The Sensor Integration Platform TSB - current status and outlook

S. Gensch et. al.
GFZ German Research Centre for Geosciences, Potsdam, Germany

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Introduction

The *German Indonesian Tsunami Early Warning System* (GITEWS) (Rudloff et al., 2006) is built upon a complex sensor system infrastructure providing seismological, near real time GPS deformation and tide gauge data via a sensor integration platform. The integration platform (called the Tsunami Service Bus TSB) implements the Sensor Web Enablement (SWE) standards and services following the paradigm of a Service Oriented Architecture (SOA). It is realized on basis of the J2EE - compliant industrial strength open source application server JBoss AS 4.2.3-GA.

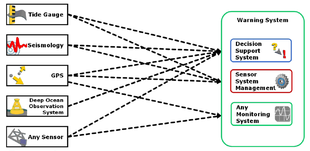


Figure 1:
Multiple sensor sources contribute fundamental data for tsunami wave prediction. Since all these sensor systems use proprietary data formats and specific behavior, a system for sensor data integration is needed (Fleischer et. al., 2010).

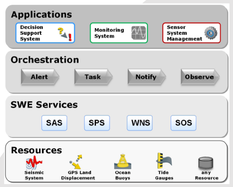


Figure 2:
Layers of SOA in GITEWS context (Fleischer et. al., 2010).

Layered Architecture

The sensor systems and the TSB provide fundamental data for tsunami wave prediction. Development of the TSB recognized the fact of being able to incorporate a changing sensor system base with possibly proprietary data formats and delivering a stable and uniform interface to consuming clients, such as the Decision Support System at the warning centre. Thus, the TSB is architecturally divided into a *sensor*, *service* or *integration* and an *application* layer. Sensor integration features two distinct interfaces: a Dispatcher as a Java Message Service (JMS)-based receptacle for incoming data and a *Sensor Manager* for sensor tasking. The integration layer is comprised of the TSB providing the SWE service interfaces up to the application layer and the before-mentioned interfaces down to the sensor layer. Currently, an implemented sensor registry provides means of sensor metadata management for sensor location.

Logical Architecture

The TSB is logically clustered into five components, Processing, Provisioning, Tasking, Registry and Database reflecting the main functional use cases of a sensor integration platform. Data transportation is performed on basis of asynchronous message oriented middleware using JMS technology via JBoss Messaging. The TSB features reliable data transportation from received sensor data up to the application layer by means of JMS. A transactional processing workflow for every incoming message ensures that it is properly handled. New sensor types are integrated via a plug-in mechanism to incorporate specific semantics and data format. Provision of sensor data for the SWE services is realized through web service implementations. The TSB is easily deployed as a single Java EE enterprise application component (`*.ear`) within the JBoss application server.

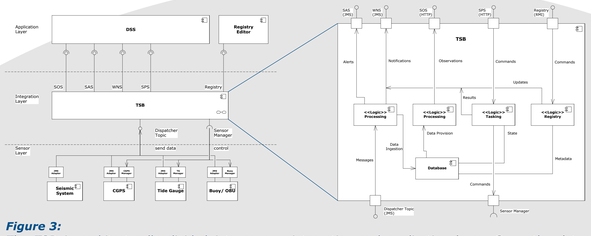


Figure 3:
The TSB is architecturally divided into sensor, integration and application layer. Currently, data streams from Buoy and Ocean Bottom Units are not actively used within the warning process.
Sensor Layer: *Sensors and sensor systems are located at the Sensor Layer, providing data for the warning system. This data contains typical sensor measurements from tide gauges, but also computationally intensive events, such as detected earthquakes from the Seismic System or land displacements from the Continuous GPS System (CGPS). Data providers from the sensor layer publish data onto a JMS dispatcher topic, where it is then processed and stored.*
Integration Layer: *The integration layer contains the TSB serving as the integration platform. The TSB provides interfaces up to the application layer comprising the four Sensor Web Enablement (SWE) services (SOS, SAS, SPS, and WNS, and interfaces down to the sensor layer comprising the generic Dispatcher Topic and the Sensor Manager interfaces. Furthermore, the TSB also implements the Sensor Registry, responsible for all sensor metadata management in GITEWS. The SWE services are implemented according the OGC specification.*
Application Layer: *The client applications reside at the topmost layer. The most important of these applications is the Decision Support System (DSS), which aggregates the sensor data further to highly aggregated information products to assist the Chief Officer on Duty in his/her decision whether a tsunami warning should be disseminated. Additionally, also the Registry-GUI has access to sensor metadata through the TSB.*

Tide Gauge GUI

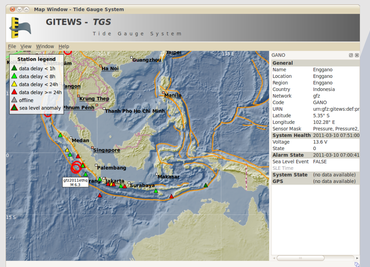


Figure 4:
Map view of tide gauge stations within the Tide Gauge GUI. (gempa GmbH)

Figure 5:
The trace view shows sea levels from the past 24 hours. (gempa GmbH)

Figure 6:
A detailed view per station for all available sensors. (gempa GmbH)

SWE Interfaces

The TSB contains implementations for the SWE specifications of *Observations & Measurements*, *Sensor Model Language*, *Sensor Observation Service*, *Sensor Planning Service*, *Web Notification Service* and *Sensor Alert Service*. Functionality of the TSB (e. g. alert/ notify, task) required by application layer consumers is provided using the interoperable SWE services. Early case studies proved the general applicability of SWE for sensor based natural hazard systems (Walkowski, 2005; Moodley et al., 2006; Chu et al., 2006).

