Earthquake Early Warning Management based on Client-Server using Primary Wave data from Vibrating Sensor

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Abstract. Early warning is a warning mechanism before an actual incident occurs, can be implemented on natural events such as tsunamis or earthquakes. Earthquakes are classified in tectonic and volcanic types depend on the source and nature. The tremor in the form of energy propagates in all directions as Primary and Secondary waves. Primary wave as initial earthquake vibrations propagates longitudinally, while the secondary wave propagates like as a sinusoidal wave after Primary, destructive and as a real earthquake. To process the primary vibration data captured by the earthquake sensor, a network management required client computer to receives primary data from sensors, authenticate and forward to a server computer to set up an early warning system. With the water propagation concept, a method of early warning system has been determined in which some sensors are located on the same line, sending initial vibrations as primary data on the same scale and the server recommended to the alarm sound as an early warning.

1. Introduction

Early warning is a warning mechanism to the public before an actual incident occurs that can be implemented on natural events such as floods, tsunamis, landslides, and earthquakes [1][2]. As with other natural events, earthquakes can be classified into two types that are tectonic and volcanic depends on the source and nature. The tremor in the form of energy propagates in all directions as Primary and Secondary waves. Primary wave as the first vibrations propagate as longitudinally, while the secondary wave propagates follows Primer like a sinusoidal. Secondary waves an actual earthquake and destructive [3][4][5]. Secondary wave arrival time difference from the primary wave is unpredictable depending on the distance from the sensor point catcher earthquake vibrations. The closer the quake point to the sensor, the faster arrival of the secondary waves. Instead farther epicenters of the sensor, then the slower the arrival of the secondary waves. Digital MEMS accelerometer is used to measure acceleration, detect and measure vibration or acceleration [6], works on 3.3 v voltage and are capable of reading, vibration or collision capture events that occur in nature [7][8]. The digital accelerometer is compatible with the microcontroller, so many developed a sensor capable of capturing and processing various natural phenomena such as landslides [9], earthquakes or engine vibration [10][11].
To be able to process the primary seismic vibration data captured by the sensor seismic accelerometer, Internet network management required the client computer that receives primary data from sensors and server set up an early warning system when receiving data from the client computer. Between the data processing client and server are not spared from a mistake (error), so the server needs to provide a data error handling mechanism. One method is a method of data error handling Go-back N, where the data does not reach the recipient will be the demand for the return shipping [12][13].

2. Methods
Management Of earthquake early warning based on client-server designed in three stages, namely building a data communication of the client to server, build error correction management and designing early warning management [14]. The communication data of the client to the server using the principle of UDP for faster data transfer process even though the chances of loss/error data also exist. With UDP, computer client does not need to do the handshake before sending data. The communication process consists of the open port and the data transmission process using go back-N methods that support retransmission when the error/loss data happen. Socket port is opened to the transmission lines to send signals bind() and followed by the data transmission of vibration. Vibration data duplication posted done beforehand to help the error-checking process on the server. Stages transmission of data to the server is shown in Figure 1.

Transmission of data in Figure 1 begins with taking the position data (data real position) in the client database and duplicate. Data took the position as much as 5 times, duplicated and then send it to the server. The server compares the real position data with a duplicate. If different, then the server will certify that the data error and immediately ask the client to resend. But if the same, then the server takes real data and store into the database as the sender client numbers. The process continued with the next position data. If the position data is already five times, then the client stop and resume data capture position data retrieval shakes consisting of x-real, y-real, z-real and Sc-real. Each data retrieval shakes to j, client duplicating the data and transmit real and duplicate data to the server. The server further examines and compares the real data and duplicate. If different, then the server stating there was an error
and immediately ask the client to send back. But if the same, then the server takes real data and save to
the database as the sender client numbers. Retrieval and delivery of data shake and duplicated ongoing.
The second stage in the management of earthquake early warning is the error handling of data on the
server. There are 2 errors handling in the server that detection error through the process of comparing
the data shakes-origin and its duplicate and correction error through retransmission request after the
error was detected. There are 2 data are duplicated and sent to the server, that are position data (latitude
and longitude) and shakes the data (x, y, z, and Sc). Figure 2 displays the error handling for data shakes.

