Report of the NEIC/CISN Integration Working Group (B)

Background

The NEIC/CISN Integration working group was charged with reviewing the NEIC (National Earthquake Information Center) and CISN (California Integrated Seismic Network) data acquisition and analysis systems in the light of ANSS (Advanced National Seismic System) system documents and recommending what components of each system, if any, should be adopted or developed for use by ANSS (See Appendix 1).

The group had several conference calls, e-mail exchanges, and one face-to-face meeting. This brief report attempts to capture the consensus reached during those wide ranging and, at times, spirited discussions.

Discussion

The two systems are in different stages of their development cycles. The NEIC system is in a development and testing phase and is not yet operational. Most components of the CISN system have been operational for several years but development continues as the California operations centers evolve toward an integrated statewide seismic monitoring system.

Differences in the two systems are related to differences in mission requirements and implementation strategy. For example, the NEIC deals with sparse networks and local, regional, and teleseismic sources while the CISN deals with dense networks and local sources. The NEIC has adapted with multi-channel pickers, spherical earth models, and allowances for longer latencies. In addition, the NEIC has a requirement to acquire and process late arriving parameter data and has adapted to the ANSS goal of acquiring and processing out-of-order waveform data. Architecturally, CISN does picking, association and magnitude determination prior to inserting results into the database management system (DBMS). The NEIC has shifted all automated processing except for picking and association to operate out of the DBMS. Because the NEIC DBMS is being updated constantly during automatic processing, its structure is quite different from the CISN DBMS schema. These and other differences between the systems are enumerated in Appendix 2.

Despite these differences, the designs of the two systems are very similar. This is not surprising because the goals and requirement of all seismic data acquisition systems are basically the same. Both systems have the USGS developed and supported Earthworm system at their cores for real-time processing. Earthworm is a system developed by and for California network operators, which is heavily used by the U.S. seismic monitoring community, including the volcano hazards and tsunami hazards programs.

Possible areas of cooperation and convergence

The following areas were identified as those in which convergence and cooperation between NEIC and CISN are most likely to succeed to the benefit of ANSS.

Real-time Data Protocols – Both systems support a variety of protocols for streaming real-time waveform data (Table. 1). These protocols are used to transport data from center to center as well as from field sites to centers. This flexibility and commonality facilitates data sharing between NEIC and CISN. Continued use of standard protocols will facilitate intercommunication among ANSS regions.

Table 1. Streaming waveform protocols supported by each effort.

NEIC	CISN
• Quanterra multishear/comserve • Earthworm import/export & rings • Antelope ORB • Nanometrics • Reftek o NSN VSAT o LISS o NRTS o CD 1.0	• Quanterra multishear/comserve • Earthworm import/export & rings • Antelope ORB • Nanometrics • Reftek o Kinemetrics K2

Real-time Parameter Formats – Both systems support a variety of formats for exchange of real-time parametric data (Table. 2). Continued use of standard formats will facilitate data exchange among ANSS regions.

Table 2. Parametric data formats supported by each effort for automated exchange.

NEIC	CISN
• Cubic • Earthworm • GSE1.0* o SEISAN o Telegraphic o Harvard CMT?? o USGS MT??	• Cubic • Earthworm

*NEIC and the international community are slowing converging on GSE1.0 as a standard for rapid exchange of phase and amplitude data

Internal Waveform Formats – Both systems use the Earthworm (TraceBuf) format to move waveform data among Earthworm modules internally. Within the CISN system,

other tasks like magnitude calculation, strong motion extraction, archiving and post-processing all use MiniSEED format. The NEIC system uses the TraceBuf format out of Earthworm WaveServers to support magnitude calculations and other real-time products. The CISN is investing significant effort to revise Earthworm modules to support a modified TraceBuf format that implements SEED location codes. These code revisions will be incorporated into the official Earthworm code base and will benefit NEIC.

Waveform Data Description – Standardized "station naming" should be supported across ANSS. At a minimum, SEED-style Net.Sta.Chl.Loc should be supported by all ANSS formats and interfaces. ANSS should support the development and implementation of a data description scheme that addresses the shortcomings of the SEED naming convention.

