Streaming Real-Time IGS Data and Products Using NTRIP

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1. Introduction

The Real-Time IGS Working Group developed the RTIGS protocol for streaming GNSS data over the open Internet. The protocol makes use of the UDP transport protocol and is capable of transmitting any type of data or product. RTIGS GNSS data streams are available in a format that incorporates the JPL SOC format for data compression. Software packages including the RTIGS's udpRelay, udpArchiver and MulticastReader have been in use for several years and have been proven to meet the demands for real-time GNSS product generation based on data from globally distributed reference stations.

At the same time, under the auspices of the "Radio Technical Commission for Maritime Services" (RTCM), GNSS vendors developed and finally agreed, in September 2004, on a new protocol for streaming GNSS data. The new protocol is called "Networked Transport of RTCM via Internet Protocol" (NTRIP) and it is also capable of streaming any kind of GNSS data. NTRIP has the potential to disseminate the upcoming RTIGS products over the Internet to stationary or mobile users worldwide. The NTRIP transport protocol provides an additional method for accessing global GNSS data in real-time and will thereby augment the existing RTIGS global network. Furthermore, RTCM's new Version 3 data format is being considered by the RTIGS to become the standard format for the transmission of real-time GNSS data.

Following an introduction of NTRIP, this paper describes the interface established as an IGS effort to merge today's real-time GNSS resources available through NTRIP and RTIGS. The network of NTRIP broadcasters and its conceptual details necessary to share the workload with regard to bandwidth limitations, availability, and reliability are shown. Finally an overview on the existing Open Source NTRIP software for stream collection, dissemination, and conversion rounds up this contribution.

2. Networked Transport of RTCM via Internet Protocol, NTRIP

NTRIP stands for a transport protocol that has been developed for streaming GNSS data over the open Internet. Although the main application in mind has been the transport of RTCM data, it can be used to stream GNSS data in any kind of format. The only limitations are that a stream content should not exceed a maximum of about 10 kilo bits per second or carry less than a minimum of about 100 bits per second. A major advantage of NTRIP is its ability to support mass usage. Hundreds of streams may be disseminated simultaneously for up to thousands of listening clients. The NTRIP system comprises the following four major components:

- NTRIP Sources represent the source of GNSS data that are being fed into the system. This is normally a GNSS receiver that provides observations or generates correction data.
- NTRIP Servers read data from an NTRIP Source and forward them to an NTRIP Caster.
- NTRIP Casters split data coming in from NTRIP Servers to simultaneously support many clients. They serve as a link between NTRIP Servers and NTRIP Clients.

- NTRIP Clients are what stationary or mobile users finally need to access the streamed GNSS data. Each client chooses a specific NTRIP Source by its ID from an NTRIP Caster.

NTRIP is composed of a subset of the widely used Hypertext Transfer Protocol known as HTTP and thus based on TCP. Consequently all streaming is carried out using one single IP port, in many cases port 80 or 2101. Furthermore, NTRIP includes the provision of metadata through a so-called Source Table maintained by the NTRIP Caster. It describes the content and provides the ID of any GNSS data stream made available.

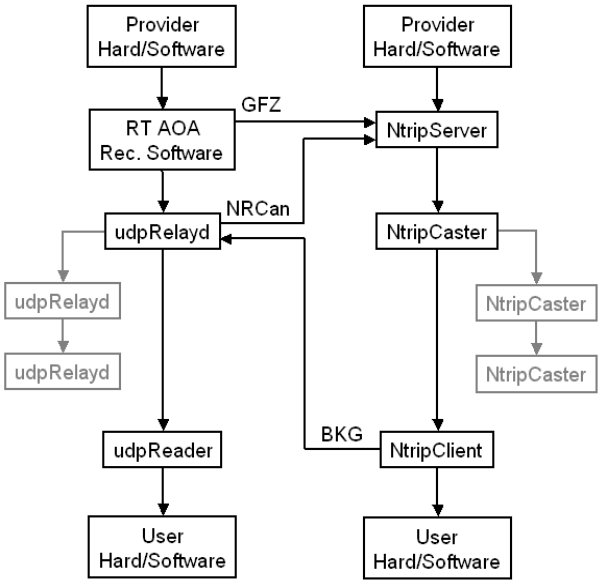
So far NTRIP Version 1.0 became an RTCM standard in September 2004. A Version 2 is under development that seeks for full HTTP compatibility in view of proxy servers and shall include an optional use of the UDP protocol. As a consequence from being recommended by RTCM, NTRIP components are today implemented in a variety of commercial hard- and software products ranging from reference station and rover receivers to PDA's and mobile phones.

