Increasing the GNSS Stream Dissemination Capacity for IGS and EUREF

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1. Introduction

Streaming GNSS data over the open Internet via NTRIP is a relatively new but nevertheless well established task for IGS and its continental densification networks like EUREF. Concerning IGS, streams are mainly disseminated using the NTRIP broadcaster www.igs-ip.net/home operated by BKG and a broadcaster operated by Geoscience Australia. Concerning EUREF it is www.euref-ip.net/home which distributes streams in Europe with support from a number of national broadcasters, see Table 1 for a complete list of participating agencies and institutions.

Because of the expected increased usage of real-time GNSS data, resources originally allocated in 2003 are going to reach their limits. It becomes necessary to involve others in stream dissemination to distribute the workload especially concerning globally distributed IGS streams. A concept for a coordinated network of cooperating IGS and EUREF broadcasters is described here where EUREF with its responsibility for Europe is to be understood as an example for IGS densifications. Other densification areas handling open real-time data are North-America (CORS, NAREF, PBO), Australia (AUSNET), and South-America (SIRGAS).

This paper also describes a backup strategy for single points of failure in the data flow. Furthermore, it may help in the specification of guidelines for operating NTRIP broadcasters.

We concentrate here on stream dissemination via NTRIP transport protocol. Other dissemination techniques like the RTIGS udpRelay transport remain unconsidered.

Table 1: NTRIP broadcasters disseminating IGS/EUREF streams

Broadcaster	**IP:Port**	**Operator**	**Country**
IGS-IP	www.igs-ip.net:2101	BKG	Germany
EUREF-IP	www.euref-ip.net:2101	BKG	Germany
FreDNet	caster.crs.inogs.it:2110	CRS/OGS	Italy
Zememericky Urad	czeposr.cuzk.cz:2101	CZEPOS	Czech Republic
Satellite Geodetic Observatory	82.131.181.15:2101	FOMI	Hungary
Geoscience Australia	192.104.43.25:2101	GA	Australia
CATNET-IP	catnet-ip.icc.es:8080	ICC	Spain
Instituto Geografico Portugues	62.48.187.123:2101	IGEO	Portugal
RGP-IP	rgpdata.ign.fr:80	IGN	France
Instituto Geografico Nacional	ergnss-ip.ign.es:2101	IGNE	Spain
Geodeettinen Laitos	caster.fgi.fi:80	Nordic-iDiff	Finland
Lantmateriet	194.16.178.79:80	SWEPOS	Sweden
Swisstopo	www3.swisstopo.ch:8080	SWIPOS	Switzerland
University of Padova	147.162.229.36:80	UniPD	Italy

2. Status of NTRIP stream usage

Today the EUREF and IGS NTRIP broadcasters handle up to 250 simultaneously incoming and 2000 outgoing streams. Figure 1 shows the increase of the outgoing data volume over the last years. From long-term experience with IGS and EUREF broadcasters, two principal user groups can be identified, see http://igs.bkg.bund.de/index_ntrip_applic.htm. They can be characterized as follows:

(1) "Standard Access" users: A large group of users formed at present by about 1000 individuals, institutions or agencies with temporary or long term interest and in need for simultaneous access to a very limited number of streams. Applications this group has in mind are

   a. Software development
   b. Education
   c. Real-time geo-referencing to ETRF or ITRF
   d. Backing up existing services
   e. Access to real-time products

(2) "Extensive Access" users: A small group of users formed by ~10+ institutions or agencies with long term interest in need for simultaneous access to up to ~100+ streams carrying real-time observations. Their interest emerges primarily from

   a. Global applications like the clock and orbit estimation in the framework of the Real-time IGS Pilot Project and the EUREF-IP Project.
   b. Ionosphere and space-weather. The affected communities are about to discover the potential of real-time EUREF/IGS resources. However, their interest is not yet organized and mainly comes from individuals.
   c. Conversion of raw or RTCM streams to high-rate RINEX files for small intervals (i.e. 15min) for post-processing and archiving purposes.

About 95 percent of stream disseminations is provided in support of the "Extensive Access" user group which comprises less than one percent of the registered users. The remaining 99 percent "Standard Access" users request only 5 percent of today's broadcast resources.

