GFZ's development of GPS real-time network

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Abstract

The presentation describes the real-time infrastructure developed at GFZ Potsdam. Currently GFZ's real-time network is composed of ten globally distributed, autonomous stations facilitating 1Hz GPS observations. The tracking station architecture with hardware and software components is described. The data is streamed over the Internet using UDP protocol. Additional S/W modules allow to dispense old data files on user request. Various aspects of the real-time network operation and data handling are discussed in detail. Finally, selected network monitoring tools and the data performance are presented.

1. Introduction

GFZ and JPL established a global High-Rate Low-Latency (1Hz) GPS ground tracking network to support the CHAMP and GRACE satellite missions. Currently, the GFZ sub-network is composed of 13 continuously tracking stations. High demands on the fiducial GPS ground tracking stations gave the motivation to upgrade the HR/LL network stations with data streaming capacity. Five stations contribute to the IGS Real-Time Pilot Project.

2. Network Topology

The development of software interfaces for GPS data streaming in real-time was completed in early 2003. A small number of HR/LL GPS ground tracking stations having satisfactory Internet data links were selected for the upgrade. Today 10 stations are ready to provide, or already provide, real-time GPS data streams. Fig. 1 shows the current real-time ground network.

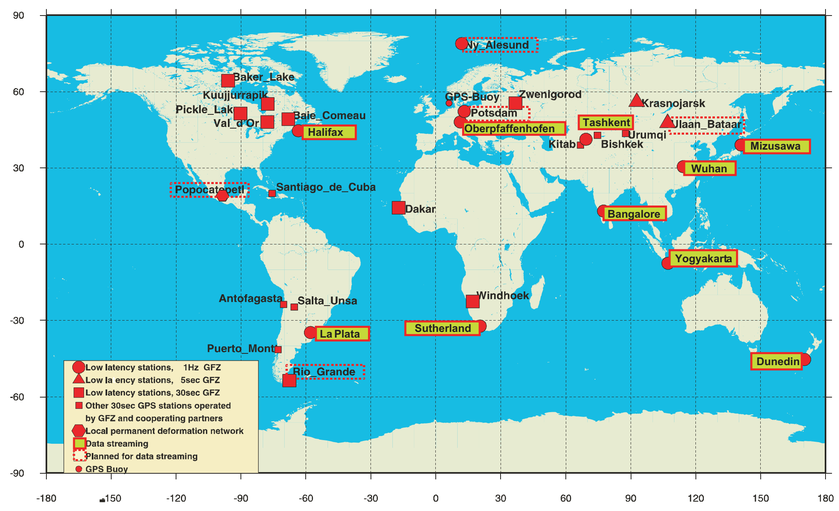
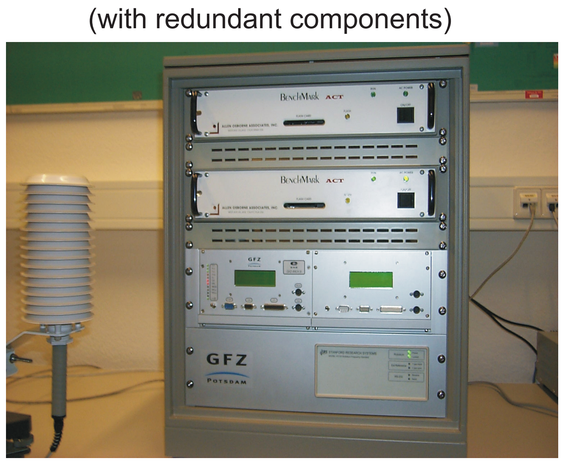


Fig. 1: GFZ's GPS global network stations and sites with real-time capacity

3. Ground tracking station hardware architecture

The GFZ HR/LL stations are equipped with off-the-shelf geodetic GPS receivers (AOA BenchMark and Ashtech Z-12), external frequency standards, station computers running under Linux OS (PC or PC-104 board), a power management system with a watch-dog, hardware relays enabling power management and a remote power cycle, meteorological sensors and interfaces for data transmission. The stations operate autonomously and are remotely maintained from GFZ. Some field stations being assigned for deformation monitoring are equipped with an OEM-type GPS receiver (Fig. 2).

