Upgrading of the Nile Delta Accellrograph Network Using the USGS Earthworm System

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Abstract: Since 2008, the earthquake acceleration at the Nile Delta region observed by the Egyptian Strong-motion Network (ESN), it consist of12 acceleration stations; five stations involve 130-SMA Accellrograph, while seven stations involves Titan-SMA Accellrograph. Each type operated by an Earthquake Monitoring System EMS for real time data transmitting, acquisition, and archiving, each system use different protocols for data transmitting and archiving, consequently it's difficult to combine between the two systems for real time data analysis. in order to make operating ESN much simpler and flexible this study use the United States Geological Survey USGS, Earthworm (EW) system to build a customized real time data acquisition and archiving combine between the two EMS systems operating the two types of accelerometers and archive data for both systems in Mini seed format and receive data from the Egyptian National Seismic Network (ENSN) velocity stations and use this data with acceleration data to get more accurate event location around the Nile Delta specially regional earthquakes from the Mediterranean Sea and local earthquakes inside Egypt.

1. Introduction

Seismic data centers today differ significantly in scope, size and type of operations. While the common goal is to collect, archive and process data for the purpose of earthquake monitoring and seismological research. The increased number of seismic monitoring stations as well as the increased availability of real-time seismic waveform data today, put high demands on software and seismic data centers in terms of acquisition, processing and quality control. The large amount of data and the demand for real-time analysis can only be handled with automated, but flexible, software systems being reliable, robust and sustainable **Damiano (2011),** Any EMS system is a group of software capable of acquiring, processing, and archiving large volumes of real-time continuous seismic dataincluding the automatic detection, location and quantification of earthquakes. New seismic networks must decide which EMS to operate, and even established networks are periodically required to updating their operational EMS, **Olivieri and Clinton (2012)**.

The EW system is worldwide automatic data processing software; EW is robust and well-tested. It uses real-time data from a diverse set of instrumentation to produce a wide range of products including automatic and reviewed earthquake locations, magnitudes, alarms, and numerous higher-level products**. Bittenbinder, and Johnson (2003).** It consists of hundreds of open source modules that can

be used as building blocks fora customized processing system.

Several Earthworm systems and derivatives are currently in operation: the great majority of US stations use Earthworm system, including the ~450-station NCSN, the ~150-station TRINET network in S. California, the ~100-station US National Seismic Network of BB stations **Peter (2002).** At University of Alaska at Fairbanks, an Earthworm system capable of processing 256 channels is in operation. Another 256-channel system is being assembled for the University of Utah at Salt Lake City, and is scheduled for installation by January1996. In addition, derivative systems are in operation at University of California at Berkeley, University of Hawak, at Hilo, and University of Washington at Seattle. **Johnson (1995)** at the Kandilli Observatory Earthquake Research Institute KOERI in Istanbul, Turkey, Since the devastating August 17, 1999, Mw 7.4 Izmit Turkey earthquake they used USGS Earthworm modules to receive the broadcasted data stream from the data acquisition PCs and convert this to Earthworm format where it is stored, Waveforms from this Earthworm formatted data stream are fed to a picker, picks are associated into events, events are located, and finally waveforms are automatically assembled into a SAC formatted event files and written to disk **Childs (2003) and childs (2008)**; the National Tsunami Hazard Mitigation Program NTHMP they use EW system to operate the PTWC to be responsible for local,

regional, and distant tsunami warnings issued to Hawaii.

Before2008 the Nile Delta was not covered by seismic networks because this area is very crowded and need specific type of sensors which was not available yet, consequently an acceleration network consist of 12 Accelerograph stations installed in the Nile Delta **Fig 1.**Five stations operated by 130-SM Aaccellrographmanufactured by the worldwide seismic equipment manufacturer Refraction Technology Company, while seven stations operated by Titan-SM Aaccellrograph manufactured by the worldwide seismic equipment manufacturer Nano Metrics company each type is operated by different EMS. Each EMS use different protocol for real time data transmitting, acquisition and archiving; For 130-SMA sensors, RTPD server used for real time data acquisition and archiving, data stored in file based archives and only accessed by Reftek data utilities; for TITAN-SMA sensor, NAQS server used for real time

data acquisition and archiving, data stored in file based Ring Buffers and only accessed by Nano Metrics data utilities; While ENSN velocity stations use APOLLO server that belongs to Nanometrics company; for real time data acquisition and archiving from 86 seismic station through satellite link, data stored in file based store files.