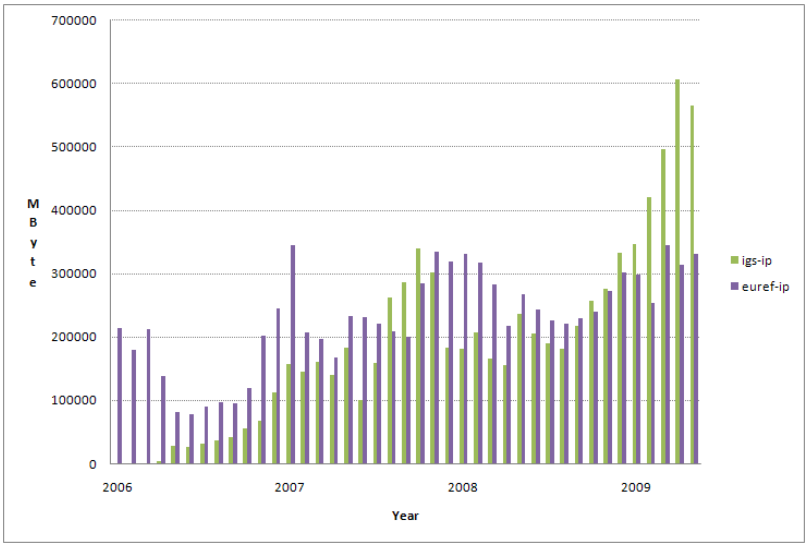

Figure 1: Monthly data volume made available by EUREF-IP and IGS-IP broadcasters

3. Structure of NTRIP broadcaster network

A global network of NTRIP broadcasters is required. The applied stream dissemination policy shall allow an exchange of streams among various caster installations. The network shall be structured in different levels, see Figure 2. It consists of

- Top-level NTRIP broadcasters and
- NTRIP broadcaster relays

Broadcaster installations can be operated with a regional or – in case of relays – thematic focus. This allows well-organized "Extensive Access" user groups to operate their own NTRIP broadcaster while pulling all streams of interest only once from other installations.

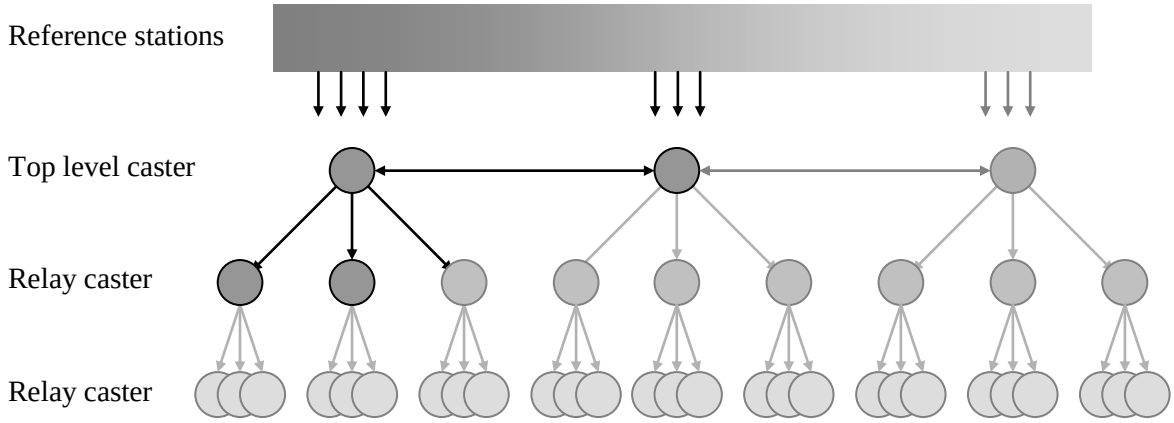

Figure 2: Stream dissemination concept

3.1 Top-level NTRIP broadcasters

Top-level NTRIP broadcasters receive their data either directly from reference stations or from other top-level broadcasters.

- EUREF and IGS operate one central top-level NTRIP broadcaster which provides access to all streams from EUREF and IGS.
- In addition, top-level NTRIP broadcasters can be operated with regional responsibilities. Although focusing on reference stations in specific areas, they can pull streams from other broadcaster installations in order to offer full access to all EUREF/IGS resources for clients in their area.

3.2 NTRIP broadcaster relays

NTRIP broadcaster relays primarily receive their streams from one or several top-level NTRIP broadcasters. Offered resources may comprise all EUREF/IGS streams or be limited to a subset of them. They may also carry protected streams which are not part of the EUREF/IGS real-time network.

- Regional NTRIP broadcaster relays help sharing the workload in support of "Standard Access" users.

- Thematic NTRIP broadcaster relays help sharing the workload in support of "Extensive Access" user groups from the clock/orbit community, meteorological community, etc.

