Realtime GNSS activities at GeoForschungsZentrum Potsdam

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Abstract:

Currently, GeoForschungsZentrum Potsdam (GFZ) is working on three different fields towards realtime GNSS:
robust on-site GNSS hardware as a foundation of a reliable data source, realtime data transfer/streaming of GNSS raw data and development of a realtime GNSS analysis software.

On the hardware side, GFZ extends its existing GNSS network of 29 stations (21 of them providing highrate / realtime data) for e.g. radio occultation and CHAMP support.
Therefore, new station hardware is being developed with improved reliability features and enhanced remote administration capabilities.

On the data transfer/streaming side, so far, both TCP data streams of proprietary data format and transfer of data files containing 15 minutes of 1-Hz-raw data has been used.
Now, in addition, these proprietary data streams are being converted into RTCM3 format and uploaded to a GFZ Ntrip-broadcaster. This approach guarantees both low latency and completeness of GNSS raw data.

1. Station hardware

The recent GFZ GNSS network consists of 29 stations (with 21 of these stations providing 1-Hz-highrate / realtime data) and is mainly used for radio occultation measurements and for CHAMP-support. In addition, it densifies the IGS network (see network map in fig. 1) in remote regions.

Current activities concentrate on the development of new GFZ GSS (Geodetic Sensor Stations) with improved reliability features and enhanced remote administration capabilities. The main features of the new rack design (see fig. 2) are:

- "no moving parts design": removeable solid state hard disks, no fans for power supplies or CPU
- "12 Volt design": all components operated with 12 Volt DC or below (except monitor)
- "off the shelf design": almost all components are bought from regular hardware providers
- no single vendor source
- integrated LCD monitor, keyboard and mouse
- low power consumption
- low heat production
- high internal UPS autonomy endurance
- climate chamber tested from -20 °C to +40 °C
- virtually no noise production under normal conditions
- secure VPN connection through VPN router, tested e.g. with VSAT
- high redundancy: two PCs installed
- high remote management capability down to PC BIOS level
- power switching for all components, either automatically or through web interface
- all switching operations are logged separately
- real power status feed back through power sensing behind switches
- remote temperature and voltage logging
- high flexibility: e.g. different models of GPS receivers possible
- upgradeable for future requirements

In the following years, it is intended to equip all GPS stations with the new GSS rack design.

