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Monitoring and Maintenance of the German Indonesian Tsunami Early Warning System (GITEWS)

S. Gensch[1], M. Günther[2], R. Henneberger[3]
Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences
[1]stephan.gensch@gfz-potsdam.de, [2]michael.guenther@gfz-potsdam.de, [3]ralph.henneberger@gfz-potsdam.de

GITEWS

Introduction

This poster presents aspects of and experiences with the monitoring and maintenance of the geographically distributed components of a Tsunami Early Warning System (TEWS) in the Indian Ocean. Many of the issues, encountered during work within the GITEWS project (German Indonesian Tsunami Early Warning System, Rudloff et al., 2009) on the design and implementation of the monitoring system, are also relevant for other types of warning systems. With this poster, insights and lessons learned are shared with the community. Failure to deliver a warning has fatal consequences. Based on an analysis of the criticalness, vulnerability and availability of single components, we describe the design and implementation of a communication and monitoring architecture, and development of standard operating procedures (SOP) for maintenance (Angermann et al., 2010).

Problems when Monitoring Remote Stations

Sensor stations often operate in remote areas with insufficient infrastructure (unreliable or no power supply, no stable means of communication). Thus, aside functional components, there are components for power supply, communication infrastructure and monitoring of meteorological data. Monitoring housekeeping data provided by these components allows an estimation on the station's health status. Since communication is often expensive (e. g. via satellite), sensor data is priorized over housekeeping data, thus (near) real-time monitoring of stations is not possible and mostly not necessary. Also, actively probing a station might not be an option, due to communication costs. Yet, failures have to be disseminated as soon as possible if stations diverge from normal operation.

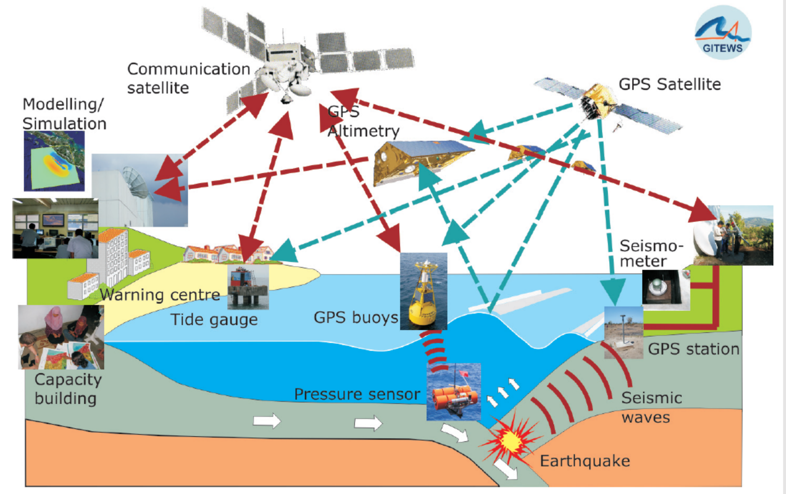


Figure 1:
Overview of systems that compose the tsunami early warning system, set up within the GITEWS project. Currently, buoys and ocean bottom units (OBU) are no longer part of the warning process. Continuous monitoring and maintenance of the components is crucial to delivering timely and accurate warnings in case of a tsunami event. (GFZ, 2009)

Monitoring Operational Assets

The GITEWS project is composed of several thousand integrated system components and software processes. During the establishment of the currently existing system, complexity grew and monitoring and maintenance needed further automatization to capture any critical states of the whole system and to establish the correct responsive means. One means of monitoring is the use of an adapted Nagios monitoring implementation covering a large number of infrastructure assets (hosts, network components, remote sensor stations, storage) and business processes (processes and applications). This is to be extended in the future for further operational monitoring of station parameters (power voltage, battery levels) with the challenge of monitoring in on- and offline modes. An aspect of maintenance is the development of practical and precise means of documenting all system properties. Providing a platform for continuous documentation of system changes and maintenance and enabling information-exchange/collaboration between the different responsible institutions, departments and companies was achieved by employing a Wiki-platform.

Scope and Concept

The scope set for this work is monitoring of widely distributed stations of seismic, continuous GPS an tide gauge type within a tsunami early warning systems. As a concept we utilize the common data streams, providing sensor data, and adding certain housekeeping data, that describes a station's health status. The integration of such housekeeping data into the free and open-source monitoring solution Nagios is demonstrated here.