Field version B
(with redundant components)



Field version C
(based on OEM-type of GPS receiver)

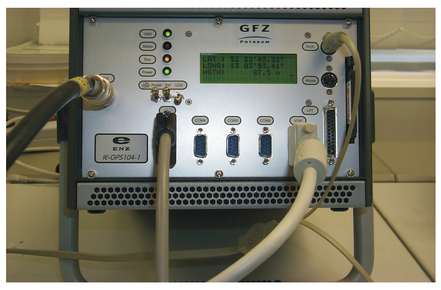


Fig. 2: Two selected types of GFZ's GPS ground tracking stations

4. Station software architecture

Fig. 3 illustrates functions of various software modules running on the station computer. There are five main modules: Station monitoring tool, HR GPS data logger, real-time interface, data logger for meteorological sensor and a tool distributing data files and house-keeping data. The real-time interfaces for data dissemination, tb-server and tb-client, are based on the UDP protocol (contrary to TCP) to enable low latency transmission. Currently receiver-dependent formats are used for GPS observations. A receiver-independent binary exchange format is presently being developed and will be implemented in the near future. The data logger creates and transmits data records to the tb-server which forwards them to the requesting end-users. The data stream is not "truly" broadcasted, therefore users periodically have to send requests to the selected UDP server in order to receive observations.

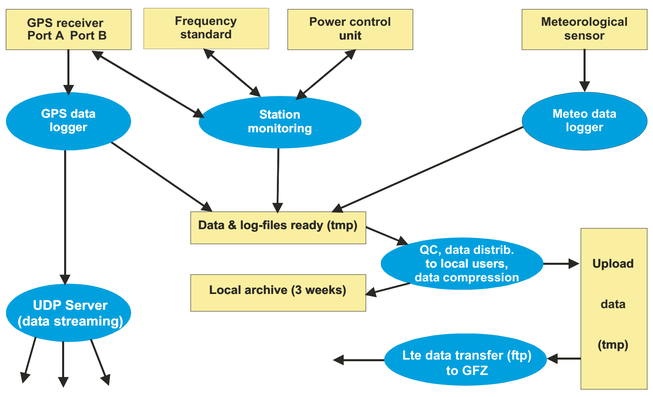


Fig. 3: S/W modules and data flow on the field monitoring computer

5. Data flow in the network and software tools

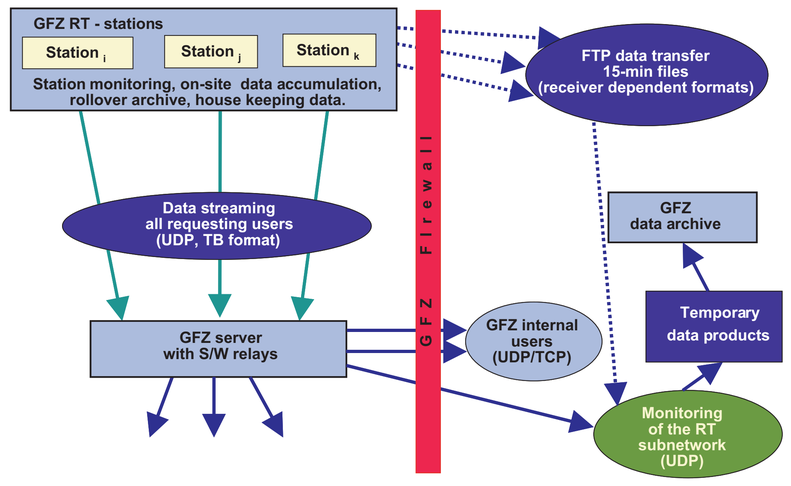


Fig. 4: Data flow in the RT HR/LL GPS ground tracking network

The UDP data stream contains 1Hz GPS observations and broadcast ephemeris provided by AOA receivers. GPS raw data is sent epoch by epoch in "turbo binary" format. Each epoch record is preceded by two control bytes. Neither additional compression nor control sums are applied. To overcome the restrictions of most firewalls, which generally filter out UDP packages, an additional software relay was developed. This relay transforms UDP to TCP packages (and vice versa). It runs on a Linux-PC host outside the GFZ firewall. This is the second data access point for users behind a firewall. Similar software tools for other GPS receivers (NovAtel, Z/Ashtech) are under development or passing final tests. According to CHAMP requirements, 15-minutes observation data files are also provided and archived in the CHAMP Information System and Data Center (CHAMP ISDC).

