Model as a Service (MaaS)

~ Position Paper ~

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Abstract. An important challenge in today's environmental models is to support the migration from stand-alone applications to services on the Web in the context of a wider environmental user community of service providers and service consumers. We refer to this shift in the way environmental models are provided as *Model as a Service (MaaS)*. This paper introduces the MaaS concept, exemplifies it with a case study from the area of oil spill risk analysis, and highlights future challenges for this emerging concept.

The *Model as a Service (MaaS)* Concept

The *Model as a Service (MaaS)* concept has evolved as a merge of the *Model Web* (Geller and Turner, 2007, Geller and Melton, 2008) and *Software as a Service (SaaS)*,[1] in the context of the current *Everything as a service*,[2] as a concept of being able to call up re-usable, fine-grained software components across a network. MaaS is a version of SaaS in this layer of services. SaaS is defined as a model of software deployment whereby a provider licenses an application to customers for use as a service on demand. The Model Web is defined as an approach to manage models on the Web. In this context, the aim of MaaS is to provide access for the scientific community to modern research models (e.g. space models,[3] ecological models[4]) through an automated request system for model runs, with modern, online visualization and analysis tools and through standard data formats for simulation data interoperability. This provision of models strongly depends on the flexibility, which should be allowed, both in respect to provided data and to changing model parameters. Many models are closely related to the underlying data and providers are often not willing to provide data access. Under the MaaS view several access options can be allowed.

From the current OGC[5] perspective, any service which allows for passing input parameters for an execution (data sets and/or other variables) can be provided as a Web Processing Service (WPS).[6] If inputs are not required/allowed, encapsulation may happen as a data-providing service, e.g. Web Feature Service (WFS),[7] Web Coverage Service (WCS),[8] or a Sensor Observation Service (SOS).[9] SOS seems most suitable for providing MaaS, because they allow for real-time data access and better handling of time series data. Notably, the

[1] http://en.wikipedia.org/wiki/Software_as_a_service
[2] http://en.wikipedia.org/wiki/Everything_as_a_service
[3] http://ccmc.gsfc.nasa.gov/modelweb/
[4] http://gcmd.nasa.gov/records/NASA_ARC_TOPS.html
[5] http://www.opengeospatial.org/
[6] http://www.opengeospatial.org/standards/wps
[7] http://www.opengeospatial.org/standards/wfs
[8] http://www.opengeospatial.org/standards/wcs
[9] http://www.opengeospatial.org/standards/sos

encapsulation as data-providing services does not allow requesting intermediate status of the model. Such interfaces are simply not supported.

Apart from the provision as services, it has to be mentioned, that (ideally) clients, i.e. user interfaces, should accompany the MaaS. These allow users to test the MaaS, which allows fitness for purpose measures.

Historically, MaaS also relates to the evolution from object-oriented frameworks, through components distributed heterogeneous services with CORBA and Java RMI/JEEE and others to services in a service-oriented architecture typically accessed through Web services.[10] The additional aspect of MaaS in the context of SaaS is the combination of technologies from Cloud/Grid computing with the use principles from Semantically Enabled Service Architectures (SESA) (Brodie et al, 2005) and Service-Oriented Knowledge Utilities (SOKU) (De Roure 2006). SOKU captures three key notions: Service-Oriented (the architecture comprises services which may be instantiated and assembled dynamically, hence the structure, behavior and location of software is changing at runtime); Knowledge (SOKU services are knowledge-assisted ("semantic") to facilitate automation and advanced functionality, the knowledge aspect is reinforced by the emphasis on delivering high level services to the user); Utility (a directly and immediately useable service with established functionality, performance and dependability, illustrating the emphasis on user needs and issues such as trust).

The convergence between Grids, Web Services, Semantic technologies, and emerging Service Oriented Architectures will enable the provision of computing, data, information and knowledge capabilities such as utility-like services in the future, including services which intersect with the physical world through a wide range of computing devices.

MaaS can be realized in different ways and on different platforms, from the use of independently managed data and processing centers through the use of Cloud computing (Chappell 2008) and Grid computing[11] technologies, and service-oriented infrastructures. Common for these is a need for a managed service directory and support technologies for service invocation and service composition/chaining.

Any framework realizing MaaS will have to implement a set of components that will enable easier use of environmental models by non ICT-skilled users and with advanced semantic technology support. Specifically, we envision tools and components for portals with a pluggable decision support framework, support for visual service chaining, migration of existing environmental modeling applications to MaaS, semantic annotation infrastructures to support visual semantic annotation mechanisms and multilingual ontology management, execution space which comprises a semantic discovery catalogue and semantic service mediator, and adaptive service chaining execution.