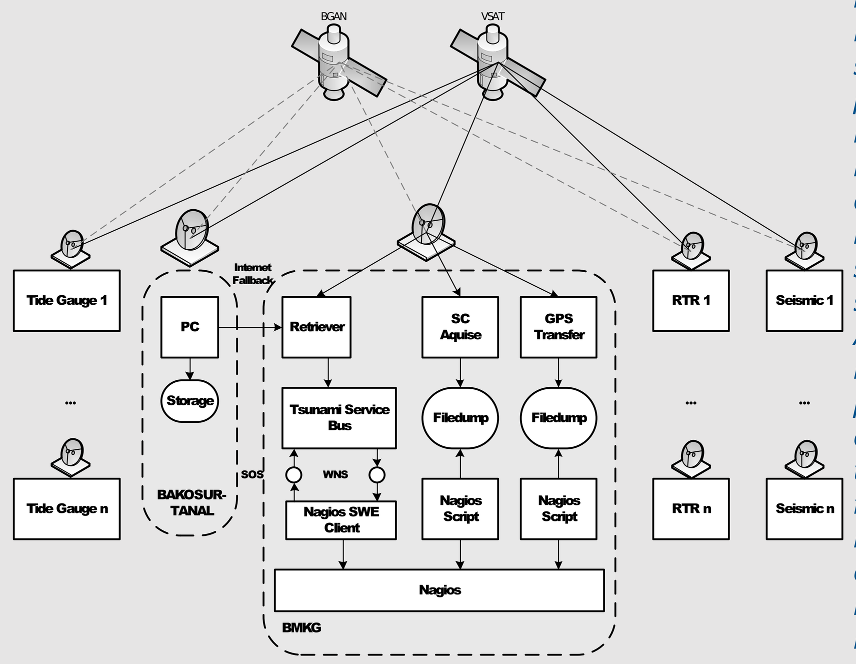


Figure 2:
Monitoring concept for distributed remote stations within GITEWS. It shows two possible approaches of aquiring and integrating housekeeping data for the monitoring solution Nagios. For seismic and cGPS stations the variant of dumping housekeeping data from the sensor data stream is employed, which is then fed via scripts to the NSCA (Nagios Service Check Accessor). Tide gauge station data is retrieved and fed into the sensor integration platform Tsunami Service Bus (TSB). It contains an existing processing module for tide gauge data and thus this mechanism for provision of tide gauge performance metrics will be employed. A client, conforming to SWE, needs to be implemented that is able to query these metrics via an SOS interface and forward this towards the Nagios server.

Monitoring of Tide Gauge Stations

During the GITEWS project, ten tide gauge stations sponsored by the GFZ were deployed in Indonesia at the coastline facing the Indian Ocean. These stations deliver timely data of sea levels and detect possible changes of water height that denote possible Sea Level Events (SLE). In total, about one hundred tide gauge stations are in effect.

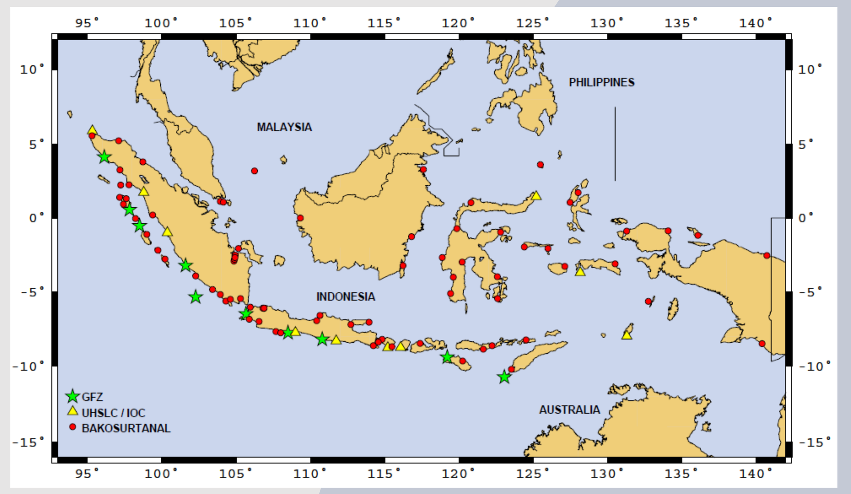


Figure 3:
Distribution of tide gauge stations in Indonesia that are part of GITEWS (Schöne et. al., 2011)

