Reducing the Costs Associated With Dense Seismic Network Management

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Abstract

Networks are increasing in complexity. The complexity of these stations and data centers can be attributed to the growing number of stations, expanding technologies, and a heterogeneous mix of instruments and devices in the field. These challenges give rise to operational concerns in the data center when considering how to administer and manage such networks cost-effectively. Nanometrics is working to address the issues of operational costs and support and management challenges via the introduction of industry-standard network monitoring and management technologies and operational workflow improvements across seismic monitoring instrumentation and related software.

Seismic Equipment Management

Standards-based Seismic Digitizer Health Monitoring via SNMP

Seismic network infrastructure comprises many devices and instruments, including power supplies, MPPT solar charge controllers, network switches/modems, and of course, seismic instrumentation in the field, as well as workstations, servers, switches, and routers in the data center. Many of these devices provide their users with the means to manage them via the Simple Network Management Protocol (SNMP). SNMP is an Internet standard protocol widely used in network management and is compatible with industry-standard tools such as Nagios, SolarWinds, and many others. On the other hand, networked seismic instrumentation, typically streams state-of-health (SOH) information in the same fashion as seismic channels, which obliges network operators to use different management solutions and paradigms for managing the wide variety of equipment in their network.

Centaur digitizers and TitanSMA and TitanEA Accelerographs now support remote management through SNMP. By enabling SNMP on these seismic instruments, network operation personnel can now include their state of health in a single common dashboard along with their other networked devices in the data center and the field. With this SNMP integration, a network operator can more easily track network uptime metrics and with which equipment is working or offline and why.

Figure 1: Screen capture of a dashboard screen (from Nagios Website)

Bulk Configuration and Firmware Update of Digitizers from a Central Interface

Seismic monitoring needs are constantly evolving and so, the ability to change a network configuration or update the firmware of multiple stations remotely from a central location is essential. In addition, as networks grow in size and complexity, the effort and cost of updating the configuration or firmware of many remote stations increase accordingly. To help network operators, Nanometrics has added a bulk remote configuration and firmware update function to the Apollo data acquisition solution to allow fast and more cost-efficient management of Nanometrics instruments from a central location.

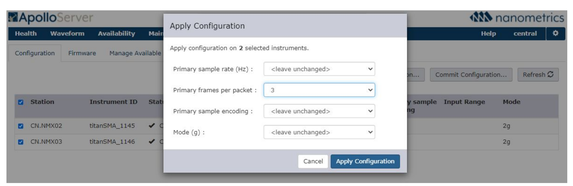

Figure 2: Screen capture of configuration interface in Apollo Server

Security, Compatibility, Extensibility

Secure and Shared IT Infrastructure using OpenVPN

The prevalence of the Internet and its low cost to access relative to private networking makes it an attractive medium to acquire the data generated by seismic stations with networked digitizers. Still, it is essential to do this securely due to the typical hazards involved with connecting devices to the Internet. In addition, network operators often have a variety of equipment from different vendors deployed in their network; consequently, there will be different communication protocols and network ports involved both at the station in the field and at the data center. Accommodating these different requirements incurs additional operational costs for network operators.

Nanometrics now supports OpenVPN® to allow its Centaur and TitanSMA/EA products to establish secure connections to their respective data centers. VPN technology enables network operators to secure communication between the data center and remote stations more easily via contemporary high-grade encryption. It also simplifies firewall configuration by normalizing access to the data center across heterogeneous network devices since the data tunnelling employed by VPN technology allows for flexibility in the potentially wide variety of application communication protocols that the data center may use.

Low Latency, Low Bandwidth Data Streaming using NP Protocol

As an alternative to SeedLink-based data acquisition, Nanometrics offers the NP data acquisition protocol, which can lower latency and easily provide redundancy: key benefits for real-time hazard warning systems such as Earthquake or Tsunami early warning. To maximize the effectiveness of such systems, network operators look for any technological gains that can help achieve data promptness metrics and completeness metrics by deploying datapath redundancy to ensure a suitable level of fault tolerance exists.

