Raymond Wingfield

PRIME: Academic Internship Program

September 2, 2010

PRIME Evaluative Research Paper

Tsunami is the term for a devastating natural phenomenon that occurs in oceans. Tsunami in open-ocean is a wave that may only be 3 or 4 centimeters in height but may extend many tens of kilometers. Earthquakes, landslides and volcanic eruptions can create the tsunami wave. This year, Summer 2010, I participated in a PRIME research project at the University of Hyderabad in India. The project revolved specifically around the event of a tsunami wave and how to properly send an early warning to the public that will prevent the displacement of many people by using a tsunami early warning system in place in the Bay of Bengal and implementing the event detection software Esper.

When beginning research for this project I focused mainly on what a tsunami is. I had to learn how a tsunami is created and what it acts like in the open-ocean as well as near the shoreline. I learned that an earthquake event is one of the most common ways that a tsunami wave is created. I also learned that a tsunami wave acts very different in deep ocean water than it does when it is within 30 kilometers from the coastline. The tsunami wave may only be 3 centimeters in the deep ocean but the wave can climb to a height of ten feet or more as it reaches the coast. Lastly, it was very important to understand what ingredients are needed from an earthquake to create a devastating tsunami event.

By researching tsunami events that were generated by earthquakes I learned that not all earthquakes create a tsunami event and thus the need for a tsunami early warning message. More specifically I found that there are a few key components of an earthquake that will cause the generation of a tsunami event. The first of these components is that the epicenter of the earthquake must be located in the ocean. The location is coupled by the depth of the epicenter having a distance of not more than 100 kilometers below the surface of the earth. Finally, in order for the earthquake to cause a devastating tsunami there needs to be at least 1000 meters of ocean water above the sea floor. If combinations of these three ingredients are met then the probability of a tsunami event is very high and the initial warning is sent to the proper authorities.

Open Source Esper is a software component designed for filtering and analyzing streaming data. Esper is a good fit for this tsunami early warning project that has been derived from the warning system that is already in place and active at the Indian Nation Center for Ocean Information Services commonly known as INCOIS. This project was based on the theory that data from the sensor system would be collected and analyzed in real time. Esper software can be used to query the streaming data that INCOIS collects from the sensor system. Esper would check for a possible tsunami event by analyzing the data in real time directly from the sensor system. Noting the possible tsunami event would allow an initial alert to be sent to the proper authorities.

Esper software is a very important aspect of this project because it allows specific event detection from multiple streams of data. The early warning system that is currently in place in the Bay of Bengal consists of three different types of sensors each having the purpose of testing a different component of the tsunami wave. The seismic sensor measures the longitude, latitude, depth and magnitude of the earthquake. This data provides the necessary information to send the first warning. The bottom pressure recorder or BPR is designed to measure the tsunami wave in the deep ocean water. Last is the tidal gauge that is designed for measuring tidal surges common with the tsunami event. The BPR and tidal gauges are used to measure the tsunami event in real time and the collected data is then compared with a model.

According to the standard operating procedures of INCOIS a prediction model is selected and used for comparison purposes with the real time event data. The prediction models are selected based on empirical formulas that are functions of the magnitude of the earthquake. At the INCOIS facility in Hyderabad there are more than 6 terabytes of archived prediction models. A proper prediction model can be selected using Esper queries that utilize the solutions to the empirical formulas. Once selected the comparison of real time data with the prediction model will help track the threat of the tsunami event.

Esper can be implemented to analyze the data from the sensor system in real time. In the same code Esper can also query the streaming data from the pre selected prediction model. By using a third set of Esper queries designed to compare both sets of data the real time tsunami event can be accurately monitored. This comparison of the two sets of data would allow the initial warning that was generated to be either upgraded or downgraded depending on the correlation of the data. For example, an upgrade to the initial warning would be necessary if the tidal gauge measurements in real time exceeded the prediction models tidal gauge measurements. This is a very important part of the operating procedures because it informs the proper authorities of the real time threat of the tsunami wave.

At the conclusion of this project I have successfully applied a simple Esper query to test an artificial input stream. This artificial stream of data is representative of the data that would be streaming in real time from the tsunami sensor system. The real-time data viewer or RDV can easily view the detected events. I have learned that Esper is a good software application for the tsunami warning system because it applies the use of queries to test the incoming data streams. Patterns can be included in the queries to detect the changes in wave height that may occur from a tsunami event. These queries can be implemented to detect the events of multiple sensors and simultaneously compare this data with the input data from the prediction model.

Works Cited

Indian National Center for Ocean Information Services. *Tsunami Early Warning Centre: Systems, Operations and Procedures.* Februrary 2009 Edition.

*Indian National Center for Ocean Information Services (An Autonomous Body Under the Ministry of Earth Sciences, Government of India).* http://www.incois.gov.in/Incois/incois800/index/index.jsp?res=800.