Tide Gauge Sensor Data

Sensor data of tide gauges is retrieved every 20 seconds and logged within a data unit, for mostly 3 sensor types (radar, pressure, level). A Data Record Definition defines the common data format and also contains data about subsystem voltage and meteorological data. It may be extended for other housekeeping data, like door sensors, CPU and board temperature, etc. Sensor data (from GITEWS stations) is passed in preprocessed and binary form via a satellite communication uplink. When being fed to the Sensor Integration Platform Tsunami Service Bus (Fleischer et. al., 2010), housekeeping data is stored there and thus appropriate for long term monitoring, statistical evaluation, and storage.

The main goal is to provide tide gauge station housekeeping data for the monitoring system Nagios. By implementing a Sensor Observations Service (SOS) Client for Nagios, housekeeping data stored in TSB or newly arriving housekeeping data changes may be reported directly via Nagios Service Check Accessor (NSCA) to Nagios. The Nagios SWE client can be actively notified about new sensor data, when it implements the Web Notification Service (WNS) interface, and can issue corresponding SOS requests.


```
<?xml version="1.0" encoding="UTF-8"?>
<sos:GetObservation
        xmlns:sos="http://www.opengis.net/sos/1.0"
        xmlns:gml="http://www.opengis.net/gml"
        xmlns:ogc="http://www.opengis.net/ogc"
        service="SOS" version="1.0.0"
        srsName="urn:ogc:def:crs:EPSG:4326">
    <sos:offering>
        urn:urnsubelement:def:offering:tideGaugeObservations
    </sos:offering>
    <sos:eventTime>
        <ogc:TM_During>
            <ogc:PropertyName>
                urn:ogc:data:time:iso8601
            </ogc:PropertyName>
            <gml:TimePeriod>
                <gml:beginPosition>
                    2012-01-29T00:00:00.000
                </gml:beginPosition>
                <gml:endPosition>
                    2012-01-31T00:00:00.000
                </gml:endPosition>
            </gml:TimePeriod>
        </ogc:TM_During>
    </sos:eventTime>
    <sos:procedure>urn:urnsubelement:stationID</sos:procedure>
    <sos:observedProperty>
        urn:urnsubelement:def:phenomenon:aggregateTideGaugeWaterHeight
    </sos:observedProperty>
    <sos:responseFormat>text/xml;subtype="OM/1.0"</sos:responseFormat>
</sos:GetObservation>
```

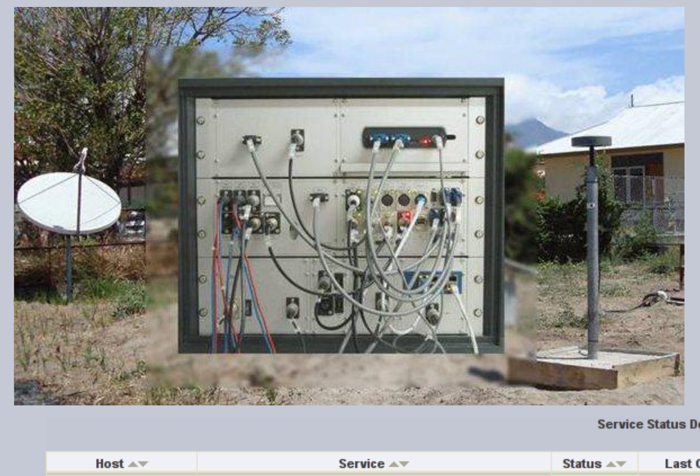
```
@@                          # Trennzeichen
2012-01-30T08:20:40.000,    # Zeitstempel
true,                       # Systemverfuegbarkeit
-0.024,                     # Sensor 1 Wert 2
13.6,                       # Subsystem Spannung
,                           # Sensor 2 Wert 2
31.6                        # Sensor 2 Wert 1
,1.766                      # Sensor 1 Wert 1
,true                       # Sensor 1 Verfuegbarkeit
,11.57                      # Sensor 3 Wert 1
,true                       # Sensor 3 Verfueugbarkeit
,true                       # Sensor 2 Verfueugbarkeit
,-0.038                     # Sensor 3 Wert 2
,true                       # Verfuegbarkeit ausgewerteter Sensor
,-0.024                     # Wert 2 ausgewerteter Sensor
,1.766                      # Wert 1 ausgewerteter Sensor
```


