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Internet-Based Network-RTK with Self-Distributed Reference Stations - Concepts and Prototype

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Abstract

Network-based RTK involves multiple Reference Stations (RS) for network corrections to assist users in single carrier phase precise positioning with RTK-GPS technique. Conventional network-based RTK implies centralized architecture to generate the network corrections and distribute them to users. The hub is typically implemented as a data center, in which some complicated control software and communication equipment are installed. However the hub can support a limited number of RSs and users because of the restricted processing performance and the communication link bandwidth. Another problem of the conventional system is higher cost to integrate, operate and maintain the RS network. It is not easy to expand or reconfigure the network, once constructed.

Recently, the Internet connections have been extended to mobile users through cellular phone or public wireless LAN services. In this study, to facilitate the precise positioning abilities, a network-RTK system composed of many self-distributed RSs connected by the Internet, is proposed. Each RS is completely independent to the others, having the role to gather neighbor RS observations, to make baseline ambiguities resolution (AR) with atmospheric parameter estimation and to compute the RTK corrections associated to the RS itself. The mobile user (rover) also could access to the nearest RS for the network corrections via the Internet. It is not necessary to involve any hub to maintain the RS network according to the architecture. The system only requires many simplified RS servers equipped GPS/GNSS receivers with the Internet connection. Each RS autonomously communicates each other, generates the network corrections and distributes them to the users. In this manner, it is easy to expand or reconfigure the RS network. This Internet-based network-RTK with self-distributed RSs well conforms to the network corrections according to the master-auxiliary concept [1]. In this approach, the correction messages contain the full correction and fixed position of a single master RS and correction differences at the same ambiguity level of some slave (auxiliary) RSs by resolving baseline ambiguities between the master RS and the slave RSs. The user can simply interpolate the corrections using the approximate user position and make the RTK-GPS processing on the baseline between the user and the master RS. The correction differences can be separated to dispersive and non-dispersive parts to optimize communication bandwidth. According to the proposed Internet-based distributed concept, each RS plays the role as both of the master and the slave. An RS transmit full correction based on the own observables as the master and generate correction differences with the neighbors as the slaves. The same situation can be applied to the other RS. In addition to the self-distributed RSs, the mechanism is necessary to search and find the

IP address of the networked RS not only for the users but also for the RSs themselves. For this purpose, at least one RS directory server has to be provided on the Internet. The RS directory server maintains the table of the IP addresses and the geodetic positions of all RSs. It responds to the query, containing the user position, with the IP addresses of RSs in the vicinity of the user. In case that a new RS intends to participate to the network, the RS issues the RS registration request to the RS directory server with the own IP address and the geodetic position. The RS directory server is also responsible to monitor the RS health periodically and to delete the table entry of the dead RS. This simple feature of the RS search enables the flexible network configuration and provides the RS redundancy to users. To maintain the reference coordinates of the RSs, each RS has the built-in static-PPP function. At the installation or periodically, this function automatically downloads the IGS precise ephemerides via the Internet and determines the RS position conformed to the ITRF in sub-cm accuracy. It is the easiest way to maintain accurate and consistent networked RS coordinates.

To demonstrate and verify the new distributed network-RTK concepts described above, the prototype system has been developed. The prototype RS server is implemented on the PC with Linux OS connected to a dual-frequency GPS receiver. The server control application program (AP) is implemented using RTKLIB, which is a simple C-based RTK-GPS library developed by the authors. The RTKLIB includes the basic precise positioning functions like coordinate transformations, atmospheric models, navigation algorithms and so on. The RTKLIB also implements the AR by popular LAMBDA integer least-square estimation. For the prototype, the functions like SP3 file handling and some precise correction models for the PPP are added. The prototype uses the message conformed to the standard RTCM 3.1 [2], which employs efficient encoding scheme based upon the master-auxiliary concept. Only the message 1004, 1005, 1014 and 1017 are implemented and distributed by NTRIP [3] based on the simple TCP/HTTP protocol over the Internet. The subset of both of the NtripServer and the NtripCaster functions is integrated to the RS server control AP. The RS directory server is implemented as the other internet-connected PC, using the custom query protocol over the NTRIP. As for the rover side, the RTK positioning AP with the network correction is developed on a Windows notebook PC with a GPS/GNSS receiver. The rover utilizes the Internet-connection service over the cellular phone network provided in Japan. The NtripClient function is also included in the rover AP to access to the network corrections. Some performance evaluation results are also presented using the prototype, from the viewpoints of the positioning accuracy, the time-to-first-fix (TTFF), the network bandwidth for the correction messages and so on.

References :

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