Before 2013 ESN was operated by sensors from 130-SMA type; no previous studies have been done to operate this network, consequently the main purpose of this study to use the USGS, EW system to build a customized data acquisition and analysis system to make operating this network more simple and efficient, which receive data from both ESN accellrograph network, and ENSN velocity network and store real time data for both system stored in standard file based Tanks and stored in Miniseed format then use data for real time processing and analysis, and get better event detection and location around the Nile Delta.
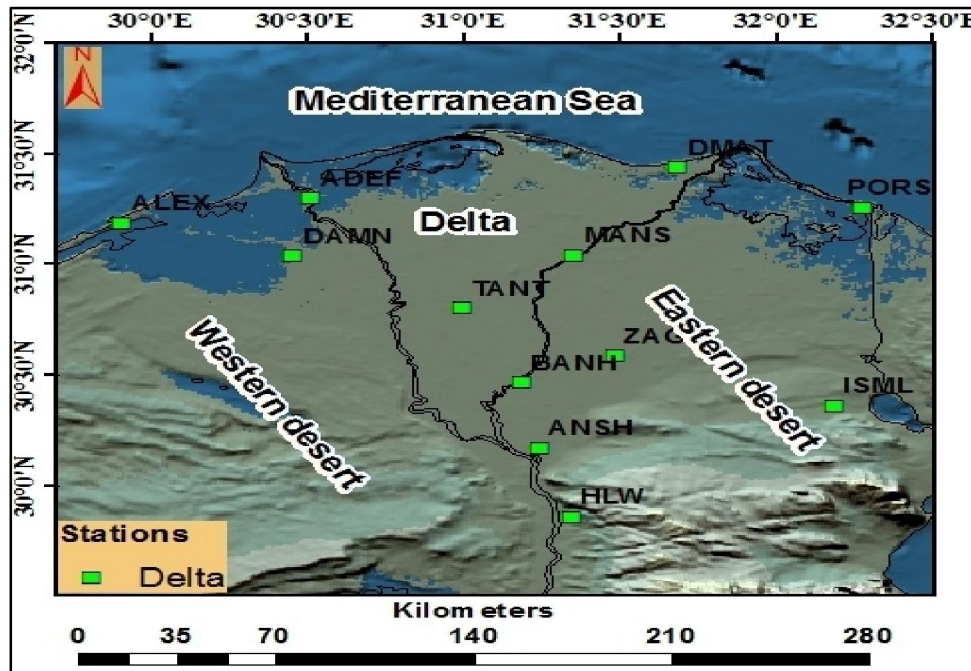
Fig. 1. ESN accellrograph stations distribution at Nile Delta region.

Methods

An EW system consists of a set of modules 'immersed' in a message passing 'medium'. Each module performs some coherent task, modules communicate by broadcasting and receiving various messages. The message passing scheme is analogous to radio communications. The modules are independent main programs. Each module has free use of the file system and other system facilities. Modules generally read a configuration file at startup

time. This file contains basic EW parameters which define the module, specify which message 'medium' (message ring) it wishes to listen to, and which message ring it wishes to broadcast its output messages to. In addition, this file can contain arbitrary operating parameters specific to its operation **USGS (2001).**

