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scoctoloc - A regional phase associator and locator module for SeisComP

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The open-source, seismological software SeisComP is widely used for earthquake monitoring world-wide. Its default automatic phase association and location module is scautoloc, which was originally developed to monitor large earthquakes with global or large-regional networks. It detects and locates earthquakes iteratively, beginning with P picks from only the nearest stations and improving the earthquake location as additional picks arrive. This process may take more than 15 minutes and the availability of early intermediate results is therefore essential for time-critical applications like tsunami early warning.

Requirements for local earthquake monitoring are quite different. The number of stations is usually smaller and the seismic wave travel times are typically below one minute. Small networks greatly benefit from the use of S picks and custom velocity models to optimize their locations, neither of which are currently supported by scautoloc.

In an effort to improve local and regional monitoring capabilities in SeisComP using only open-source software, we adapted the phase associator PyOcto [1, 2] to the SeisComP framework. PyOcto was specifically designed for fast processing of large amounts of regional network picks. This is particularly important because of the vast improvements in the amount of picks obtained using machine learning techniques [3, 4]. Its efficient implementation and low computational overhead also make PyOcto a perfect phase associator for real-time earthquake monitoring.

The new SeisComP module scoctoloc [5] leverages the use of PyOcto to improve processing of local and regional network data in SeisComP. The ability to process both P and S picks and the convenient support for either homogeneous (0D) or custom layered (1D) velocity models overcome the main limitations of scautoloc. Small networks may choose to run scoctoloc as a drop-in replacement of scautoloc, though both modules may also be run in parallel.

The factors limiting the real-time processing speed are the network dimension (and hence seismic travel times) and pick latency. The latter depends on the latency of the data telemetry and on the processing delay imposed by the picking technique used. In our real-time test setup, a virtual seismic network in Northern Chile, earthquake locations are usually produced within three minutes after an event using P and S picks produced by the scdlpicker module [4]. Where processing speed is more crucial than optimum pick accuracy, the standard SeisComP scautopick with S picking enabled is still the picker of choice.

The use case that PyOcto was developed for originally, the bulk processing of huge amounts of picks read from a database, is supported by scoctoloc as well. In addition it is possible to run "pick playbacks" from a SeisComP database in order to simulate real-time operation. This mode is useful in order to fine-tune the configuration parameters relevant for real-time monitoring based on past events.

[1] Münchmeyer, J. (2024). PyOcto: A high-throughput seismic phase associator. Seismica. doi:10.26443/seismica.v3i1.1130.
[2] https://github.com/yetinam/pyocto
[3] Münchmeyer et al. (2022), https://doi.org/10.1029/2021JB023499
[4] https://github.com/SeisComP/scdlpicker
[5] https://github.com/jsaul/scoctoloc