3. RTIGS-NTRIP Interface

NTRIP has its roots in an EUREF initiative and is therefore a standard within the EUREF-IP Pilot Project for streaming GNSS data, obviously with a focus on Europe. Parallel to EUREF's efforts, the Real-Time IGS Working Group developed a different data format and data transport protocol that is based on UDP. This streaming technique, known as RTIGS is used today by global IGS contributors like NRCan, ESA, and GFZ and is also meant for streaming GNSS data over the open Internet. From the technical point of view, the current situation suggests to implement interfaces between the RTIGS and the NTRIP technology to satisfy the need of both EUREF and IGS to ensure access to well-distributed GNSS data world-wide.

In fact, the system architecture behind RTIGS is similar to that of the NTRIP system, see Fig. 1. An on-site software forwards data from a continuously operated reference station to a central relay acting as splitter caster. There, streams are accessed by a reader software that may feed a real-time GNSS application.

Fig. 1: RTIGS⇔NTRIP Interface, left: RTIGS, right: NTRIP



For the purpose of gaining experience, an RTIGS⇒NTRIP interface has been implemented by EUREF that makes data transported in RTIGS format using the RTIGS transport protocol available within the NTRIP system. Concerning data from NRCan, streams are picked up by an NTRIP Server on BKG premises in Frankfurt to feed a EUREF-IP NTRIP Caster. Concerning data from GFZ, an NTRIP Server is operated directly on GFZ premises in Potsdam with the advantage of saving about half a second data delivery time. ESA is expected to join the Interface with some stations from its global GNSS network.

NRCan intends to set up the counter Interface NTRIP⇒RTIGS to make data from NTRIP Casters available for the RTIGS stream dissemination system. An NTRIP Client integrated in a UDP relay demon software will be set up later this year as part of an RTIGS Pilot Project. The content of NTRIP streams, usually encoded in RTCM format, have to be converted to the RTIGS format for that purpose.

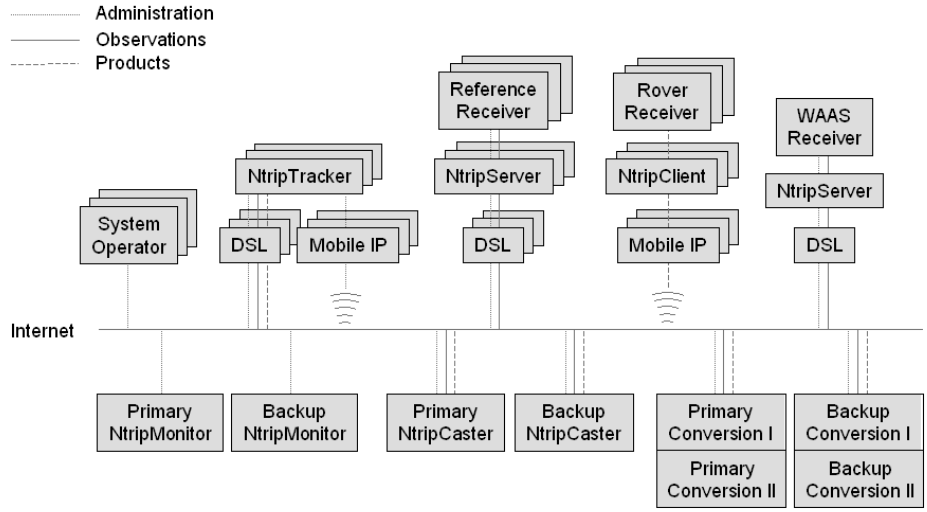
4. NTRIP Broadcaster Network

The open data policy anticipated for both, the EUREF-IP and the RTIGS Pilot Project, may lead to a strong interest in acquiring access to global real-time data. The intention is to accept any data requests as far as dissemination capability allows. In a first effort, BKG operates an NTRIP Caster for IGS at www.igs-ip.net, ports 80 and 2101. This installation will serve as an initial hub used by analysis centers to generate and broadcast satellite orbit and clock information in real-time. However, a single NTRIP Caster installation on its own will very soon not in the position to provide enough resources to satisfy all needs. In order to share the workload, a global net of NTRIP Casters needs to be set up. Establishing an NTRIP Caster on each continent and pursuing a suitable concept for the global data flow should be the next step, optimally accompanied by the operation of additional regional Caster installations.