The suite of modules available in the EW system is quite varied, but can be classified into several categories:
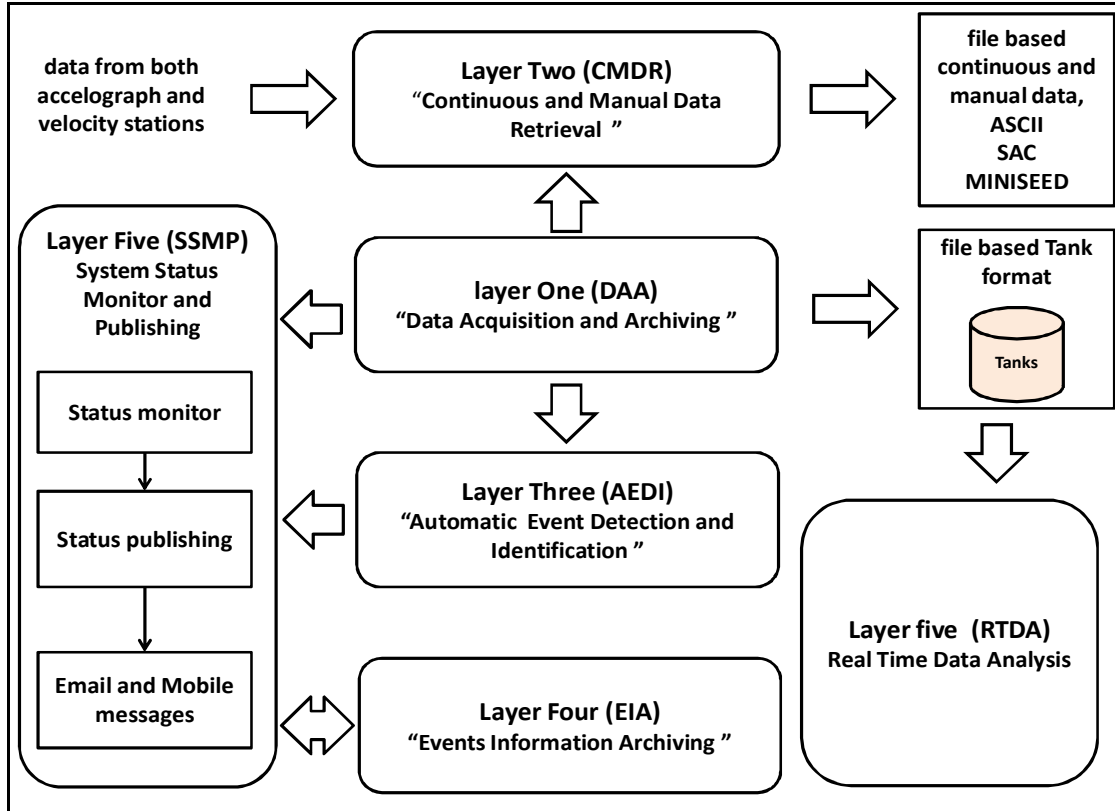
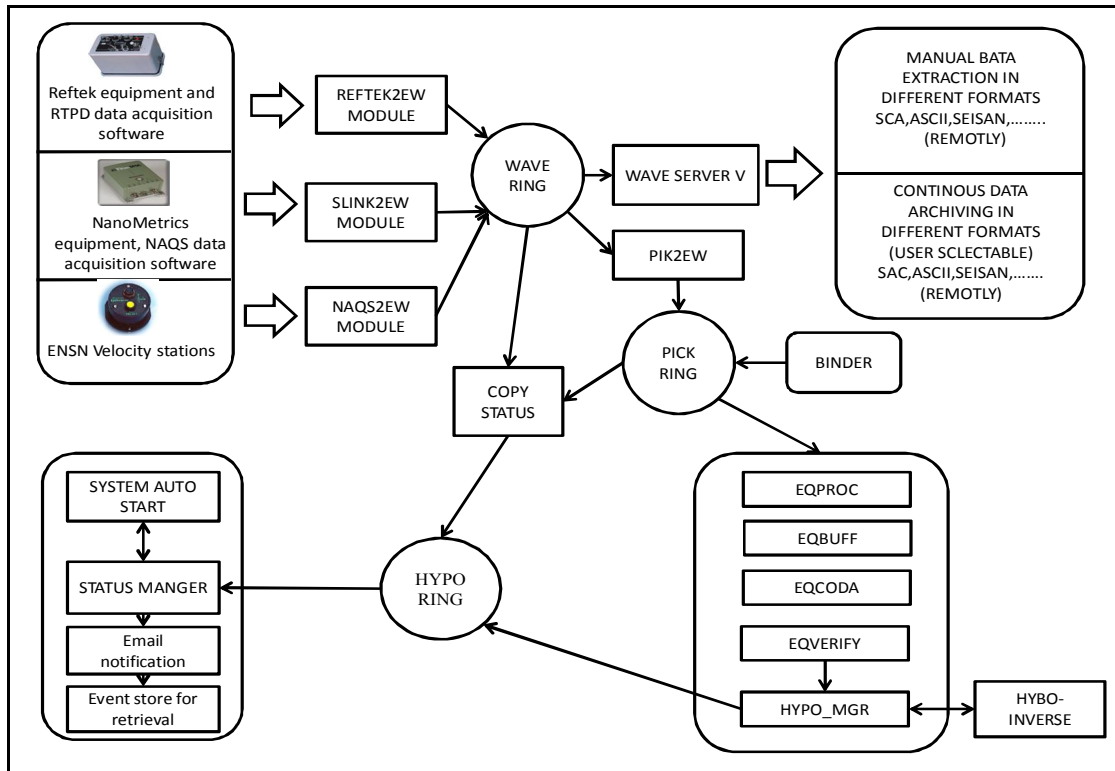**Fig 2. Layers systems in use to simplify system design**

Fig. 3. modules and shared memories used in system design

System: Several modules are used to provide control over the system and error reporting.

Data Sources: These are modules that introduce data into an EW system.

- **Data acquisition modules**, which perform realtime control of data acquisition hardware and produce streams of trace data messages.

- **Data import modules**, which connect to distant processing systems and receive various types of messages. These are then typically checked for validity, converted into locally known message types and broadcast into the local EW.

- **Data players**, which can read historic data from archive files and broadcast them in the correct time order.

Processing Modules: These include the majority of the modules. They receive their input by listening for some specific type on a specified message medium, perform some seismic function, and produce occasional output messages.

Output Modules: These modules move data from an EW system into post- processing systems of various types.

