Planning for the Advanced National Seismic System: Network Architecture and Interconnection

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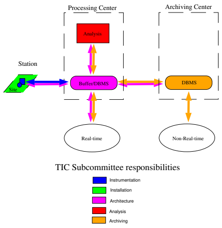
Technical development of the ANSS

As described in a recent article in SRL, the Technical Integration Committee of the ANSS has formed 5 subcommittees to develop standards for network architecture, instrumentation, station installation, products, and archiving.

Subcommittee on Network Architecture and Interconnection
Develop consensus-based guidance for the integrated design of national, regional, and urban monitoring components and for communications among the components (sensors, data centers, and real-time recipients of data and products). This includes the technical design of communications protocols and data center design and functionality, but does not include specification of data formats. The system should include consideration of appropriate levels of timeliness, completeness, robustness, redundancy, and quality control. The design must examine distributed data acquisition and processing, and must allow for distributed data archiving and distribution. The capability to incorporate data from sensors and networks owned and operated by other organizations should be included. Performance specifications for the data acquisition and exchange hardware/software system nationwide need to be identified.

Because of the very close tie between the activities of this Subcommittee and the Data Archiving and Distribution Subcommittee, it is anticipated that this committee may conduct some joint meetings with the Archiving and Data Distribution Subcommittee.



Subcommittee on Data Analysis and Products
Based on the needs of users, develop guidelines or standards for ANSS data processing and generation of information products. This subcommittee must coordinate among existing organizations and leading scientists and engineers to develop consensus for earthquake and ground motion parameters. The algorithmic basis for data processing and acceptable performance underlying the products must be specified, but alternative computational methods could be used to satisfy these requirements. The subcommittee must also coordinate the development of standards for preparation of such publicly released products as ShakeMap, Community Intensity Maps, other map-based products, and other earthquake information products. Procedures for evaluating, prioritizing, developing, and implementing future products to meet user needs shall also be developed by this Subcommittee. . Procedures for ANSS quality assurance/quality control should also be addressed.

Subcommittee on Instrumentation
Establish standards and procurement specifications for sensors, data loggers, and other hardware components to meet user needs. These standards or specifications should build on specifications of current instrumentation, modified as appropriate for current or anticipated advances in technology. Classes of instruments that need to be considered are:
- Standard ANSS broadband sensor packages and data loggers
  - national network
  - regional networks
- Standard ANSS urban monitoring sensor packages and data loggers
  - in-structure
  - reference
  - free field

The functionality of each of these instrument types and sub-types needs to be carefully defined. Instrument package designs need to consider such aspects as raw data formats, field data recording, data communications to a data center, on-board data analysis, and long-term maintenance.

Subcommittee on Site Installation
Prepare guidance documents for all aspects of sensor siting and installation, including:
- Distribution of new sites in the context of existing sites
- Necessary and desirable site characteristics (noise, geology, geotechnical parameters, data communication, proximity to buildings, etc.)
- Site preparation, construction, instrumentation installation, and site and installation documentation

These documents must include guidance for national, regional, and urban (in building, reference, and free field) sites. The data quality needs of users must be carefully considered in preparing this guidance. This guidance must be realistic, addressing acceptable compromises in siting arising from requirements for space, power, communications, security, etc. Procedures for review of siting plans should be established. Procedures for ANSS quality assurance/quality control also should be addressed.

Subcommittee on Data Achiving and Distribution
Based on the needs of users, develop standards or specifications for ANSS data archiving and distribution, including the specification of data and information formats. It would be desirable for this Subcommittee to develop meta-SQL and/or API standards such that databases with different underlying schemas can be accessed in the same manner. This subcommittee must coordinate among existing organizations and leading scientists and engineers to develop consensus standards for distribution of data to scientific and engineering users and centers, and archiving of data. Format coordination for raw data shall be carried out with the Subcommittee on Instrumentation, and for processed data with the Subcommittee on Data Analysis and Products. Specifications or standards for data archiving shall include standards for the minimum required amount of ancillary information (metadata) that must be managed in addition to the management of waveform data.

Procedures for quality assurance/quality control should be formally addresses in all the products of this subcommittee.

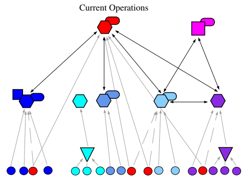
In general, close coordination, including joint meetings when necessary, with the Subcommittee on Network Architecture and Interconnection is encouraged.

Models of System Architecture

Discussions about ANSS architecture are often complicated, due to differing interpretations of common terms. In particular, the ANSS uses the term regional in a different sense than has been traditional (i.e., regional seismic network).

- National: Activities or operations pertaining to the Nation as a whole.
- Regional: Activities or operations pertaining to one of the ANSS regions.
- Local: Activities or operations in one of the existing seismic networks.