If demands develop in a way that a single level of NTRIP broadcaster relays is not enough to support all needs of the real-time GNSS community, lower-level relays can be set up which pull their streams from upper relay installations.

Note that each re-broadcast adds up to 0.5 seconds for stream transport compared to the direct client access to top-level broadcasters. Therefore, the number of involved levels should be kept small where latency is of importance.

4. Stream retrieval authorization

For technical reasons, access to real-time EUREF/IGS resources needs to be kept under control. In case of problems, broadcaster operators must at any time be able to contact stream providers as well as stream users. Personal user accounts for stream retrieval are provided per broadcaster following an online registration procedure.

Each broadcaster operator periodically reports anonymized information about registered users and their applications to the affected EUREF/IGS working group chair or the person responsible for coordinating the data flow.

4.1 Authorization procedure

Each EUREF or IGS NTRIP broadcaster operator shall maintain his own online user registration procedure. The registration procedure shall allow users to suggest preferences for an account ID and password. As a result it becomes possible for users to use the same account details for all broadcasters dedicated to support EUREF/IGS.

4.2 Authorization policy

Following an open data policy, accounts are provided free of charge for any purpose as far as stream dissemination resources allow.

- "Standard Access" user accounts shall be provided for simultaneous access to a maximum of five streams.
- "Extensive Access" user accounts for simultaneous retrieval of more than five up to all EUREF/IGS streams shall be provided only for institutions ready to help in the re-distribution process through setting up an NTRIP relay. The idea is to have thematic relays maintained by specific communities in support of their clientele. As a result of this policy, only one "Extensive Access" account is necessary per topic (e.g. orbits/clocks). That account allows to pull all streams from top-level NTRIP broadcasters to feed a thematic relay where the re-broadcast is done.
- Latency critical applications should be granted a priority concerning access to top-level broadcasters.

Accounts need not to be provided for conversion of streams from EUREF and IGS networks to high-rate RINEX files for small intervals – a heavy application because all available EUREF/IGS streams are continuously involved. Conversion to RINEX and archiving of resulting files is understood as a "one for all" task to be carried out by a regional or global

EUREF/IGS data center. Whoever is interested in such files can download them from there via FTP. This strategy helps avoiding unnecessary workload on the NTRIP broadcaster side.

Furthermore, accounts shall not be misused for pulling the same streams many times. A user may consider to establish an NTRIP relay and let his applications pull data from there if he needs access to the same set of EUREF/IGS streams more than once.

5. NTRIP broadcaster backups

While the concept described so far helps distributing the workload between various NTRIP broadcasters, top-level casters remain a single point of failure. Although the availability of the complete chain of involved streaming components from reference to rover has proven to be often better than 99 percent, introducing backup resources is desirable to reduce outages. Therefore, backup broadcasters are introduced in the stream dissemination concept. The backup mechanism already foreseen in the NTRIP transport protocol consists of the URL transmission of a backup broadcaster. Hence each broadcaster provides information where on the Internet its backup (if existing) is available. This allows establishing the following simple backup strategy shown in Figure 3:

- Any reference station uploads its stream twice, to a primary and to a secondary (backup) NTRIP broadcaster installation. As a consequence, IGS and EUREF recommend using reference station firmware which allows uploading two (or more) streams in parallel.
- NTRIP clients know the URL of the secondary installation from the so-called sourcetable of the primary broadcaster. Clients switch to this backup in case of an outage.
- As primary and secondary resources are continuously operated, it is up to the NTRIP client to switch back to the primary broadcaster as soon as possible after the end of an outage.

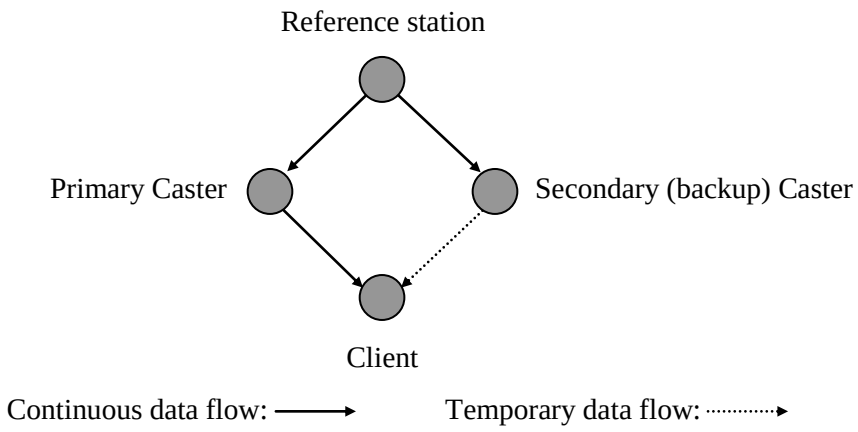

Figure 3: Backup concept for NTRIP stream flow

It is understood that some reference stations may suffer from limited communication resources. When on-site Internet bandwidth is a problem, neglecting a backup stream is accepted. In this case, it is up to the reference station operator to switch to a backup broadcaster as soon as his primary broadcaster has an outage.

