The EUREF-IP Ntrip Broadcaster: Real-time GNSS data for Europe

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Abstract

The Internet is an excellent medium for the real-time collection and exchange of GNSS data. It is best qualified for broadcasting differential corrections as well as other observed or derived GNSS products. The EUREF community, as being responsible for the regional densification of IGS in Europe, decided to set up and maintain a real-time GNSS infrastructure on the Internet using stations of its European GPS/GLONASS Permanent Network EPN. A pilot project has been established called EUREF-IP (IP for Internet Protocol). The purpose of this project is the dissemination of Differential GPS corrections (DGPS) for precise positioning and navigation and the dissemination of raw GNSS data in support of various other real-time activities.

The EUREF-IP real-time GNSS data service uses a new dissemination technique called "Networked Transport of RTCM via Internet Protocol" (Ntrip). Ntrip stands for an HTTP application-level protocol streaming GNSS data over the Internet. The main component of the service is an Internet Broadcaster which currently provides access to about 140 real-time data streams.

This paper introduces the EUREF-IP Ntrip Broadcaster with its available real-time data streams from different networks. It focuses on data availability and latency, positioning accuracy, and service monitoring aspects.

Introduction

Due to the increased capacity of the Internet, applications which transfer continuous data-streams by IP-packages, such as Internet Radio, have become well-established services. Compared to these applications, the bandwidth required for the transfer of real-time GNSS data is relatively small. As a consequence, the dissemination of GNSS real-time data streams via Internet and mobile IP-Networks becomes an alternative to the usage of conventional terrestrial broadcasting techniques. No significant degradation of performance has to be expected, but some remarkable advantages. Wireless or mobile Internet access is available nowadays almost everywhere. In addition, data streams from various reference station networks can be received with one single hardware tool like a Laptop or a PDA with integrated GPRS modem.

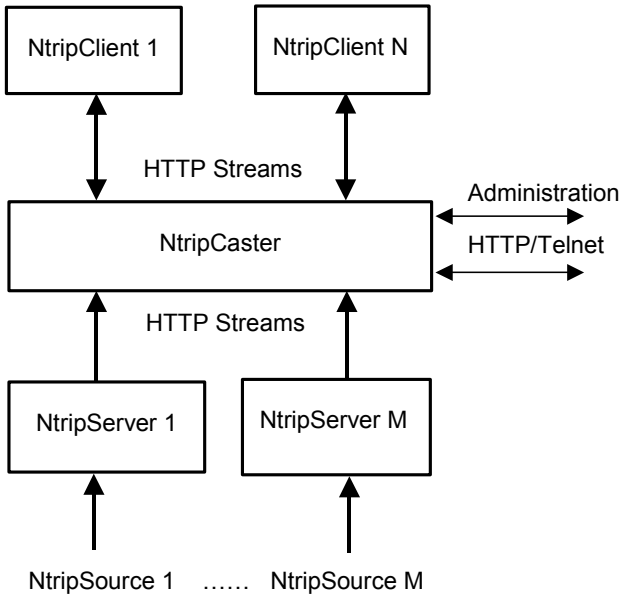
Ntrip

The BKG, in cooperation with the University of Dortmund, has developed a HTTP-based technique for streaming DGPS data, or other kinds of GNSS data, to mobile receivers via the Internet. This technique establishes a format called "Networked Transport of RTCM via Internet Protocol" (Ntrip). Ntrip stands for an application-level protocol streaming Global Navigation Satellite System (GNSS) data over the Internet. Ntrip is a generic, stateless protocol based on the Hypertext Transfer Protocol HTTP/1.1. The HTTP objects are enhanced to GNSS data streams.

Ntrip is designed for disseminating differential correction data (e.g in the RTCM-104 format) or other kinds of GNSS streaming data to stationary or mobile users over the Internet, allowing simultaneous PC, Laptop, PDA, or receiver connections to a broadcasting host. Ntrip supports wireless Internet access through Mobile IP Networks like GSM, GPRS, EDGE, or UMTS.

Ntrip is implemented in three system software components: NtripClients, NtripServers and NtripCasters. The NtripCaster is the actual HTTP server program whereas NtripClients and NtripServers are acting as HTTP clients.