Fig. 2 shows a service concept enabled by NTRIP system elements globally spread over the Internet. The data flow starts at reference stations, comprises NTRIP Casters and stream converters, and ends up at NTRIP Clients connected to rover receivers. Backup facilities together with monitor software for checking stream availability and content are vital components to ensure reliability. As to the data format streamed in NTRIP systems it is recommended to use RTCM 2.x or RTCM 3.0 whenever possible. Firmware of geodetic reference station receivers often has the ability to generate these formats. In case an RTCM encoding is not possible, raw data should be streamed in a vendor format.

Due to limited NTRIP Caster stream dissemination resources, it may be necessary to give some priority to specific groups of clients. When delivering data, a high priority should be given to stream providers, followed by analysis centers and then re-broadcast installations.

Fig. 2: RTIGS Internet Broadcast Service Concept



5. NTRIP Software

As NTRIP has already been an RTCM standard for about two years, a considerable number of devices supports it today. Client software is integrated in rover receivers or resides stand-alone in mobile phones or PDA's. NTRIP Server functionality comes as firmware part of reference station receivers. Caster software is delivered by major vendors together with their Network RTK packages.

From an IGS perspective one should see some basic software elements developed under GNU General Public License (GPL). The Open Source concept fits to the voluntary and best-effort contributions from the public research and development area. The BKG assists IGS and EUREF in the development of GPL software. A current topic here is stream decoding and data conversion from RTIGS to RTCM and vice versa, as well as the conversion of both formats to RINEX. Multi-stream NTRIP Clients will soon enable the generation of RINEX batches for short periods of time and thus help in Near Real-Time data processing.

The NTRIP homepage (see Internet Links) provides access to GPL software as well as commercial hard- and software products supporting NTRIP. The software list includes programs of all NTRIP system elements plus several decoders and converters that are available for UNIX and Linux operating systems and a variety of Windows systems.

6. Recommendations

At present, the IGS maintains a global network of GNSS reference stations providing its data in the form of hourly files. Even though some of these stations already are available in real-time using either the RTIGS or the NTRIP model, the vast majority only delivers hourly sets of data. As GNSS is working in real-time by nature and both RTIGS and NTRIP have proven to be feasible methods to provide GNSS data in a reliable manner, it is highly recommended to upgrade all IGS reference stations to real-time as soon as possible. Besides, virtually all reference stations are already connected to the Internet. Therefore, the only necessary change at each reference station would be to run an NTRIP server program on a computer on the premises of the reference station.

When providing real-time data of IGS reference stations, one or several data formats being applicable by the clients should be used for the transmission. Only then the user can take the greatest possible advantage of the data streams generated at the reference stations, which also should be considered as an IGS product. Due to its acceptance within the global GNSS community either RTCM 2.x or the highly compressed RTCM 3.0 should be used as recommended data format. If that is not possible, raw data should be sent instead.

The generated GNSS data streams should have a data rate of about one second. The relatively large data sets could then be saved in files for post-processing applications at the data and analysis centers. Following the NTRIP concept, each data stream gets sent to the next NTRIP Broadcaster. From there it is available for every interested user, within or outside the IGS. To keep track of the availability and quality of the real-time data streams a monitoring system constantly checks the stream flow and content and informs providers about outages and corruptions.

By augmenting more IGS reference stations to real-time the existing efforts of RTIGS, EUREF-IP and others could be substantially supported. This will also mark an important step towards

global and unrestricted stream exchange. As a result, this will pave the way to generate and disseminate real-time products like satellite orbits and clocks.

Internet Links

Real Time IGS Working Group	http://igscb.jpl.nasa.gov/projects/rtwg/index.html
IGS NTRIP Caster	http://www.igs-ip.net/home
NTRIP Homepage	http://igs.bkg.bund.de/index_ntrip.htm
EUREF-IP Pilot Project	http://www.epncb.oma.be/_organisation/projects/euref_IP/index.html
EUREF NTRIP Caster	http://www.euref-ip.net/home
Global NTRIP Caster Overview	http://www.rtcm-ntrip.org/home