By realizing the MaaS vision in domains such as the environmental domain, several benefits can be envisioned:

- Publication and high-level, multi-lingual re-use of models
- Different levels for access to models can be provided (completely encapsulated, with modifiable parameters, or loosely-coupled components)
- Models may be used to interact with each other, e.g. in service chains

[10] http://www.w3.org/2002/ws/
[11] http://en.wikipedia.org/wiki/Grid_computing

- Enables formation of user communities
- Enables faster/real-time decision making process
- Enables a shared modeling infrastructure

We envision the core application of MaaS is in the area of online environmental decision support systems. In the following we give an example of such an application in the context of oil spill risk analysis.

Case study: Oil Spill Risk Analysis

Accidental oil discharges do happen and may potentially severely harm the natural environment. Oil spills at sea call for a quick and adequate response in order to minimize biological and other consequences. Knowledge about the behavior and fate of oil spills is crucial for preparedness and for taking adequate response actions. SINTEF[12] has developed the OWM (Oil Weathering Model) and OSCAR (Oil Spill Contingency And Response model) modeling applications to support decisions in this domain. Both OWM and OSCAR will utilize the MaaS composition tool for making existing environmental models available as services. In the Oil spill pilot case in a Norwegian context, we can envision the following providers and services (Figure 1).

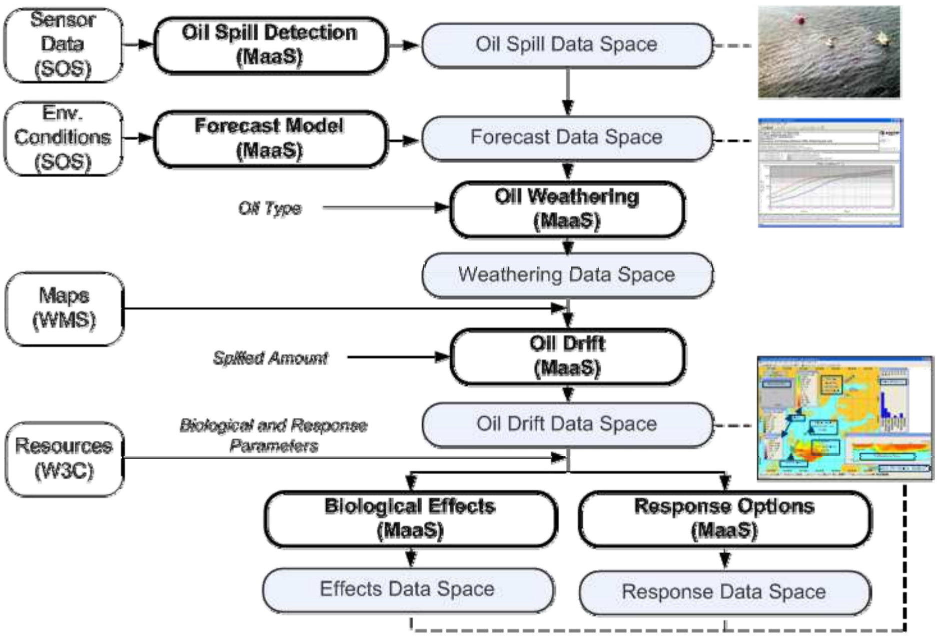

Figure 1. Oil spills in Norway: Service-based modeling.

The aim of this use case is the validation of the MaaS-enabled framework to a demanding application area of environmental modeling. The MaaS-enabled framework provides the means for encapsulating environmental models as services and for the connection of data services, such as OGC WFS, SOS, WMS, and traditional Web services.

[12] http://www.sintef.no

Challenges

When migrating an environmental application to a MaaS, a number of challenges arise. Some of them are quite mundane but may be time-consuming:

- Extracting the model logic from the rest of the source code
- Transforming data between external standard formats and internal proprietary formats
- Handling differences between old and new platform on various levels: Operating system, compiler, libraries, file systems etc.

The availability of sensor data in the MaaS world presents a specific challenge. If such data are used to update an environmental model, the model needs to support *data assimilation*. Data assimilation is by far more complex than a regular data import.

- Extending an environmental model with data assimilation capabilities is definitely a non-trivial task.
- Data assimilation is highly CPU-intensive. Both Grid and Cloud computing approaches are viable options.

MaaS's can conceivably be combined in different ways. In batch style, models are executed in a sequential manner. In distributed style, models affect each other during execution. Hence, we have parallel and distributed simulation. This is how nature works but it is highly complex to implement for models.

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