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# Advanced Cascading Sensor Observation Service

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Main goals of "Global Monitoring for Environment and Security" (GMES, see http://www.gmes.info/), and "Global Earth Observation System of Systems" (GEOSS, see http://www.earthobservations.org) can be summarized as: "how to remove the obstacles for sharing environmental information?".

Austrian Research Centres (ARC) participates in development of the IT-infrastructure, architecture and services capable of addressing this challenge in the context of risk management through ORCHESTRA IP (http://www.eu-orchestra.org/), and in the context of environmental monitoring networks through SANY IP (http://sany-ip.eu/).

In order to minimize the cost associated with "bridging the technology gaps" between the networks, ORCHESTRA proposes an abstract architecture and a methodology for mapping this abstract architecture onto the technical platform of choice. At the level of information exchange, ORCHESTRA demands self-description of all services and data offered in a network. In particular: "*all meta-information MUST be provided at least in a form suitable for interpretation by humans*"; "*syntactic meta-information MUST also be provided in a form suitable for interpretation by machines*"; and "*providing semantic meta-information in a form suitable for interpretation by machines (e.g. by means of an ontology) is highly encouraged*" [Schimak (Ed.), 2007].

An analysis of the service specifications developed by Open Geospatial Consortium "Sensor Web Enablement" working group (OGC SWE; see http://www.opengeospatial.org/projects/groups/sensorweb) performed by SANY IP [Havlik et. al 2007; Bartha,(ed.), 2006] has shown that OGC SWE services are both very generic and compatible with the ORCHESTRA architectural model [Usländer, 2007]. Consequently, SANY IP decided to embrace the OGC SWE service interfaces as they are, and concentrate on implementing the advanced "GEOSS (software) building blocks", extending the functionality and optimizing the overall sensor network performance. One such "building block", which will be firstly discussed at this workshop, is the advanced cascading SOS service (SOS-X).

As its name suggests, the cascading SOS is a client to underlying SOS service(s) [Na, 2007] and provides alternative access routes to users (or services) interested in accessing the data. In its simplest form, cascading SOS *replicates* part of the data offered by underlying SOS service with no changes to the data model (Figure 1a). This kind of service replication can be e.g. used to assure controlled access only to a subset of data offered by lower-level SOS, without relying on complex security mechanisms. In fact, many of the organisations ARC collaborates with use this type of gateway services as a reliable

mechanism for separating the information that may be seen only within their own network from those offered to a wider public.

Second example of the cascading SOS deployment is the *simple aggregation* of data from several underlying services; e.g. aggregation of offerings from several data loggers into complete sensor network offering, or aggregation of offerings from EU states on a single service (Figure 1b).
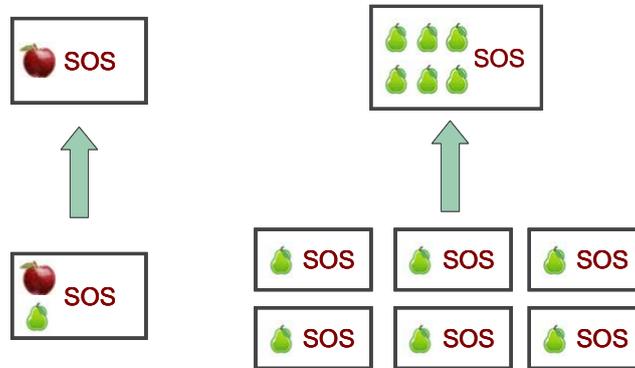
**Figure 1: Two forms of simple cascading: (a) replication; and (b) aggregation**

*Simple SOS replication* and *simple SOS aggregation* described above are only feasible in the context of a single environmental domain with a single data model accepted by all involved parties. Unfortunately, this is rarely a case in the context of GEOSS or GMES, because (a) information models often aren't standardized above the level of a single state; and (b) different tasks require different views to information.

With this in mind, we decided to develop a service capable of transforming the SOS information model (Fig. 2), similar in spirit to ORCHESTRA Translating Feature Access Service (FAS-X) [Anders, 2008]. Following the ORCHESTRA naming convention, the advanced form of the cascading SOS service may be called "Translating Sensor Observation Service" (SOS-X) in later versions of the SANY architecture.
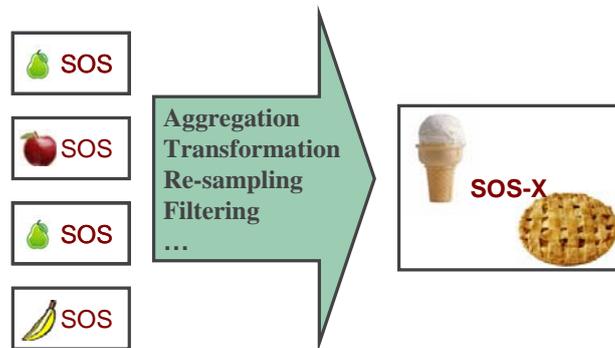
**Figure 2: Advanced SOS cascading with SOS-X**