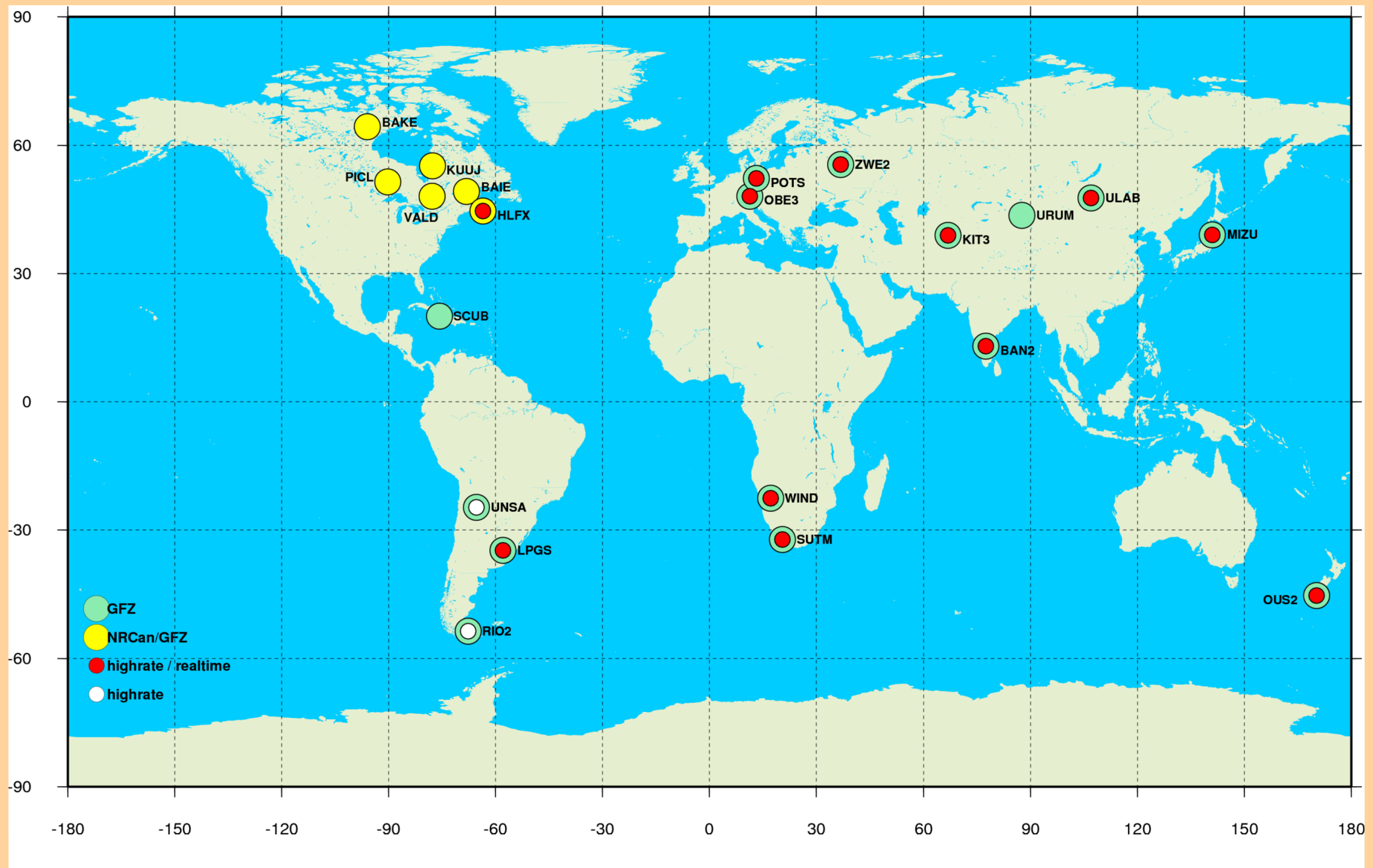
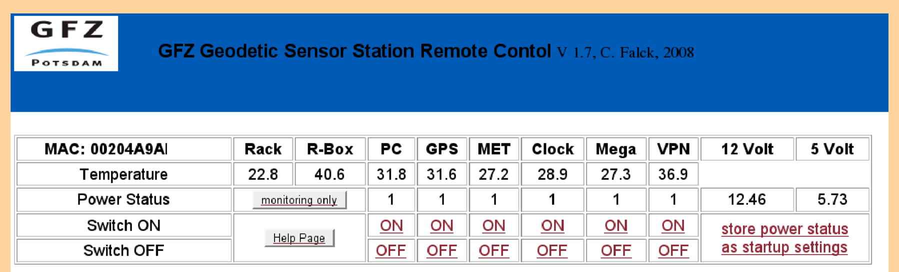


Figure 1: GFZ GNSS station network

Figure 2a: GFZ GSS (Geodetic Sensor Station), test installation at Potsdam

Figure 2b: Fold-away KVM unit



MAC: 00204A9AI	Rack	R-Box	PC	GPS	MET	Clock	Mega	VPN	12 Volt	5 Volt
Temperature	22.8	40.6	31.8	31.6	27.2	28.9	27.3	36.9		
Power Status	monitoring only		1	1	1	1	1	1	12.46	5.73
Switch ON	Help Page		ON	ON	ON	ON	ON	ON	store power status as startup settings	
Switch OFF			OFF	OFF	OFF	OFF	OFF	OFF		

Figure 2c: Monitoring and switching GUI

2. Data transfer

As shown in fig. 3, proprietary raw data of each GFZ GNSS network station is transfered to a GFZ server as a realtime stream with file transfer as backup solution in case of detected data gaps. More precisely, the data transmission is controlled by two monitor programs, one running on the local host at the receiver's location and the other running on the remote host at GFZ.

The **local monitor program** performs two tasks:
- streaming of individual data packets delivered by the receiver instrument to the remote host at GFZ using Transmission Control Protocol (TCP)
- assembling of the same raw data from a period of usually 15 min into a file.

The **remote monitor program** at GFZ collects the TCP packets and assembles another file from the streamed raw data. If the data file at GFZ has a different size compared to the original data file stored on the local host, the latter file is transmitted to GFZ using scp protocol and replaces the remote copy; otherwise, the file on the local host is moved into a local archive. This method combines the speed of realtime streams with the reliability of file transfer mechanisms.