Backup NTRIP broadcasters are to be operated continuously. In addition it is suggested to have a “cold standby” system waiting next to each broadcaster enabling a quick replacement when necessary.

The capability for an automatic switch between primary and secondary casters shall be implemented in NTRIP clients such as BKG’s BNC.

6. NTRIP broadcaster operation requirements

Considering a bandwidth of ~2500 bits per second and stream, an NTRIP broadcaster operated for IGS/EUREF shall be capable to handle the following limits:

- Maximum number of simultaneous incoming streams: at least 100
- Maximum number of simultaneous outgoing streams: at least 1000
- Total incoming plus outgoing stream bandwidth: at least 3 Mbits per sec
- Total input plus output stream volume: at least 1 TB per month
- Permanent and uninterrupted operation: at least 98 percent availability

Any NTRIP broadcaster software should be accepted . However, software supporting NTRIP Version 2 should be preferred. BKG is ready to share its Open Source software free of charge with any institution willing to dedicate a broadcaster to IGS/EUREF stream dissemination.

Since it is expected that the broadcaster software is operated with an availability of 98 percent, it is recommended to run it on the premises of an Internet Service Provider (ISP) if owned IT resources are not reliable enough. Using the service of an ISP would also have the advantage of more flexibility in regards to restrictions coming from proxy server or firewall installations.

7. How to proceed

A number of institutions answered the already launched IGS and EUREF Calls for Participation with the intention to help in the GNSS stream dissemination. Table 2 lists the corresponding points of contact. The list has been extended by some agencies known for their interest or experience in the broadcast issue and expected to help as soon as possible.

We recommend that EUREF and IGS now encourage the mentioned institution to start activities in the broadcast area based on the concept described in this paper.

Table 2: List of potential organizations for IGS/EUREF real-time GNSS data dissemination

Institution	Point of Contact	Email	Source
ASI	Rosa Pacione	rosa.pacione@telespazio.com	Personal communication
AUTH	Christos Pikridas	cpik@topo.auth.gr	Personal communication
CDDIS	Carey Noll	Carey.E.Noll@nasa.gov	IGS RT-PP
DLR	André Hauschild Oliver Montenbruck	andre.hauschild@dlr.de oliver.montenbruck@dlr.de	User[1]
ESOC	Loukis Agrotis	loukis.agrotis@esa.int	IGS RT-PP[1]
GFZ	Markus Ramatschi	maram@gfz-potsdam.de	User[1]
GOPE	Jan Dousa	jan.dousa@pecny.cz	IGS RT-PP
GSA	Michael Moore	Michael.Moore@ga.gov.au	IGS RT-PP
IGN	Bruno Garayt	bruno.garayt@ign.fr	IGS RT-PP

[1] IGS RT-PP proposal delivered but no proposal for data centre

IGN	Miguel Angel Cano Villaverde	macano@fomento.es	Personal communication
IIT (Indian Inst. of Technology)	Kamal Jain	kjainfce@iitr.ernet.in	IGS RT-PP
KASI	Jong Uk Park Jung Hyun Jo (Sungki Cho)	jupark@kasi.re.kr jhjo39@kasi.re.kr (skcho@kasi.re.kr)	IGS RT-PP
KNMI	Siebren de Haan	Siebren.de.Haan@knmi.nl	User[2]
NOAA / NGS	Jim Ray	jim.ray@noaa.gov	IGS[2]
NRCan	Mark Caissy Ken McLeod	caissy@NRCan.gc.ca KMacleod@NRCan.gc.ca	IGS RT-PP
UCOR (Univ. Cordoba)	Juan Carlos Villella	villellajuan@yahoo.com	IGS RT-PP
UNAVCO	Steve Fisher	fisher@unavco.org	IGS RT-PP
UNSW	Chris Rizos	c.rizos@unsw.edu.au	Personal communication
UPA	Alessandro Caporali	alessandro.caporali@unipd.it	IGS RT-PP
Wuhan Univ. GNSS Research Center	Shi Chuang	shi@whu.edu.cn	Personal communication

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[2] No IGS RT-PP proposal