler
- Patterns
  - Publish-find-bind
  - Workflow patterns

This is the machinery,  
or components  
to build architectures from.

The classes for modelling  
objects inherit from these.

Then the distributed modelling  
applications use those as  
first-level objects?

# Conclusions

- Three areas of interest; regarding standardisation:
  - linking: *model web enablement?*
  - modelling: *workflows*
  - collaboration: *descriptions of modelling?*
- Types of modelling
  - "routine" (requirements of WFD for example...)
  - unstructured (research, problem solving)

Thank You!

<http://geoinformatics.tkk.fi/dem/>