Ntrip's system components are



- NtripClients, receiving data of desired sources from the caster
- NtripCaster, the major stream-splitting and broadcasting system component
- NtripServers, which transfer the data from one or multiple sources in Ntrip format
- NtripSources, which generate DGPS data-streams at a specific location

Fig. 1: Ntrip Streaming System

Ntrip is meant to be an open none-proprietary protocol. Major characteristics of Ntrip's dissemination technique are:

- Based on the popular HTTP streaming standard; comparatively easy to implement when having limited client and server platform resources available.
- Application not limited to one particular plain or coded stream content; ability to distribute any kind of GNSS data.
- Potential to support mass usage; disseminating hundreds of streams simultaneously for up to thousand users possible when applying modified Internet Radio broadcasting software.
- Considering security needs; stream providers and users don't necessarily get into contact, HTTP streaming often not blocked by firewalls or proxyservers protecting Local Area Networks.
- Enables streaming over any fixed-line or mobile IP network because of using TCP/IP.

Available data streams

As of March 2004, about 140 GNSS real-time data streams are available through Ntrip from reference stations of various institutions.

The European Permanent Network (EPN), comprising approx. 160 GPS permanent stations distributed over the whole continent and operated by European National Mapping Agencies (within the scope of the IAG Sub-commission EUREF), constitutes an appropriate source for data streams straddling national borders. In June 2002 EUREF adopted a resolution to provide real-time RTCM data via Internet to serve DGPS positioning and navigation applications. In this way, a continental DGPS service is being set up known as EUREF-IP. EPN stations operated at close proximity to Internet ports and using GPS receivers that can generate RCTM correction data are considered for integration into EUREF-IP.

In Germany, a continuously operated network called GREF, comprising about 20 GPS/GLONASS reference stations monitored by BKG on a daily basis, is currently converted to real-time operation. The stations involved will be successively networked over leased lines or Internet connections with a central processing unit. Based on these networked reference stations a service called GREF-IP (IP for Internet Protocol) has been created, which derives DGPS correction data for about 20 virtual reference stations spread over the territory of the Federal Republic of Germany. This service feeds its RTCM data into the Internet through the EUREF-IP NtripCaster.

In addition, a number of public or private institutions from all over the world, have indicated an interest in providing DGPS, RTK or raw measurement data over the Internet. Many of them already make available real-time data streams through EUREF-IP Ntrip Broadcaster.

An overview on today's real-time GNSS data availability on EUREF-IP Ntrip Broadcaster in Europe is given in Fig. 2 .

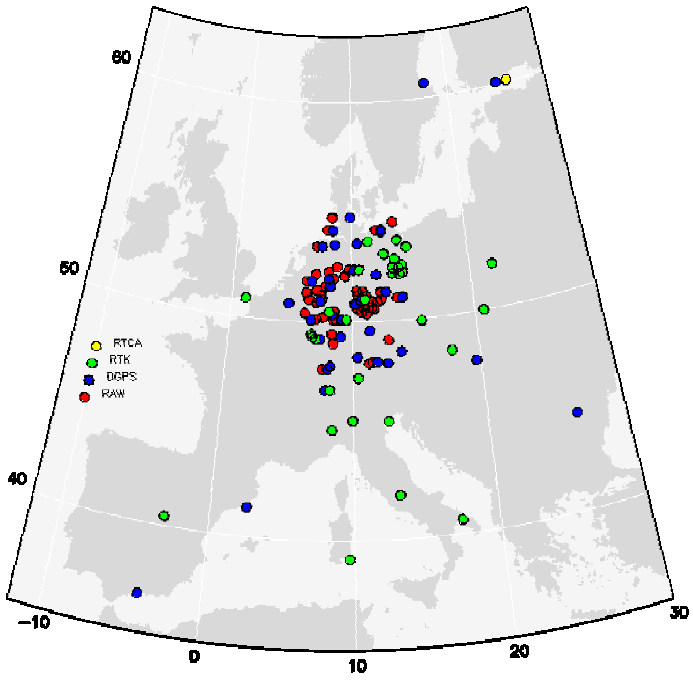


Fig. 2: Available GNSS data streams, Europe, March 2004

The EUREF-IP Ntrip Broadcaster supports the dissemination of real-time data streams from reference stations, Virtual Reference Stations (VRS) or networking solutions in various formats. Its purpose is to duplicate GNSS data or derived products for up to thousand simultaneously connected clients accessing up to a few hundred different sources. The Broadcaster does not alter the data.