The NP data acquisition protocol can be run over UDP or TCP (Websockets). It includes the means to control latency by controlling the size of the packet in addition to the standard approach of changing the digitizer sample rate. This yields more flexibility to the network designer when trading between network/processing overhead and lower latency. Running NP over UDP requires 2.5x less packet overhead in the header compared with TCP/SeedLink, and is also better suited to low latency applications when occasional packet loss can occur. This is because NP/UDP prioritizes the transmission of live packets over the retransmission of packets previously dropped in the network. TCP-based protocols cannot provide this differentiation which is why low-latency applications work best using UDP. Beyond low latency applications, NP offers configurable throttling, allowing link bandwidth to be easily managed when sharing or constrained radio links, for example. Furthermore, NP provides the ability to deploy high availability/redundancy streaming architectures in the data center without the cost of additional network bandwidth through IP multicasting.

It should be recognized, however, that many data analysis products expect to receive live data via SeedLink. The Apollo Server product that Nanometrics offers the ability to enjoy the benefits of NP-based data acquisition from remote stations while also seamlessly presenting the live datastream in real-time for analysis via SeedLink. The benefits of using the NP protocol can be realized without sacrificing any compatibility with applications in the data center expecting to consume data via SeedLink.

Customized Workflow with Application Programming Interfaces (APIs)

Integration into existing or new network maintenance tools, such as calibration verification, site noise analysis or others, can prove challenging. APIs (application programming interfaces) can help streamline these workflows to their unique integration constraints. The Centaur digitizer TitanSMA and TitanEA accelerographs, offer a rich set of APIs that facilitate the integration needed to normalize operations and reduce operational costs. Notable APIs include:

- Data Availability - provides details regarding the time intervals for which contiguous data is available on the instrument's internal media.
- FDSN-WS Data Retrieval - an industry-standard web service to download from the primary media, waveform and SOH data in MiniSeed format selectable based on the clients requested time range
- Calibration – initiates a sensor calibration based on user-defined parameters such as signal type (e.g., Sine, Step, PRBS), calibration mode (voltage or current), and more.
- Instrument Response - Download an overall instrument response, including sensors

Simplified Acquisition

Powerful and Flexible Data Acquisition using Apollo Server

Many modern seismic networks include high-value instrumentation, such as broadband seismometers and strong motion accelerometers supplemented with geodetic instruments. This gives rise to operational challenges for the station's design regarding acquiring geodesy data, such as Binex, with the seismic data into a common acquisition system. Likewise, for example, additional challenges may arise from implementing redundant data transmission for maximum uptime when the telemetry infrastructure may have reliability issues. These needs and more can be addressed using Nanometrics Apollo data acquisition software to acquire continuous sensor data, state-of-health data, event triggers and alerts from seismic stations. Key benefits of using Apollo data acquisition software include:

- **Protocol choice**: when communicating with both Nanometrics and 3rd party digitizers at remote stations, NP or SeedLink may be used. And, if the unique benefits of NP-based data acquisition are being leveraged, there is the ability to provide the live data to downstream consuming applications via Seedlink for compatibility.
- **Optimized low latency data acquisition**: although SeedLink is supported, NP over UDP is best for low latency applications. For example, when network outages and occasional packet loss occur in the network, using NP over UDP offers unique benefits for low latency data acquisition - live packet prioritization, less network overhead, and more efficient data recovery
- **Flexible data acquisition and streaming topologies**: includes the ability to support, via IP multicast, redundant streaming data paths where data is received multiple times but sent only once to minimize network bandwidth usage
- **Multi-Disciplinary Data Acquisition**: support for geodetic data acquisition (e.g., BINEX), including backfill.
- **Event trigger detection**: STA/LTA and event reporting
- **Data archiving**: real-time archiving of seismic and state of health data in MiniSeed format with a highly configurable directory structure and file naming scheme

When recovering from a station or data center communication degradation or a full outage:

- When using SeedLink or NP-based data acquisition, unlike other SeedLink implementations, the resumption of live data acquisition is explicitly prioritized over missed data when communication is re-established
- Retransmitted data can be configured to a preferred lowest-cost network path, and the amount of retransmitted data can be capped based on operational requirements.

Apollo Server has a user-friendly Availability display, providing data availability, latency, and retransmit percentages to view problematic stations or channels quickly.

Figure 3: Apollo Server interface showing the availability and latency for a stations on a channel basis