Handling errors of vibration data in Figure 2 begins with collecting the original vibration data from the
client. The data includes x-real, y-real, z-real and Sc-real. The original data is then duplicated so that
each has a duplicate. The original and duplicated data is subsequently combined into a package data’s
ready to be sent. The composition of each package into x-real y-real, z-real, Sc-real, x-duplicate, y-
duplicate, z-duplicate, Sc-duplicate. The next package is sent to the server via LAN network. On the
server data packet is received and partitioned back into 2 parts: the original and duplicate data. The
server compares the data if at the server takes the data packet correctly, partitioning and save to a
database provided and continued to receive the next shipment data. If the data is not the same, then the
server will declare error and ask the client to send back data error.

The final stage is set early warning management. Early warning involves Server, admin, Client, and
Alarm. The server as a central data processing for all clients provides a database for position data and
data shakes from all clients, saving the admin account as the responsible application GUI, Admin is the
staff who maintain the servers, displays application server interface and is responsible for observing and
guarantee the earthquake alarm. The client is a computer base station and microcontroller-based seismic
sensors. Client duty duplicating and sending position data and the data to the server shakes. The alarm
is output to sound when the results of the data verification shake all clients connected to the same server
showed Sc. The server is turned on by Admin through the provision account (id, name, and position)
when first entered into the GUI earthquake. Admin server enables connection to all clients and observes
the data flow and data shakes position that enters the database and displayed on the graph GUI. Admin
also tasked to ensure that the early warning passed on to the public. The process of giving early warning
carried out through several stages as shown in Figure 3
Stages of early warning in Figure 3 begin with reading and retrieving data shakes each client on the database server. Latitude and longitude position data are only taken once and instantly displayed in the GUI as the location information when the sensor captures the primary vibration. As for the early warning, performed data collection shakes x, y, z, and Sc every 100 data. Of every 100 data, the data x, y, z will be displayed as a graph, while Sc of client1, client2, and client3 will be compared. If the data is three client 100 has the same value, then the server brought out the alarm as a sign of an earthquake will actually arrive. But if not the same, then the retrieval process 100 next data will be performed by the server.

3. Result and Discussion

Vibration data is sent from the client to the server with a number of the ship is $2^{16}-1$ – 20-byte header - 8 byte UDP header to 65 KB. IP Address Client and Server using the internet local network (LAN) and uses port 3306 that supports MySQL. After the server compares and makes sure the data is correct (no error), then the server took the correct data to be displayed and referenced early warning. Classification IP address of each configured on a condition, client1 192.168.43.114/255.255.255.0, client2 192.168.43.115/255.255.255.0, client3 192.168.43.116/255.255.255.0 and IP Server 192.168.43.117/255.255.255.0. Each client is connected to the sensor with a microcontroller-based seismic testing scheme is shown in Figure 4.
Testing in Figure 4 uses a table board measuring 1 x 2 meters. Vibrating center placed in the middle of the table and then measured for each direction of a certain size to get the same placement point Base Stations (BS). One Base Station consists of earthquake sensors, microcontrollers, and Client. Placement of every client at equidistant points from the midpoint of the table due to the nature of the waves that propagate from the center will spread with the same strength. There are 3 sizes are taken in testing, the First test with a distance sensor quake from the center shakes of 50 cm, the second test with a distance sensor quake from center shakes 100 cm, the third test with a distance sensor quake from center shakes 150 cm. The server is placed adjacent to the test table LAN connected. The sensor is connected to the client computer using an Ethernet cable 10 cm and a client connected LAN. Tests carried out sequentially provides vibration at the vibration source.

From the Sensor vibration simulation and data processing from client to the server, taken 15 initial vibrations to be processed. The results show that the alarm server will only sound if the three clients provide the same Scale (Sc) value. When one of the 3 clients give different values, then the alarm will not sound and its means vibration that received from the client is not a Primary wave. The data test for BS1, BS2, and BS3, shown in Table 1.