Export modules: which connect to distant systems and manage the long-distance sending of specified message types.

Record/Playback Modules: This is a set of modules which can create and play back segments of trace and pick data. The main use for this is for fault analysis and creation of test suites. Wave_serverV, tankplayer, and waveman2disk for creating and replaying trace data.

- **The Wave_serverV,** can be used to extract everything in an EW ring to a circular buffer file for special client programs to extract time periods into permanent files.

- **The data player**, tankplayer can read historic data from archive files and broadcast them in the correct time order into an EW ring.

In order to build our system and achieve the main aims of the present work, system will be broken into layers each layer involve group of EWsystem modules doing dedicated tasks and produce outputs used as input to another layer. Layers system makes system design and implementation simpler.**Fig.2.** the first and second layers, two data import modules REFTEK2EW and NAQS2EW used for acquiring data from both 130-SMAand TITAN-SMA sensors, and SL2EW module to receive data from ENSN velocity stations modules broadcast data messages into Wave Ring 'shared memory', then Wave_serverV archiving module listen to data messages in Wave Ring and continuously archive data in file based Tank archives; then Wave_serverV broadcast data to EW2MSEED modules which continuously archive

data into MINISEED files only for accellrograph stations, then open connection for WAVEMAN2DISK modulefor manual or triggered data archiving in SAC format upon user request in layer number five a SWARM real time seismic data analysis program used t access to the system data tanks and used for real time data analysis (SWARM MANUAL reference), in layer number three a group of automatic event detection modules, PICK_EW, EQVERIFY, EQPROC, EQCODA, EQBUF and association with BINDER and HYPO_INVERSE module, are used for automatic event detection and identification **Dietz (2002) and Klein (2002)**; this group of modules always listen to the Wave Ring for coming data and apply algorithms to make sure that the first arrival in the event is the P-wave, once event is carefully identified, PICK_EW module broadcast a message to Pick Ring to be used for event location and publication. in layer number four a group of status modules STATMGR, COPYSTATUS used to monitor the entire system status, those two modules always check the Wave Ring for all modules heartbeats and check if modules are life or not; then copy status for all modules to HYPORING for status publishing, then EWHTMLEMAIL, EWHTMLREPORT modules used to create and send a graphical alert emails told users about the entire system status and all information about identified and extracted events, finally continuously archive all information about extracted events and system information in file based archives. Complete block diagram for all modules and shared memories used to design the system is shown in **Fig 3**.

3. Results

A group of earthworm modules used to build a customize real time data acquisition and archiving system for operating the ESN network, three data acquisition modules REFTEK2EW, SLINK2EW and NAQS2EW are used to acquire data from EMS systems operating 130-SMA and Titan-SMA accellrograph stations and ENSN velocity stations and archive data for all stations in file based tanks using Wave_serverV module; while two data archiving modules EW2MSEED and WAVEMAN2DISK used for continues real time data archiving ESN data in standard Miniseed format and manual data extraction in SAC, Miniseed, ASCII format upon user selection; also a group of data processing modules PICK_EW, EQVERIFY, EQPROC, EQCODA, and EQBUF used for real time event identification and location; while a group of status check and publishing modules STATMGR, COPYSTATUS, EWHTMLEMAIL and EWHTMLREPORT used for monitoring the entire status for the system and create a graphical html

messages sent to the used containing all information about system modules status and operation also create graphical html messages sent to the user contain information about identified and located events; also an real time seismic data analysis program SWARM used for real time access to the data and analyze data from both ESN accellrograph network and ENSN velocity network.

4. Discussion

The USGS earthworm system flexible and robust system, and used to build our system, the main goal for this study was to build a customized real time to improve existence EMS systems operating ESN accellrograph network, comparing our resulting system with existence system; the RTPD server store data in RTU format and NAQS server store data in store format while the resulting system combine between the two system and store data for both systems in Miniseed format; both RTPD server and APOLLO sever use different manual data extraction utilities while the system save data in file based Tanks and use certain modules to manual extract data for both system in the same time, data extracted in many seismic data format upon the user request; both RTPD and NAQS servers do not offer real time event detection and identification and each system use analysis programs that use data from its own system while the resulting system use a group of high precise automatic events detection modules for real time events identification, **Allen (1982)** and use SWARM analysis program to access the data tanks for both systems; data coming from both RTPD and NAQS servers cannot use with ENSN velocity stations for event identification and location while our resulting receive data from ENSN velocity stations and use this data with ESN stations for real time event detections, besides detected events are published in an html messages to the users and the entire status for the system also sent to the users in text messages.

The resulting system will be used to make operating ESN Accellrograph more simpler and flexible, and data events recorded by this network will added with ENSN velocity stations to get more accurate events location around the Nile Delta.

Acknowledgments

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