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Improvement on the Computational Efficiency and Robustness of Real-time Multi-GNSS Satellite Clock Estimation

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Real-time multi-GNSS precise point positioning (PPP) requires the application of high-frequency satellite clock corrections. Due to the large number of ambiguity parameters, it is difficult to update satellite clocks at high frequency in real-time for a large reference network. With the increasing number of satellites of the multi-GNSS constellations and of the number of real-time stations, this task becomes one of the big challenges in real-time high-rate clock estimation.

In this contribution, we propose a decentralized clock estimation (DECE) strategy, in which both un-differenced (UD) and epoch-differenced (ED) modes are implemented and can be running separately on difference computers for different GNSS systems and networks and their clocks are combined in another procedure to generate the final products. The clock estimation procedure has higher efficiency and can always provide high-rate clock products if one of the redundant ED solutions and one of UD solutions are working well.

In order to further enhance the robustness of the clock estimation, a new strategy is developed for rapid convergence of the clock estimation. Usually, a dozen hours of continuous observation is needed in order to provide accurate clocks after (re-)starting a clock estimating process. Instead of directly processing real-time streaming data, the latest available filter information and the following past observations up to the latest 24 hours are also employed. The past observations are firstly fed to the filter but in a rather larger sampling interval in order to catch up with the real-time data and afterwards they are changed to real-time streams seamlessly. It reduces the convergence time from more than a dozen hours to less than one hour for the starting run and a few minutes for restarting with saved filter information.

The new strategies above are realized based on the Position And Navigation Data Analyst (PANDA) software package and are experimentally validated with about 110 real-time stations for clock estimation and with 12 stations for real-time PPP.