**TSUNAMI WARNING SYSTEM**

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**COMPUTER SCIENCE AND ENGINEERING**

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*Abstract -* **On December 26, 2004, a massive underwater earthquake off the coast of Indonesia's Sumatra Island rattled the Earth in its orbit. The quake measuring 9.0 on the Richter scale is the largest one since 1964. Dozens of aftershocks with magnitudes of 5.0 or higher occurred in the following days. But the most powerful and destructive aftermath of this devastating earthquake is the tsunami that it caused. The death toll reached higher than 225,000, and many communities suffered devastating property damage**

**The devastation of this tsunami overshadowed the devastation of any other tsunami we've seen in recent history, but scientifically, the course of events followed the same basic sequence of a typical tsunami. In this paper, we'll look at what causes tsunamis, the physics that drives them and the effects of a tsunami strike. We will also examine scientists' worldwide efforts to monitor and predict tsunamis with the help of a TSUNAMI WARNING SYSTEM in order to avoid disasters like the one that occurred in the final days of 2004. This paper also focuses on an improved version of the TSUNAMI WARNING SYSTEM called the DART (DEEP OCEAN ASSESMENT AND REPORTING OF TSUNAMIS).**

 **1. INTRODUCTION:**

 A future without fear that tsunamis will again cause such huge loss of life is the main goal of today's scientists that is bringing together leaders of the worst-hit nations and key aid donors. The world must unite to ensure that next time, everyone will be ready. Countries around the Indian Ocean, from Asia to Africa, were caught off-guard by the December 26 tsunami, with waves up to 10m high crashing into coastal communities and packed holiday resorts. United Nations experts say that an effective warning system, modeled on mechanisms that have existed around the Pacific Ocean for more than half a century, could have drastically cut casualty figures.

**2. WHAT IS A TSUNAMI?**

Tsunamis consist of a series of very long waves generated by any rapid, large-scale disturbance of the sea. Most are generated by sea floor displacements from large undersea earthquakes. Tsunamis can cause great destruction and loss of lives within minutes on shores near the source, and some tsunamis can cause destruction within hours across an entire ocean basin.

Most tsunamis occur in the Pacific region but they are known to happen in every ocean and sea. Although infrequent, tsunamis are a significant natural hazard with great destructive potential. They can only be dealt with effectively through programs of warning, mitigation, and education.

Another major problem is tsunamis cannot be seen at sea or by air. This is because in the deep ocean, tsunami wave amplitude is usually less than high speeds. The tsunami may be perceived as nothing more 1 m (3.3 feet). The crests of tsunami waves may be more than a hundred kilometers or more away from each other. Therefore, passengers on boats at sea, far away from shore where the water is deep, will not feel nor see the tsunami waves as they pass by underneath at than a gentle rise and fall of the sea surface. The deep-water height of this tsunami was only about 40 centimeters when it passed them and yet, when it arrived on the shore, it had transformed into huge waves that killed people, destroyed the ports and villages along the coastline. For the same reason of low amplitude and very long periods in the deep ocean, tsunami waves

cannot be seen nor detected from the air. From the sky, tsunami waves cannot be distinguished from ordinary ocean waves.

**3.0 DEEP SEA TSUNAMI ALERTING SYSTEM:**

 Development of an operational tsunameter was an extraordinary engineering accomplishment. The task was to design, develop, test, and deploy real-time reporting, deep ocean instrumentation capable of surviving a hostile ocean environment while performing with the quality and reliability demanded of an operational tsunami warning system. To measure tsunamis many technologies has been tested. At present the best way known to detect a tsunami is to measure very accurately water pressure on the sea bottom. The tsunami detection algorithm works by first estimating the amplitudes of the pressure fluctuations within the tsunami frequency band and test these amplitudes against a threshold value.

The pressure acquisition station is a critical component of the tsunameter system and includes an ultra stable, high precision, high accuracy, pressure depth sensor, a computer, a data logger and an acoustic modem to communicate with surface buoy. The remarkable performance of depth sensor is achieved through the use of a precision quartz crystal resonator whose frequency of oscillation varies with pressure-induced stress. A quartz crystal temperature signal is provided to thermally compensate the calculated pressure and achieve high accuracy over a broad range of temperatures. The depth sensors include waterproof housings with integral shock protection buoy.

**4.0 DIGIQUARTZ BROADBAND PRESSURE SENSING TECHNOLOGY:**

 The bottom pressure recorder (BPR) is a critical component of the tsunameter system and includes a Digiquartz Broadband Depth Sensor, a computer, data logger and an acoustic transducer to communicate with the surface buoy.

Tsunameter BPR

The Digiquartz Broadband Depth Sensor is the main sensing element in the bottom pressure recorder. This sensor monitors pressure continuously and if the pressure reading changes above a set threshold, then the tsunameter automatically transmits data to a surface buoy. The surface buoy makes a satellite connection to Tsunami warning centers that evaluate the threat and issue a tsunami warning.

The most important sensing requirement is the detection of very small pressure changes at water depths up to 6000 meters. The change in water depth due to a tsunami in the open ocean is generally less than one centimeter. The resolution capability of Digiquartz Broadband Depth Sensors makes it possible for tsunameter to detect water level changes of less than one millimeter at the deployed depth of 6,000 meters (one part in six million).