Phase Pickers – It seems likely that a single sophisticated phase picking code could satisfy the requirements of both regional seismic networks (RSN's) and the NEIC. Such a general-purpose picker would need to be configurable to function well in various geologic settings, band passes, and with a wide range of instrument types. The feasibility and desirability of developing a common phase picking code should be explored.

Association/location – Work is being completed at NEIC on an associator/locator named GLASS that works for events at all distances (local, regional, teleseismic). As with the picker, this association code may satisfy the requirements of both RSN's and the NEIC if it is sufficiently configurable. A current limitation of this code is that it is platform dependent. The feasibility of using the GLASS associator at all ANSS networks should be evaluated.

Locator – Earthquake location modules and techniques may be too specialized and may evolve too rapidly for one to suit all ANSS regions. However, ANSS could foster a degree of standardization and interoperability by supporting standard interfaces for input and standard parameterization of the errors for the resulting solutions. This would allow the results of various techniques to be reasonably compared.

Magnitude methods – Some magnitude types (M_L, M_W, M_{WP}) are used by both RSN's and NEIC. These magnitude determination methodologies and codes should be shared. Disparate magnitudes from different sources are a source of confusion for our customers. An ad-hoc group was formed by ANSS to address issues related to the reporting of earthquake locations and magnitudes. While this group has made some progress on understanding the differences in earthquake location methods and the calculation of residual statistics and errors, further work by this group in conjunction with CISN and NEIC development could significantly improve the community's ability to report meaningful (quantifiable) earthquake source parameters

Archive Schema – NEIC is currently looking for an archive database schema. Through CISN the USGS/ANSS uses and supports the CISN schema. CISN controls the schema specification and it can be modified if necessary to meet ANSS needs. NEIC is

considering adopting this schema for archiving. ANSS should maintain close communications with IRIS and adopt IRIS data access interfaces where practical.

Station Metadata – All networks need to store station instrumentation history, location and response information ("metadata"). CISN stores metadata in the CISN schema, which is designed around the SEED standard. NEIC uses the Earthworm "cooked" response schema and is developing a method to derive full SEED from inventory information. The CISN schema does not accommodate all station information; in particular, it does not hold items of interest to field technicians that does not affect station response (e.g. contact information, site visit dates, power supply type, etc.) Station status and hardware inventory schemas and tools being developed by NEIC may be useful to CISN and other ANSS RSN's. All efforts should be tightly integrated to avoid the pitfalls of denormalized data.

State processing – NEIC has developed a "state processing" scheme that allows control of post processing functions. This was done to provide a consistent substrate for real-time and post-processing out of the DBMS. This scheme should be evaluated to determine if it would be beneficial in the RSN context.

Earthquake Information Distribution System – In the past year, the CISN and ANSS convened a panel to review earthquake information distribution systems. As part of this panel, specifications for a new system were developed and an RFP is currently being developed. The CISN and NEIC agree to use the new transport layer for applications such as Recent Earthquakes, CISN Display, and ShakeCast when the software is fully operational.

Communication among operators and developers.
The ANSS should actively promote communication among operators and developers in the ANSS regions and at NEIC. This could be done with meetings, conference calls, and site visits. They should also promote ties with the larger community like IRIS and COSMOS and customers like emergency responders, researchers, and engineers.

Standards – There are no ANSS data, software or processing standards. The ANSS should foster the sharing of data and code among ANSS regions by developing standards for formats, protocols, and interfaces and supporting development within these standards. The Working Group on XML Standards for Earthquake Information is an encouraging step in this direction. This effort might be lead by the USGS Integrated Products Team (IPT).

Conclusions

The developing CISN and NEIC systems have many aspects in common for which they can share code and development effort. However, there are a number of significant differences in the systems that make independent development of significant parts of each system necessary. Because of differences in mission, the types and timing of data each

system acquires and developments already completed there appears to be no reasonable way to converge development efforts into a single system short of starting over from scratch. Nevertheless several specific areas of cooperative development have been identified.

During the, sometimes heated, discussions of this working group several topics arose which we want to report back to the TIC or other working groups for their consideration.

While we were focused on the NEIC and CISN efforts primarily it became obvious that other networks have systems or modifications that provided services or capabilities comparable or better than the two being discussed. We tried not to get off topic, but realized that a comparison of some of these other systems should be done. We recommend that the Working Group on Evolutionary System Architecture (E) engage in a serious evaluation of ALL current systems to learn what currently works well and what doesn't. This should include commercial systems like Antelope, which is the primary system at several networks.