At the moment it provides

- Raw GNSS receiver data, different formats (about 5 kbit/s per stream)
- RTK corrections, RTCM format (about 5 kbit/s per stream)
- DGNSS corrections, RTCM format (about 0.5 kbit/s per stream)
- DGNSS corrections, RTCA format, EGNOS and WAAS
- Real-time Orbit information, SP3-format
- Real-time RINEX data

GNSS Internet Radio

The client software for receiving the real-time data streams from an NtripCaster could be integrated in rover equipments. The Ntrip protocol is already part of the geodetic GPS rover of a major vendor. A good number of other vendors are working on the implementation. Thus, in the future, the NtripServer and NtripClient programs will become part of your reference or rover equipment or DGPS/RTK software.

Fig. 3: Pocket PC with GNSS Internet Radio / GPRS modem

It seems expedient to implement the client software on a separate device in particular when using simple C/A code receivers. A Pocket PC (Personal Digital Assistants, PDA, see Fig. 3) under the operating system Windows CE is a suited component in this respect. When equipped with PCMCIA-

Modem slots for Internet connections via mobile radio, it may serve as an efficient and convenient platform for “Location Based Services“.

The BKG, in cooperation with the University of Dortmund, has developed an NtripClient program for the access to real-time data from Ntrip Broadcasters. The so-called “GNSS Internet Radio” is available for different operating systems and can be downloaded from BKG’s website.

Monitoring System

The function of the EUREF-IP Ntrip Broadcaster is continuously monitored by an alarm system that generates "Notice Advisories to Broadcaster Users" (NABUs). If a data stream is unavailable for several minutes due to any reason, the monitor system generates a NABU message and sends it by e-mail to the affected stream provider. An additional message is sent when the stream becomes available again. All messages are stored in a NABU Archive. Daily-generated Outages Graphics as well as daily and monthly-generated Outage Tables show the overall availability of data streams.

The outage information is based on a minute by minute check of a separate monitoring system and not on recordings of the broadcaster: Stream interruptions shorter than 60 seconds as well as failures of the monitoring system or its Internet connection may leave some outages undetected.

The broadcaster outages usually remain below 3 %. They mainly reflect problems of the monitoring system, only a small portion is due to problems of the Casters or its Internet connection. In the near future the Broadcaster will be shifted to a professional Internet Service Provider (ISP) for improving the overall performance of the whole system. The temporal availability of individual data streams is quite varying and depends mainly on the different Internet Service Providers used. The mean outage time reachs 10 %, but individual network and streams are much better, continuously providing data for more than 99 % of the time.