The raw data streams of each station are additionally converted into RTCM3 format and forwarded to a GFZ Ntrip Broadcaster. Using an Ntrip client (e.g. BKG Ntrip Client), the data streams can be directed to a realtime analysis software or to a RINEX conversion tool.

Currently, data streams of 21 stations are available at GFZ's Ntrip Broadcaster. One of these stations consists of a movable antenna on the roof of a GFZ building and can be used to generate pre-defined height changes which are used to validate both realtime and post-processing analysis strategies.

Details of access to the GFZ Ntrip broadcaster may be requested from the authors.

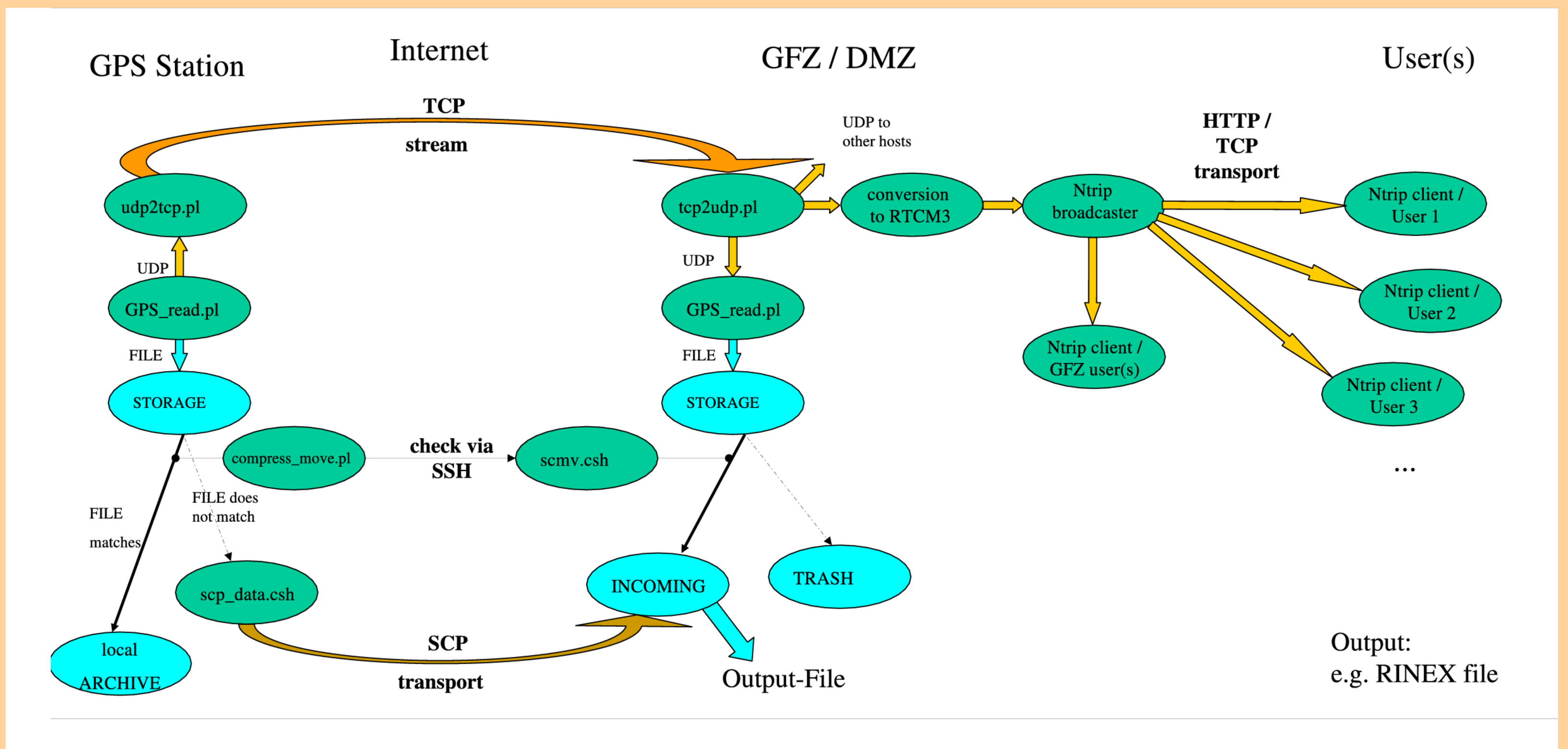


Figure 3: GNSS raw data flow from GNSS sensor station to GFZ

3. Realtime software

For the analysis of realtime GNSS networks GFZ currently uses a realtime-capable, square root information filter (and thus epoch-by-epoch) analysis software based on PANDA, originally developed at Wuhan University, China. Using this software satellite orbits, satellite clocks, network solutions and PPP solutions for single stations can be obtained. Results of this prototype software are shown in figures 4 and 5.