TSB Clients

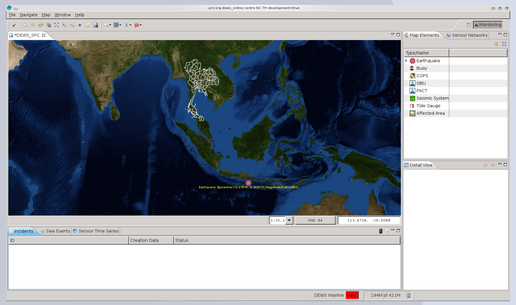
The Tsunami Service Bus is currently used by several client applications. The Decision Support System of the DLR is currently one of the main consumers of the TSB SWE interface. It aggregates sensor data into highly aggregated information products to assist in decision making of tsunami warning dissemination.
The Distant Early Warning System (DEWS) uses the TSB within its CCUI component as a source for sensor data accessed by a monitoring plugin.
A GUI for tide gauge data in relation to seismic events has been developed by gempa GmbH that accesses TSB SOS.
For testing and maintenance, three lightweight web UIs have been developed to issue test queries (SOS Test Client), to perform database maintenance (SOS DB Utility) and to manage sensor metadata (Registry Editor).

```
<?xml version="1.0" encoding="UTF-8"?>
<sos:GetObservation
    ...
  <sos:offering>...tofferingtideGaugeObservations</sos:offering>
  <sos:eventTime>
    ...
            <gml:beginPosition>2012-04-19T00:00:00.000</gml:beginPosition>
            <gml:endPosition>2012-04-21T00:00:00.000</gml:endPosition>
    ...
  </sos:eventTime>
  <sos:procedure>...rprocedure:tgr:stationsrade</sos:procedure>
  <sos:observedProperty>...rphenomenon:aggregateTideGaugeWaterHeight</sos:observedProperty>
  <sos:responseFormat>text/gml;subtype="OM/1.0"</sos:responseFormat>
</sos:GetObservation>
```

Figure 7:
Sample SOS request for accessing observations of a tide gauge station withing a given time frame.

DEWS

Figure 8:
The monitoring view of the DEWS system accesses the SOS web service via SWE conformant SOS requests, as any client would to to access TSB sensor data. Incoming requests are received and parsed by an SOS servlet and converted from XML into an internal Java structure, representing the SOS request. This request is transferred to an SOS Bean for execution of the submitted SOS request.



Outlook

The TSB features an implementation for a set of functional requirements, such as standard interfaces for processed sensor data provision and tasking, and a mid-term storage of incoming sensor data. Over the course of the GITEWS Project, the implementation of the TSB proved to be reliable and robust, operating 24/7 since 2009 at the BMKG tsunami warning center in Jakarta, Indonesia. It is also employed by the decision support system *Distant Early Warning System* (DEWS) and the monitoring system *Water in Central Asia* (CAWa)
Currently, the TSB is deployed on a JBoss 4.2.3-GA application server. Development is directed at elevating the TSB to be deployed onto the new JBoss 7.x application server, while also allowing a more flexible incorporation of new sensor system sources and sensor system types. This will allow reuse of the TSB in other projects, where reliable provision of sensor data by means of SWE interfaces is applicable. Furthermore, the TSB will be published open source as a sub project of the FOSSLAB community.
Another idea in development is to extend alert notification feeds using RSS/Atom feeds and notification via XMPP. XMPP is the preferred means of communicating sensor alerts and web notification service messages in SWE. The current TSB employs JMS as a messaging service.

Figure 9:
www.fosslab.org//web/ssb/about
The Tsunami Service Bus is intended to be published under the FOSSLAB community und a working title SSB, which might be subject to change.

References

Rudloff, A., Lauterjung, J., Münch, U., and Tinti, S.: Preface "The GITEWS Project (German-Indonesian Tsunami Early Warning System)", Nat. Hazards Earth Syst. Sci., 9, 1381-1382, doi:10.5194/nhess-9-1381-2009, 2009.

Fleischer, J., Häner, R., Herrnkind, S., Kloth, A., Kriegel, U., Schwarting, H., and Wächter, J.: An integration platform for heterogeneous sensor systems in GITEWS – Tsunami Service Bus, Nat. Hazards Earth Syst. Sci., 10, 1239-1252, doi:10.5194/nhess-10-1239-2010, 2010.

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