Figure 4:
Sensor Observation Service (SOS) example request for an offering `tideGaugeObservations` *from Jan. 29, 12 p.m. to Jan. 31, 12 p.m. of station* `stationID`*. The resulting XML-Document returns elements of distinct measurements as given in the example from Jan. 30, 8:20 a.m.*

Monitoring of cGPS Stations

At the beginning of the GITEWS project, Real-Time-Reference (RTR)-stations could only be queried for availability via ping command. Thus, the station could be detected as unreachable, but no causes, such as failure of V-SAT connection, power or computer failure, can be resolved. Using the proprietary RINEX format, data transmission has been extended to meteorological data, that allows tracing of the stations environment. Through future updates of the station's kernel, the data transmitted will be extended to specific performance metrics of the station's internal hardware components.

Using the RINEX format, the performance metrics are dumped to files and forwarded via a script to the NSCA component of Nagios.



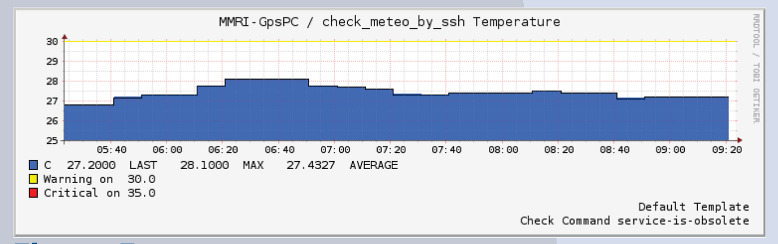


Figure 5:
A cGPS RTR station (left), performance metrics shown in Nagios for cGPS station NIAS, Indonesia (bottom) and detailed temperature values shown in a pnp-graph for the cGPS station in Maumere, Indonesia (top)

Service Status Details For Host 'NIAS-GpsPC'

Host	Service	Status	Last Check	Duration	Attempt	Status Information
NIAS-GpsPC	check_meteo_by_ssh Humidity	OK	04-16-2012 11:11:08	0d 3h 49m 36s	1/3	Check NIAS : humidity : Ok. 89.1 %, Ok. Time 869 sec
	check_meteo_by_ssh Pressure	OK	04-16-2012 11:12:51	31d 3h 34m 31s	1/3	Check NIAS : pressure : Ok. 999.5 mbar, Ok. Time 1073 sec
	check_meteo_by_ssh Temperature	OK	04-16-2012 11:14:22	1d 6h 18m 29s	1/3	Check NIAS : temperature : Ok. 28.1 C, Ok. Time 263 sec
	ping	OK	04-16-2012 11:18:01	4d 7h 44m 41s	1/3	OK - 172.16.48.55: rta 616.612ms, lost 60%

Monitoring of Seismic Stations

Housekeeping data is to be integrated into the SeedLink-stream, which is currently only transmitting seismic data. These are fed into a SeedLink-server that allows any TCP/IP-capable client that may connect to this server, to obtain the data sets. The Nagios server queries performance metrics from the SeedLink server, processes and displays them.

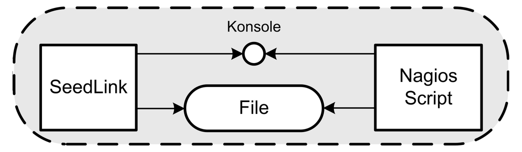


Figure 6:
Accessing the SeedLink server from Nagios (top), performance metrics shown in Nagios for technical electrics of a seismic station (bottom) with door sensor, mains power, V-SAT, seismic system voltage and water sensor.