Most of the SOS servers in SANY IP organise information in time series. Consequently, a decision was made to integrate an enhanced version of the UWEDAT "formula server" [Schimak, 2003] called "Formula 3" (F3) into SOS-X prototype. F3 shall be described in details in a separate publication. For the sake of current discussion, it is important to understand that F3 works independently from UWEDAT monitoring system, and that it allows arbitrary algebra operations on time series, annotation, and re-mapping of the meta-information.

As a result SOS-X shall be capable of sophisticated pre-processing of the data from underlying SOS servers, including on the fly information model transformation; unit conversions, temporal and spatial interpolation; temporal and spatial re-sampling

(interpolation and aggregation/averaging); and filtering (e.g. finding the pollution episodes; merging of offerings; cutting the offerings in smaller sub-offerings; etc.).

At the time of writing this article, the cascading SOS is in the early prototype phase, and some parts of the functionality are still under discussion. Current prototype is capable of simultaneously accessing the data from one or more SOS servers and from the ARC's UWEDAT monitoring system, and exposing them over SOS interfaces with no changes to the information model. F3 pre-processing engine itself is developed in parallel, with the intention to integrate the two pieces of software into first SOS-X prototype and evaluate its usability in SANY architecture and pilot applications (v1) by the end of 2008. This leaves enough time to development the improved version of the SOS-X (v2) before the end of the SANY IP (Q4 2009). Depending on the feedback from v1 evaluation, SOS-X v2 development may either concentrate on stability, interface standardization and user friendliness, or on additional features.

In the long run, ARC is interested in expanding the SOS-X into universal "bridging" service that would minimize the price of sharing the information in the context of GEOSS and GMES. Therefore, the SOS-X implementation architecture foresees a plug-in mechanism for extending the cascading mechanism to other sources of information, such as data files, proprietary legacy systems, ORCHESTRA Feature Access Service, or OGC Web Coverage Service. As a proof of concept, SOS-X can be already used as a front end to UWEDAT monitoring system (Figure 3).

Another interesting feature which may be integrated in for the v2 of the SOS-X service is pre-fetching and caching of information. This could significantly diminish the time needed to query the archived information, especially in the case when caching server is positioned on a fast LAN, near to the data consumers (Figure 3). This could significantly enlarge the usability of OGC SOS service for handling large data sets, as compared with the more common situation where data needs to be transferred over (slow) Internet lines. In addition, the caching server could also improve the robustness and scalability of the data access, e.g. in the case the original server itself or the Internet connection is temporarily inaccessible or overloaded.
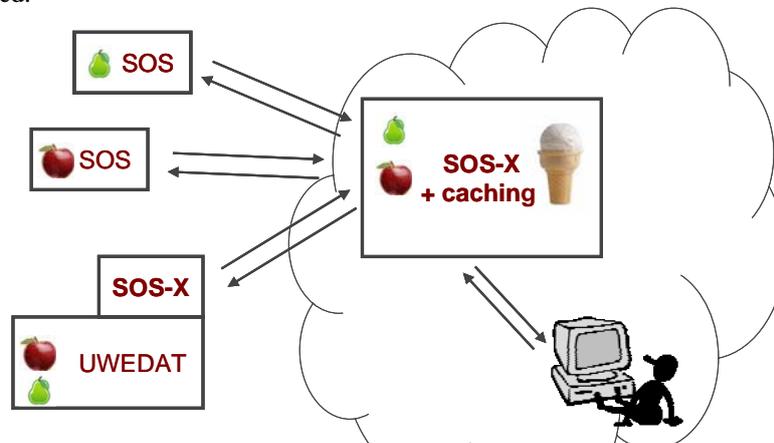


**Figure 3: Caching SOS-X as a gateway to UWEDAT system and as SOS proxy**

However, caching opens up a number of challenging questions. In fact, the efficient work of the cache (with SOS specifications v1.0.0) can only be assured if two important rules are followed: (1) all data offered by underlying SOS must carry a publication date; and (2) no data is ever deleted. A number of other measures can be taken to further improve the efficiency of the caching, such as (1) adding the information on expected frequency of updates to the offerings; (2) designing the offerings in a way that minimizes the duplication; (3) offering a subscription mechanism to notify when updates are available; or (4) even push complete updates to subscribers.

**ACKNOWLEDGEMENTS**

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