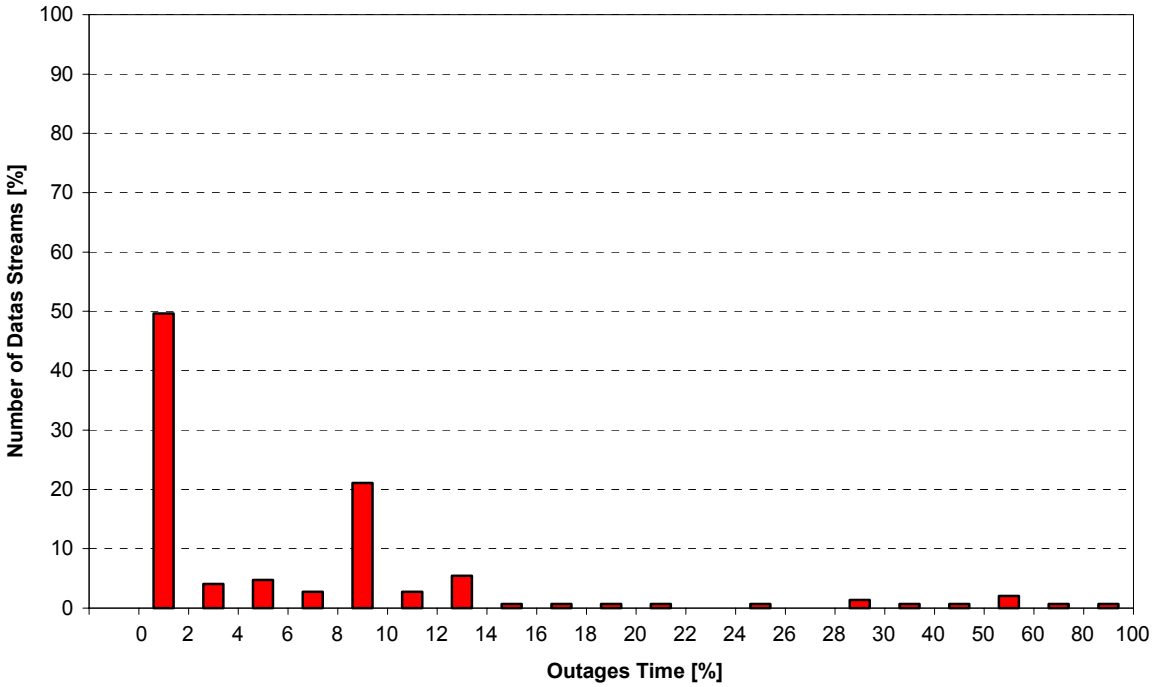


Fig. 4: Stream Outages, February 2004, All Data Streams

In February 2004 the Boadcaster was fould unavailable for 2.9% of the time (mainly due to networking problems or failures of the monitoring system). More than 50% of the data streams reach a temporal availability of better than 95%, 35% even more than 99%. Only 5% of the streams show outage times for more than 50% (Fig. 4).

Data latency and accuracy

For any kind of transmission technique the travel time of GNSS real-time data is of decisive importance. The software on the user side requires the relevant data almost instantaneously (depending, to a certain degree, on the application). Considerably delayed, missing or irregularly arriving data will degrade product latency and/or position accuracy.

When using the open Internet for communication, the GNSS real-time data streams share resources of an ISP with other applications and hence the bandwidth cannot be controlled. The question arises in this context as to what extent the usual resources offered by professional ISPs meet the requirements of real-time GNSS applications.

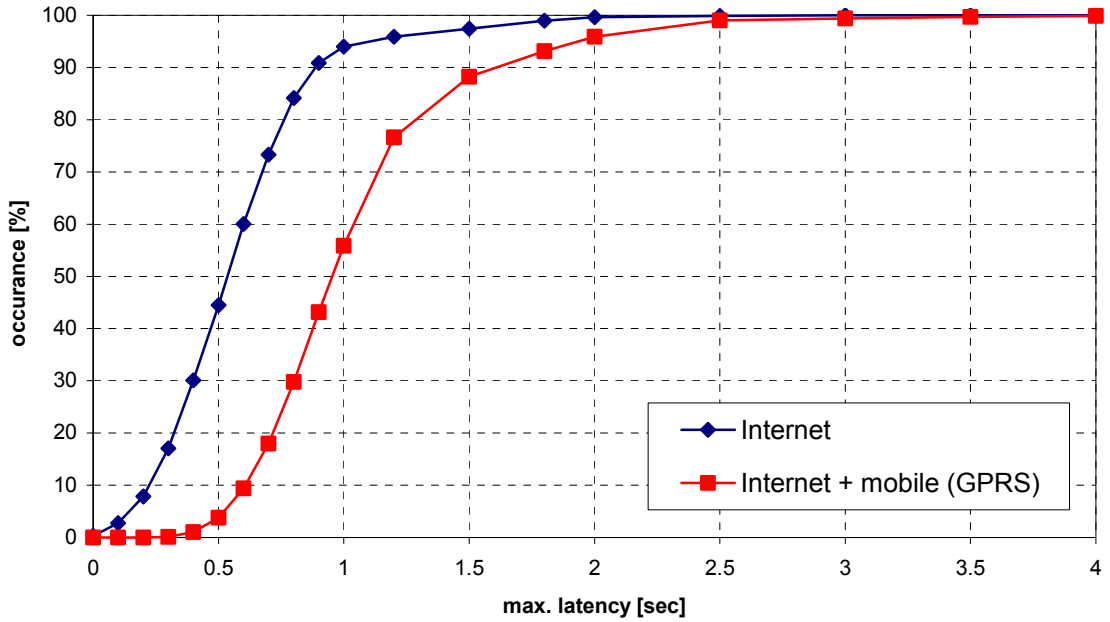


Fig. 5: Latencies of Pseudorange corrections from BRUS0 (Bruessels), Time Interval 2h

Fig. 5 presents statistics on the latencies of DGPS correction data (format RTCM 2.0) as derived from empirical tests. The communication over Internet and fixed-line as well as wireless phone networks (GPRS) has been investigated. Latencies in the order of less than two seconds are typical for the situation in Europe. The latency of correction data caused by the inclusion of wireless Internet networks can therefore be considered as so low that no noticeable influence on the achievable positioning accuracy exists.