In our working group's discussions of recommendations it became obvious that there were differences of opinion as to what constituted the ANSS and what our mandate was to make recommendations for it. Since the ANSS is not fully funded and other sources of funds are often used for system development, some members of our working group thought our recommendations should only address those issues independent of internal development efforts within a network. Others felt that it was appropriate to examine all aspects of development and possibly make recommendations specific to current development efforts. Without clear guidance from top USGS managers regarding what currently makes up the ANSS, differences of priority and direction will continue to confuse such efforts.

Membership of the NEIC/CISN Integration Working Group (B)

Chair: Doug Given (USGS-CISN)
Harley Benz (TIC-NEIC)
Glenn Biasi (UNR)
Ray Buland (USGS-Golden)
Roger Hansen (UA)
Lynn Dietz (USGS-CISN)
Lind Gee (TIC-CISN)
Pete Lombard (UCB-CISN)
Steve Malone (UW)

Appendix 1. Charge to the Working Group

TIC Working Group on NEIC/CISN Integration (B)
Duration: Short-term
Associated TIC Tasks: 2
Timetable: June 30, 2004

Charge

This working group is responsible for investigating the current development of acquisition, processing, notification and distribution systems at the National Earthquake Information Center and the California Integrated Seismic Network in order for the seismic monitoring community to benefit from these efforts and to avoid duplications of effort and to leverage resources. The intent is to avoid developing divergent and/or incompatible systems that make it hard to evolve ANSS into a functional nationwide system. With few exceptions, developments within the CISN and NEIC will strongly influence the path that all networks take in their implementation of new acquisition, processing software and operational procedures.

Following are specific tasks to be performed by this working group.

1. Review of existing systems, which include a thorough understanding of mission and performance requirements, and operational constraints. The numerous design, requirement and specification documents that have been produced by various groups contributing to these efforts need to be assembled and distributed for background information. This working group should identify common frameworks and common modules, and document areas of divergence.

2. Review ANSS documents (e.g., Circular 1188; OFR 02-92; USGS Program Announcement 04HQPA0002, June 2003, Attachment A; 2002 white paper by A. Lerner-Lam on performance-based assessment, Booz-Allen-Hamilton report) to ensure that developments meet ANSS goals. This group should identify system engineering issues and report them to the Evolutionary Implementation Working Group (E).

3. Based on a review of NEIC/CISN systems and/or sub-systems, make specific recommendations on components that should be further developed for use by ANSS supported networks or simply adopted for use by the network community.

4. The working group should work closely with the TIC to disseminate the results of its ongoing deliberations as they affect other ANSS networks.

Activities of the WG need to be coordinated with the TIC Working Groups on National Performance Standards and Evolutionary Implementation and the USGS's Integrated Products Team to ensure a consistent framework on the development of national systems for exchange, processing and distribution of earthquake information products.

Appendix 2. Differences between NEIC and CISN

NEIC	CISN
• Responsible for location and magnitude at regional and teleseismic distances.	• Responsible for location and magnitude at local and regional distances. (May record regional and teleseismic events)
• Events are of long duration (global propagation time)	• Events are of short duration (local propagation time)
• Contributed parameter data often arrives late, days or weeks after the event.	• Contributed parameter data generally arrives quickly.
• Design decision to allow late data to automatically change solution.	• Design decision not to allow late data to automatically change solution.
• Receives waveforms from many sites not operated by NEIC.	• Most waveforms are from sites operated by CISN partners.
• Picker could be the same but, associator, locator are global	• Picker could be the same but, associator, locator are regional
• Produces data-less ShakeMap.	• Produces data-full ShakeMap
• Operational center not in region of earthquake shaking.	• Operational center possibly in region of earthquake shaking.
• Main customers do not generally include engineers.	• Main customers include engineers.
• Local waveform archive, but only limited distribution.	• Local waveform archive and public distribution.
• Plans to use RT optimized schema (extended Earthworm) for RT system. No archive schema.	• Uses same schema for RT, analysis and archive (CISN schema).
• Single processing center	• Multiple cooperating centers
• Acts as backup to regions.	• Backed up by partners and NEIC.