Service Status Details For Host 'BNDI-TElektronik'

Host	Service	Status	Last Check	Duration	Attempt	Status Information
BNDI-TElektronik	Doorsensor	PENDING	N/A	13d 2h 28m 19s+	1/1	Service is not scheduled to be checked...
	MainsPower	OK	04-09-2012 00:27:15	10d 2h 49m 51s	1/1	237.176 - availability of 230V mains power
	V_24V	OK	03-25-2012 06:11:54	22d 5h 10m 31s	1/1	26.0814 - availability of 24V for VSAT
	V_sum_SC1_2	OK	04-16-2012 07:15:13	10d 2h 48m 2s	1/1	12.7266 - availability of 12V for seismic equipment
	Waterlevelsensor	CRITICAL	03-26-2012 18:09:16	20d 17h 13m 9s	1/1	30208.0 - inflow (status information < 500 means no water)
	ping	OK	04-16-2012 11:15:20	0d 2h 17m 8s	1/3	OK - 172.16.144.102: rta 793.418ms, lost 80%

Restrictions

Data for satellite communication is packaged and transmitted in regular time slots due to communication costs. Thus, real-time monitoring is not feasible. For cGPS stations, we used meteorological data as placeholder for our proof of concept. They do not represent valuable station metrics yet, but can be replaced as soon as the station component monitoring allows to do so.

Lessons Learned

Monitoring helps to detect system malfunction and documentation provides means to further interpret possible causes and consequences. The documentation also serves as a knowledge base for maintenance and corrective measures. Yet, corrective and preventive measures have to be properly defined as standard operating procedures (SOP). Together with the Indonesian personnel, sets of SOP are defined for various system component failures. System component failures have a defined impact on the overall system and thus SOPs are developed with different priority levels and service level agreements (SLA). To enact the proper sequential execution of SOPs by the different responsible institutions, departments and companies, a ticketing system meeting the special needs of timely collaboration is going to be established. Together, with extended monitoring of sensor stations, the establishment of a ticketing system represents the current focus of work.

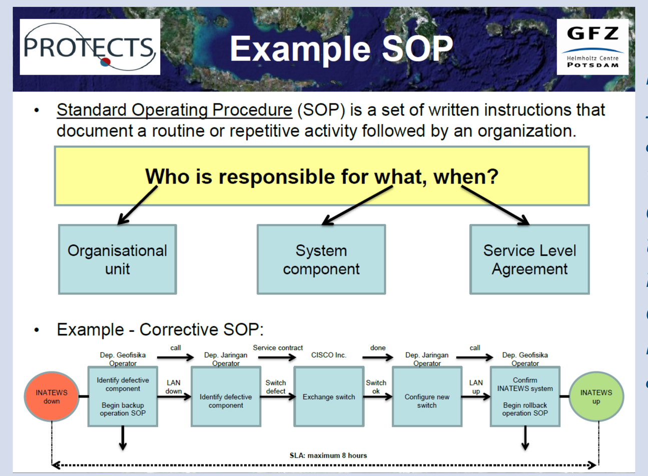
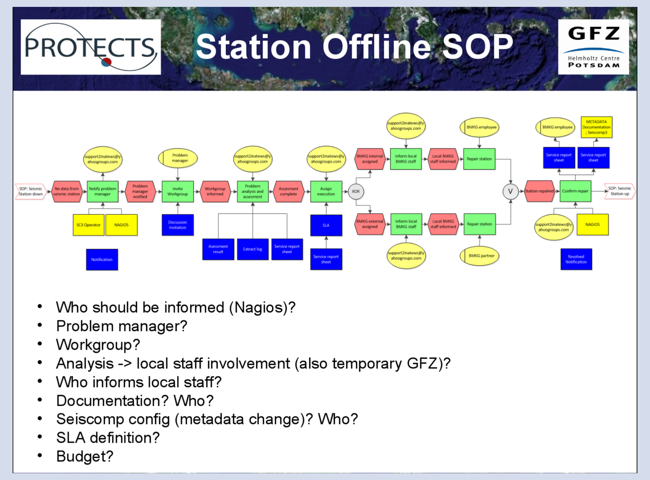


Figure 7:
In workgroups, SOP are defined for various system component failures to recover. One main focus is to describe events as means of business process analysis.



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Angermann, M., Guenther, M., and Wendlandt, K.: Communication architecture of an early warning system, Nat. Hazards Earth Syst. Sci., 10, 2215-2228, doi:10.5194/nhess-10-2215-2010, 2010.
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