By means of Fig. 6, results of an exemplary 1s-recording of a static position determination at a known site are presented. RTCM corrections were received via the Internet and mobile radio (GPRS). The

figure shows differences to a known reference position over a period of one hour. Neither for DGPS nor for RTK applications the achievable accuracies were degraded by RTCM data transmission via mobile communication.

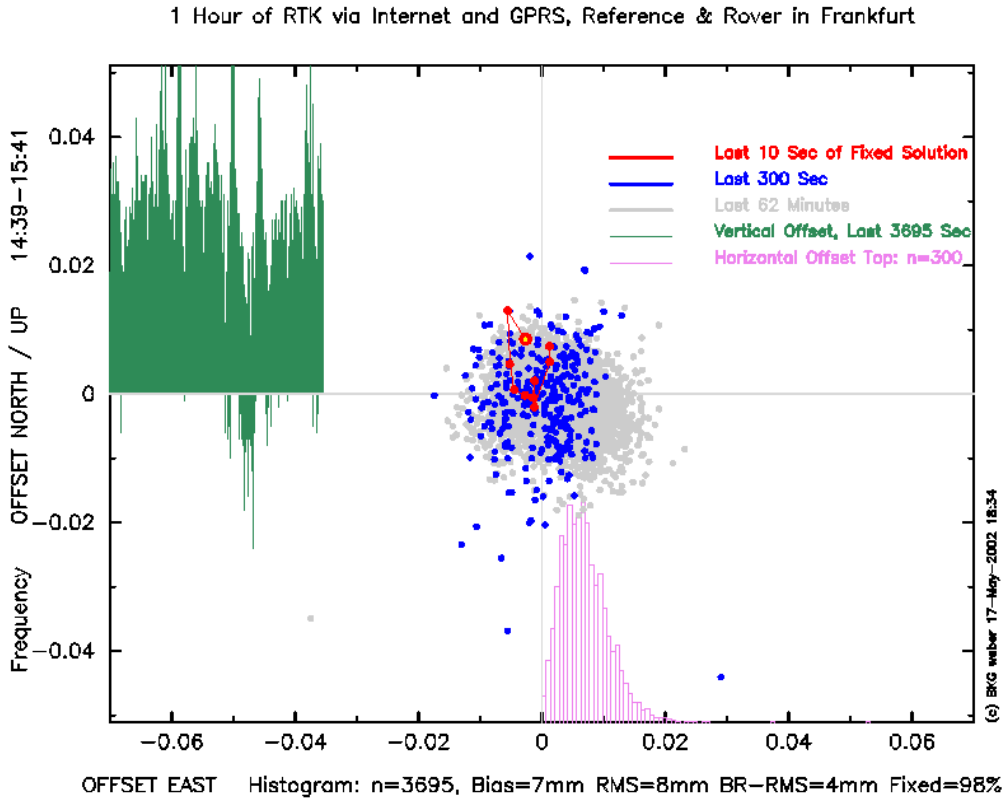


Fig. 6:Accuracy of RTK over Internet and GPRS

Summary and Outlook

Ntrip is a new technology to transfer GNSS data (for example RTCM correction data) via the Internet and mobile IP networks. Practical tests do not show a significant degradation of performance compared to using other transportation media. RTCM's Special Committee 104 has set up a Working Group "Internet Protocol" to further develop Ntrip towards an international standard. Due to its almost worldwide availability and the widespread hardware for wireless Internet access, Ntrip is the GNSS data streaming method of the future.

EUREF has set up and maintains an Ntrip Broadcaster which provides GNSS real-time data (raw measurement data as well as RTCM correction data and derived products) for Europe. Further Broadcaster implementations have been build up by various institutions. The goal is to establish a network of NtripCasters all linked with each other. Each NtripCaster will provide access to regional as well as global data streams. With this concept, gapless distributed streams could be reached from everywhere at low latency level while sharing the broadcasting workload. At the moment eight NtripCasters exist in four European countries. Further implementations will follow.

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