Figure 4 shows a comparison of estimated satellite clocks with respect to IGS final clocks using different orbits. Compared to the IGS final orbits the estimated satellite clocks agree within a standard deviation of 0.11 [ns].

Figure 5 shows an example of a precise point positioning solution for MAC1 (Australia): The agreement with respect to the IGS Weekly solution is about 2.1 [cm] (accuracy) and about 2.3 [cm] (precision) for X, Y, Z. Similar results are obtained for other stations.

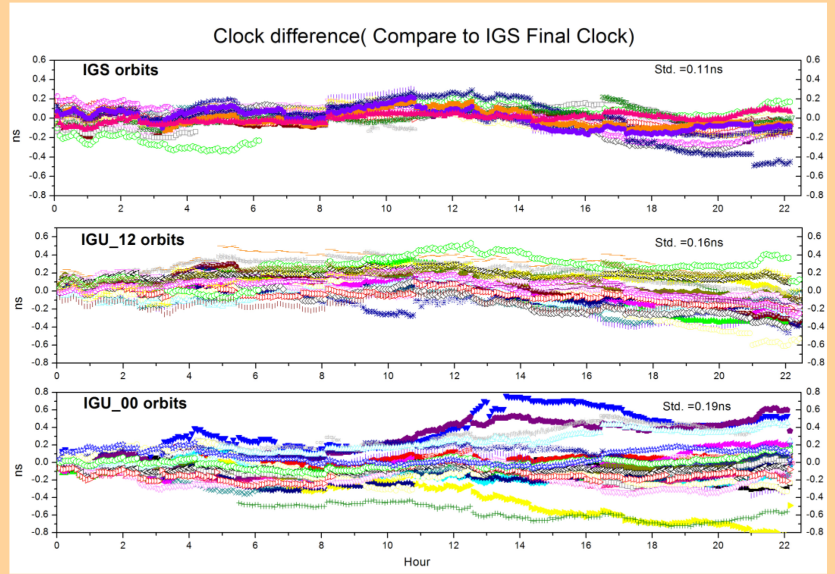


Figure 4: Differences of satellite clocks estimated with GFZ realtime prototype software and IGS finals using different IGS orbit products.

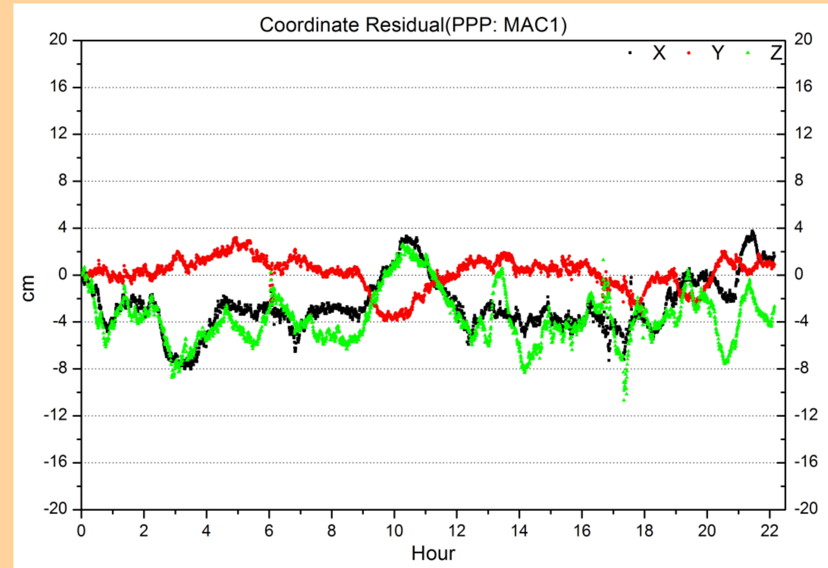


Figure 5: Precise point positioning solution for MAC1 generated with GFZ realtime prototype software.

