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Development of Tsunami Early Warning Systems and Future Challenges

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The Boxing Day Tsunami 2004 triggered various international efforts focused on tsunami early warning for the Indian Ocean Basin. The activities resulted in a considerable progress in tsunami science, in particular concerning sensor systems and tsunami modelling. Stimulated by innovations in the field of Information Technology (IT) the architecture of tsunami early warning systems could be improved considerably. Warning system architecture has been specifically addressed in two complementary projects, firstly, the German Indonesian Tsunami Early Warning System (GITEWS) funded by the German Federal Ministry of Education and Research BMBF and, secondly, Distant Early Warning System (DEWS) a European project mainly funded under FP6.

GITEWS focuses on the upstream information from sensor systems to the warning centre and on the delivery of reliable tsunami warning messages as fast as possible. In order to check whether a strong earthquake had generated a tsunami, GITEWS includes in addition to the seismic networks other sensor systems, e.g. buoys, tide gauges and GPS. The different sensor systems deliver data in proprietary data formats and exhibit specific types of behavior. To utilise these sensors for decision support processes a flexible integration approach was developed based on the principles of a Service Oriented Architecture (SOA) and the specifications of the Open Geospatial Consortium's (OGC) Sensor Web Enablement Initiative (SWE). SWE services offer standardised interfaces to access all different sensor systems. Additionally, a flexible sensor plug-in mechanism, enabling the run-time integration of new sensors has been developed. The sensor integration platform is implemented as deployable enterprise application fulfilling the requirements for reliable asynchronous messaging, transactional processing, and scalability. GITEWS has proven its robustness at the BMKG tsunami warning centre in Jakarta where it is operational since 2009.

While taking advantage of the massive investments in the deployment of sensor systems in the Indian Ocean area, DEWS has the objective to constitute the headstone of a new generation of interoperable early warning systems based on a generic reference architecture including upstream, decision support and downstream components. Based on GITEWS results, DEWS integrates OGC SWE compliant sensor systems for the rapid detection of hazardous events, like earthquakes, sea level anomalies, and ground displacements for the detection of tsunami. The improvements of downstream capacities at warning centres included the redevelopment of information logistics for effective and targeted, custom-tailored warning message dissemination in a multilingual environment via a very large variety of telecommunication channels. The DEWS reference architecture for early warning systems is based on international standards for crisis information systems. In particular, standards of the OGC and the Organization for the Advancement of Structured Information Standards (OASIS) have been incorporated. While OGC standards serve in the upstream to deliver information via WMS, WFS, SWE and WPS to create the overall situation picture, standards of OASIS are used within the information logistic component to communicate warning messages by means of the Common Alerting Protocol (CAP) and the Emergency Data Exchange Language – Distribution Element (EDXL-DE).

These developments are continued by the FP7 project TRIDEC (Collaborative, Complex, and Critical Decision Processes in Evolving Crises) funded under the European Union's FP7. TRIDEC started in September 2010 and will be concluded in August 2013. TRIDEC focuses on real-time intelligent information management in Earth management. The addressed challenges include the design and implementation of a robust and scalable service infrastructure supporting the integration and utilisation of existing resources with accelerated generation of large volumes of data. These include sensor systems, geo-information repositories, simulation and data fusion tools.

In particular unconventional sensors and sensor networks will play an important role in TRIDEC including, e.g. accelerometers, social network facilities, cameras and customized apps of mobile devices, accelerometers of hard disks deployed in server farms and proper algorithms capable of detecting earthquakes and calculating their local effects. The improved information acquisition on possible effects of disasters will help to improve the information basis for the organisation of rescue and relief operations. Additionally, TRIDEC will adopt enhancements of SOA in terms of event driven architectures. This will enable the communication and synchronisation of activities between warning centres on local, national and wide-area levels.