6.Station performance monitoring

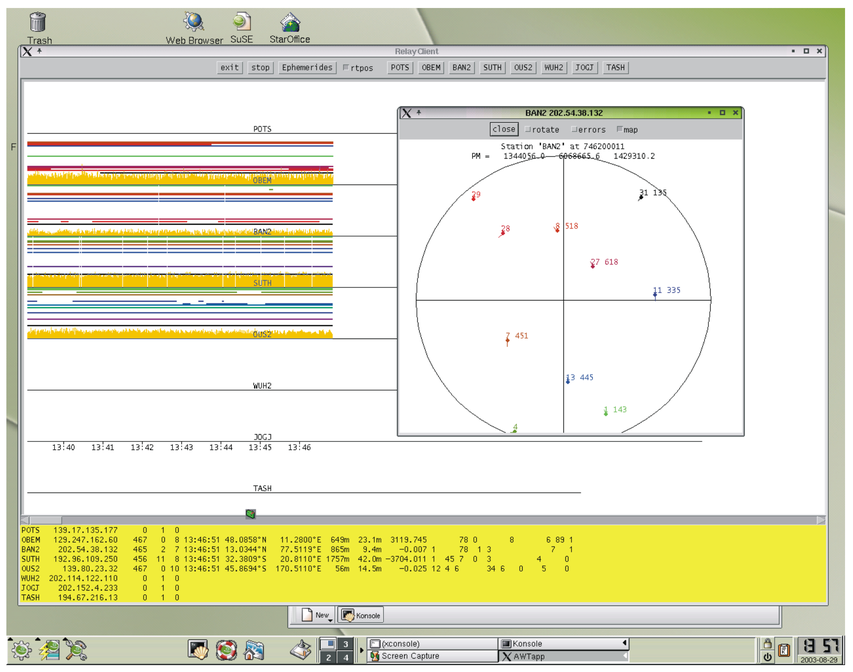


Fig. 5: Network status display

The performance of each real-time tracking station is continuously monitored. Receiver clock corrections are determined together with instantaneous point positions in real-time using Broadcast Ephemeris. Additional software extensions for integrity and quality monitoring in real-time are being developed and implemented.

7. Data performance

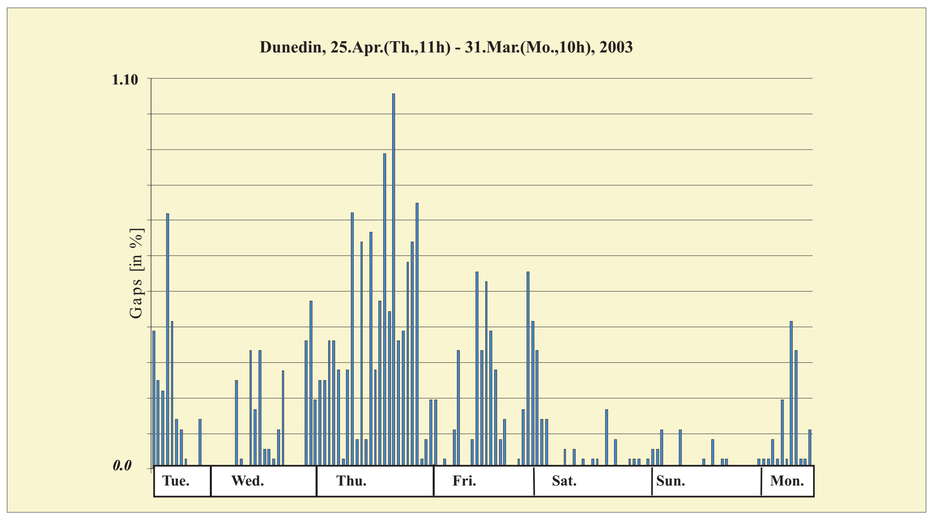


Fig. 6: Tracking performance of Dunedin

8. Forthcoming activities

- **The data streams from field stations are received at the GFZ server and put onto a UDP relay. At this third acces point the data will be available to authorized external and GFZ users.**
- **Further development of network performance monitoring tools**
- **Implementation of real-time integrity monitoring**
- **Implementation of exchange data formats (e.g., GFZ-BINEX)**
- **Development of real-time S/W tools for other GPS receivers**
- **Installation of further real-time stations**