The current software is the basis for a new realtime GNSS analysis software which is currently being developed at GFZ. Figure 6 shows an UML diagram of the components of the new software. The new system will be used in various applications, such as realtime satellite orbit and clock determination or deformation monitoring of volcanos or landslides.

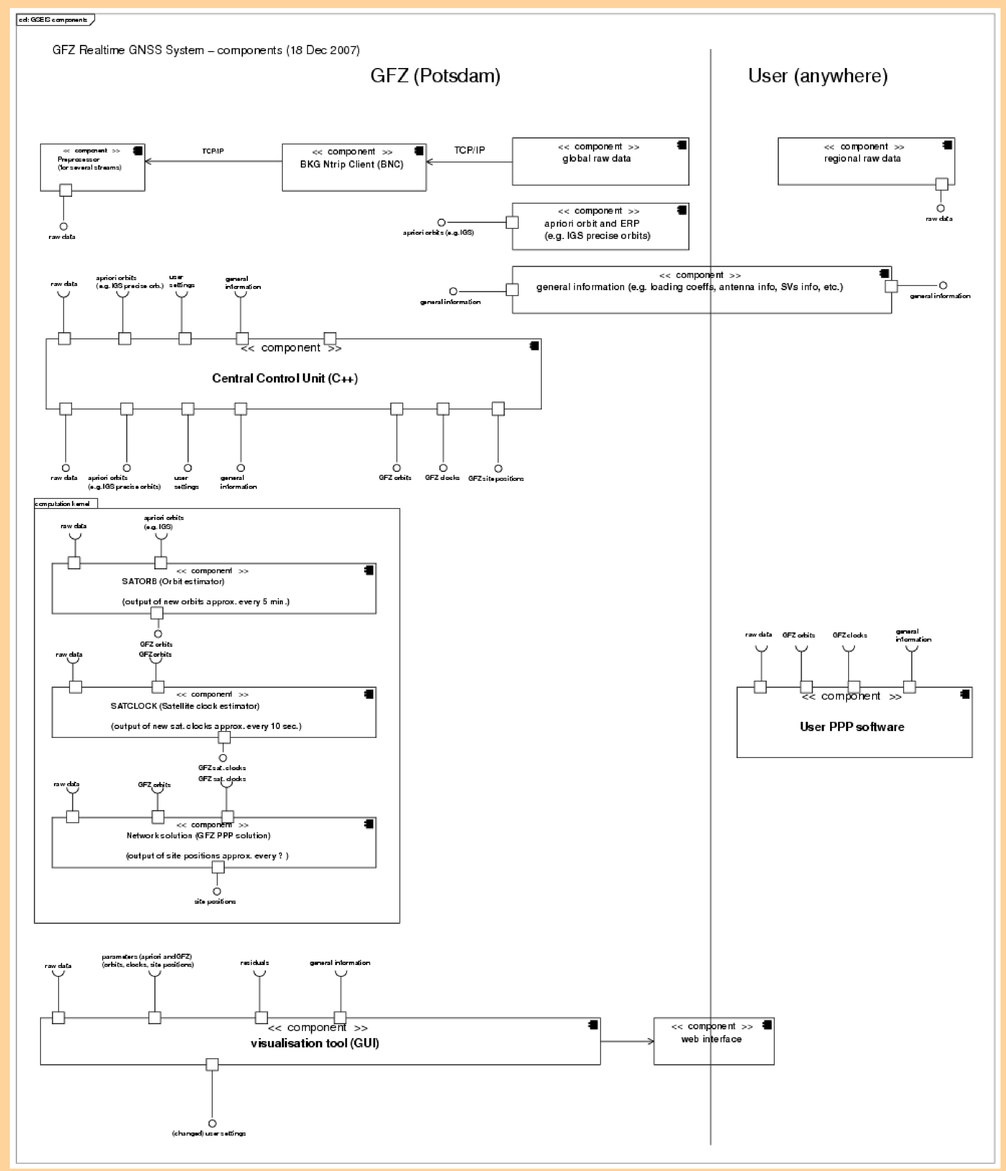


Figure 6: UML component diagram of future GFZ GNSS realtime software

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