The quartz crystal consists of two identical beams driven piezoelectrically in 180° phase opposition such that very little energy is transmitted to the mounting pads. The high Q resonant frequency, like that of a violin string, is a function of the applied load; increasing with tension and decreasing with compressive forces. The digital temperature sensor consists of piezoelectrically-driven, torsion ally oscillating tines whose resonant frequency is a function of temperature. Its output is used to thermally compensate the calculated pressure and achieve high accuracy over a wide range of temperatures. The ultimate resolution achievable with a transducer is limited by its noise level. The goal is to have the sensor noise levels much smaller than the expected real signals at all frequencies of interest.

The total system consists of an anchored seafloor bottom pressure transducer and a companion moored surface buoy for real-time communication. A powerful acoustic spread spectrum modem transmits data from submerged platform to the surface buoy. The data are then relayed via Inmarsat-C satellite link to land stations, which forward the signals for immediate dissemination to warning centers. Digiquartz Bourdon Tube Broadband Depth Sensor

Digiquartz Broadband Depth Sensors are based on the inherently digital, highly stable, vibrating quartz crystal technology developed by Paroscientific over the last three decades. Paroscientific pressure transducer mechanisms, oscillator circuits, and digital interfaces are carefully designed for high resolution.

Digiquartz Broadband Depth Sensors employ a Bourdon tube as the pressure-to-load generator. Pressure applied to the Bourdon tube generates an uncoiling force which applies tension to the quartz crystal. The change in frequency of the quartz crystal oscillator is a measure of the applied pressure. Temperature sensitive crystals are used for thermal compensation. The mechanisms are acceleration compensated with balance weights to reduce the effects of shock and vibration. The transducers are hermetically sealed and evacuated to eliminate air damping and maximize the Q of the resonators. The internal vacuum also serves as an excellent absolute pressure reference.

The high performance of the Digiquartz Instruments is achieved through the use of a precision quartz crystal resonator whose frequency of oscillation varies with pressure induced stress. Quartz crystals were chosen for the sensing elements because of their remarkable repeatability, low hysteresis, and excellent stability. The resonant frequency outputs are maintained and detected with oscillator electronics similar to those used in precision clocks and counters.

**5**. **WHAT HAPPENS WHEN A TSUNAMI ENCOUNTERS LAND?**

as a tsunami approaches shore, it begins to slow and grow in height. Just like other water waves, tsunamis begin to lose energy as they rush onshore - part of the wave energy is reflected offshore, while the shoreward-propagating wave energy is dissipated through bottom friction and turbulence. despite these losses, tsunamis still reach the coast with tremendous amounts of energy. Tsunamis have great erosional potential, stripping beaches of sand that may have taken years to accumulate and undermining trees and other coastal vegetation. Capable of inundating, or flooding, hundreds of meters inland past the typical high-water level, the fast-moving water associated with the inundating tsunami can crush homes and other coastal structures. Tsunamis may reach a maximum vertical height onshore above sea level, often called a run up height, of 10, 20, and even 30 meters.

**6. TSUNAMI SAFETY RULES**

􀂃 all earthquakes do not cause tsunamis, but many do. When you hear that an earthquake has occurred, stand by for a tsunami emergency.

􀂃 An earthquake in your area is a natural tsunami warning. Do not stay in low-lying coastal areas after a strong earthquake has been felt.

􀂃 A tsunami is not a single wave, but a series of waves. Stay out of danger areas until an "all-clear" is issued by competent authority.

􀂃 Approaching tsunamis are sometimes preceded by a noticeable rise or fall of coastal water. This is nature's tsunami warning and should be headed.

􀂃 A small tsunami at one point on the shore can be extremely large a few kilometers away. Don't let the modest size of one make you lose respect for all.

􀂃 The Pacific Tsunami Warning Center does not issue false alarms. When a warning is issued, a tsunami exists. The tsunami of May 1960 killed 61 people in Hilo, Hawaii, and they thought it was "just another false alarm."

􀂃 All tsunamis-like hurricanes-are potentially dangerous, even though they may not damage every coastline they strike.

􀂃 Sooner or later, tsunamis visit every coastline in the Pacific. Warnings apply to you if you live in any Pacific coastal area.

􀂃 During a tsunami emergency, your local civil defense, police, and other emergency organizations will try to save your life. Give them your fullest co-operation.

􀂃 Never go down to the shore to watch for a tsunami. When you can see the wave you are too close to escape it.

**7. CONCLUSIONS**

DART to do a much better job predicting the height of tsunamis. The improvements will help emergency managers decide who to evacuate and how long to keep them away from coastal areas. The new system will enable scientists to predict the duration of the event, which in some cases can be a series of waves lasting several hours.

The system is economically critical and would help woo back tourists scared away by the mass loss of life. The system, which comprises hundreds of seismic stations worldwide, which can detect the earthquakes that are precursors to a tsunami.

Tsunami-the nature’s deadly beauty which leads to massive destruction of life could be avoided by using the system.

**8. REFERENCES**

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