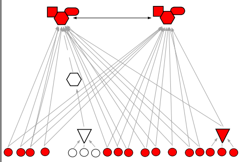
Current Operations



- Station: A site where seismological instrumentation (either weak motion or strong motion or both) is deployed.
- Data Concentrator: A facility where seismological waveform data from multiple stations are consolidated onto high-bandwidth communications circuits.
- Data Processing Center: A facility where seismological waveform data are acquired and processed to produce summary parameters.
- Data Archiving Center: A facility where seismological data are archived and where custom user requests are satisfied.
- Data Outlet: A facility where seismological data are interpreted for emergency managers, the media, and the public.

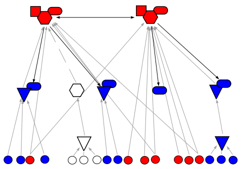
Many models of ANSS architecture may be constructed from the building blocks described here. Figure 1 illustrates the current situation, where the ANSS is developing within a legacy infrastructure which has evolved over the last century, particularly over the last 40 years. Of the 30-40 local seismic networks fewer than 20 are supported by the USGS today. The local processing centers are characterized by a wide range of hardware and software solutions. All of the USGS-funded centers have established data exchange with the national center (NEIC) and, in some cases, with other local centers. Some local networks archive their data at IRIS, while others have established local archives (for example, the NCEDC and SCEC DC).

National or Centralized Model



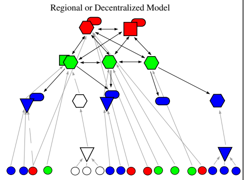
One end-member is the highly nationalized model in this figure. This model provides for two or more national processing centers, receiving data from all ANSS sites. Data may be contributed from non-ANSS elements (open components). This model is simple, homogenous (all ANSS nodes operate the same software), and symmetric (all nodes perform the same level of processing). Multiple processing and archiving centers are required to fulfill the ANSS goal of robust and reliable earthquake information.

Alternative Centralized Model



A variant on the nationalized model is shown in this figure. In this case, the local networks contribute to the ANSS by providing local communications points. Data are forwarded from the local networks to the national centers for processing. This figure also introduces the role of data outlets. Local networks - and other seismological centers - may act as data interpreters for local emergency response operators as well as other users of ANSS data.

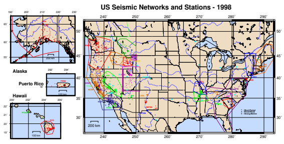
Regional or Decentralized Model

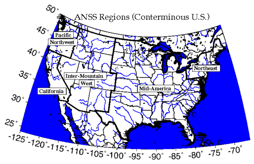


This figure is a model which builds on a regional, rather than national, structure. In this realization, local networks would coordinate to create a "regional" processing center which would be the authoritative source for earthquake information within a region. The number of regional processing centers would be relatively small.

Organizational Framework

What do we have now?
Earthquake monitoring has a long history in the United States. From early seismographic stations in California to USGS-sponsored networks in the 1970s to the development of the TriNet project, the uneven evolution of seismic monitoring has left a complex legacy of spatially variable infrastructure and capability. This figure from the 1998 inventory created by the Council of the National Seismic System illustrates the "patchwork quilt" which has developed.





Where is the ANSS going?
Because of the complexity created by 30-40 local networks with variable hardware, software, and missions, the ANSS is organizing on a regional basis. 7 regions have been recognized thus far: Alaska, Hawaii, Pacific Northwest, California, Inter-Mountain West, Mid-America, and Northeast. The regional structure allows for coordination of effort among the local networks to produce a national program.

Issues and Tradeoffs

Should ANSS processing centers use mostly homogeneous software? What are the alternatives? How realistic are they? What is the best way to handle regionally varying needs?

Should data processing center functions be symmetrical? What are the advantages in making the system intentionally asymmetric?

Should the number of regional processing centers be minimized? Should processing centers be moved away from areas of earthquake, fire, flood, and severe weather risk? What technical reasons are there for more than one processing center per region? Are there architectural implications?

What are the disadvantages of an integrated, nationally consistent, centrally produced, national catalog? Can this approach met regional needs? Are there architectural implications?

What is the best way of involving seismologists and engineers in network operation, evolution, and planning without overwhelming them in day-to-day operations? How can the "data feel" necessary to good interpretation be maintained? What are the architectural implications?

What is the best way to interface with contributing centers? Should it be done at the ANSS processing centers, at the contributing center, or some combination?

NAI Report

The NAI subcommittee submitted a draft report to the TIC on March 5, 2001. A copy of the report is available at

http://quake.geo.berkeley.edu/anss-nai/

The NAI subcommittee is currently revising its report in response to feedback from the TIC and other reviewers. The NAI is interested in comments and suggestions. Please feel free to contact us at

anss-nai@seismo.berkeley.edu