Figure 4. Simulation to making a primary wave.
In Table 1 every client consists of the value of the acceleration (A) and value of Scale (Sc) taken from vibration value of each axis (x-real, y-real and z-real) and indicator (LED). While alarms can only connect from the server and do not depend on the LED of each client. Vibrations data were sampled from each sensor numbered only 13 initial data sent from the sensor to the client and forwarded to the server. Thirteenth initial data is the data the primary wave (P-wave) seismic events. Data is processed as an indication of the arrival of the real earthquake (S-wave).

When one client transmits the vibration data, indicator LED on the sensor will be active (ON), but does not guarantee that the data generated from the initial earthquake vibrations. For the two other Client as the comparison is true or not data is received at the server shakes the initial earthquake vibration data. The results of the third test client that does not sound the alarm shown in Figure 5.
Figure 5. Vibration from 3 Client (50cm) does not sound alarm.

Client 1 in Figure 5 generated scale (Sc) from the 13 vibrations data received early in the constant server in grades 4, while on Client2 the value scale (Sc) in the fourth data value is 4, but experienced a change in data is vibrating to 5 to 13. So there are differences in the data received by the initial shakes from Client1 and Client2. When Client3 transmit the 13 shakes the beginning data, the value scale (Sc) client3 showed similar results with Sc of client1 is constant in 4. In these conditions led installed on all the sensors indicate the ON position, but the alarm is installed on the server wheezes (OFF), because of differences Sc client2 with 2 other clients. This means that 13 initial vibration which is the vibe primary (P wave) sent from 3 Client to Server and not a P wave that signifies the coming earthquake real (S wave) so that the server does not need to sound the alarm for rescue action community around the source earthquake. The results of the third test client that sound an alarm are shown in Figure 6.

Figure 6. Vibration from 3 Client (100cm) that sound an alarm.

Client 1 in figure 6 generated Scale (Sc) from the 13 vibrations data received early in the server changed from 4, 5, 4 and 7 in accordance with the third axis vibration accumulated received. Client2 while accepting the distribution of vibration per axis slightly different, but the scale value generated from the data 13 initial shakes showed the same change to client1, which is 4, 5, 4 and 7. When client3 sends the data 13 shakes early, it turned out the value of scale (Sc) client3 showed similar results with client1 and client2. In these conditions led installed on all the sensors indicate the ON position and the alarm on the server also sound (ON). This means that 13 initial vibrations which are the primary vibration (P-wave) sent from Client to Server 3, expressed by the server as the P wave indicates upcoming real earthquake(S-wave) so the server needs to issue an alarm signal to the public rescue action around the earthquake source. The results of the third test client that sound an alarm are shown in Figure 7.

Figure 7. Vibration from 3 Client (150cm) that sound an alarm.

Client1 in Figure 7, generated Scale (Sc) from the 13 vibrations data received early in the server change of 4, 5 and 6 in accordance with the third axis vibration accumulated received. Client2 while accepting the distribution of vibration of each axis are slightly different, but the scale value generated from the 13 vibrations initial data showed the same change to client1, which is 4, 5 and 6. When client3 sends the 13 data initial, turns scale value (Sc) client3 showed similar results with client1 and client2. In these conditions led installed on all the sensors indicate the ON position and the alarm on the server also sound.
(ON). This means that 13 data initial vibration which is the primary vibration (P-wave) sent from Client to Server 3, expressed by the server as the P wave indicates upcoming real earthquake (S-wave) so the server needs to issue an alarm signal to the public for rescue action around the earthquake source.

4. Conclusion
Management of earthquake early warning in server requires vibration data from multiple clients for ease of comparison of the truth and accuracy of primary data that is sent. Error handling is the fulfillment of the terms of early warning seismic processing because each client must send the same amount of data in a group or a certain time. Differences in the amount of data received and authenticated by the server, will provide early warning wrong. Authentication is performed by the server to compare the truth and similarity-scale data (Sc) received from all Client. Data vibrate only used as a graph. Warning given if some Client provide the same Sc data to the server.

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