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The "Quasar" Network Observations in e-VLBI Mode Within the Russian Domestic VLBI Programs

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Abstract

The purpose of the Russian VLBI "Quasar" Network is to carry out astrometrical and geodynamical investigations. Since 2006 purely domestic observational programs with data processing at the IAA correlator have been carried out. To maintain these geodynamical programs e-VLBI technology is being developed and tested. This paper describes the IAA activity of developing a real-time VLBI system using high-speed digital communication links.

1. Introduction

At this point, all observatories of the "Quasar" Network are equipped with UNIX servers for data buffering. The observatories have "last mile" communication channels plus Internet connection at a rate of 100 Mbps. Some experiments have been made for transmission of Intensive VLBI session data from Svetloe, Badary, and Zelenchukskaya observatories to the Institute of Applied Astronomy of the Russian Academy of Sciences (IAA) Control and Processing Center. Intensive session data of ∼40 Gbytes have been transmitted at 50 Mbps rate over shared networks using the Tsunami-UDP protocol in near real-time e-VLBI mode.

To date, 22 Intensive sessions have been transmitted from the Zelenchukskaya and Badary observatories and two Intensive sessions from the Svetloe and Badary observatories to the IAA Control and Processing Center. The transmitted data were processed at the IAA Analysis Center to obtain corrections to UT1. The values of the UT1 corrections obtained from all sessions are in the 1–160 μs range with an RMS deviation of about 61 μs.

2. Detailed Status

Institute of Applied Astronomy (IAA) of the Russian Academy of Sciences performs regular observations on the "Quasar" Network (Figure 1) within international and domestic programs. There are two types of VLBI domestic observational sessions: the 24-hour Ru-E series for EOP determination and the 1-hour Ru-U sessions for UT1 evaluation in near real-time mode. Both series are carried out four times per month. All observatories are equipped with Mark 5B recording terminals. The observations are correlated at the IAA Control and Processing Center in Saint Petersburg.

At present all observatories of the VLBI "Quasar" Network are linked by optical fiber lines (Figure 2) to provide both e-VLBI data transfer and real-time remote monitoring of site equipment. The data rate available for both the "last mile" channels and the overall end-to-end Internet

communication is about 100 Mbps. All observatories of the “Quasar” Network are equipped with UNIX servers for additional data buffering.

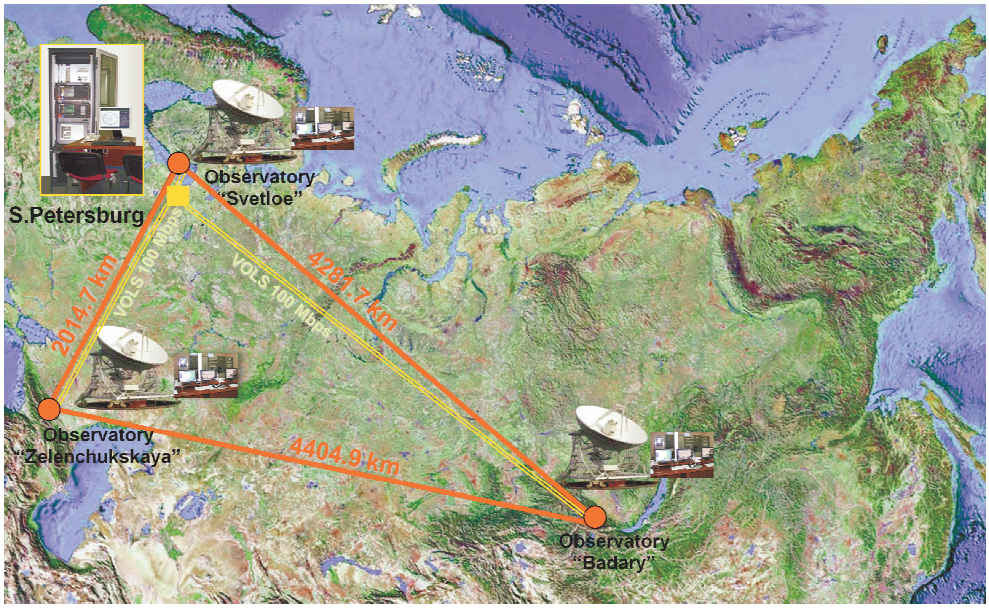

Figure 1. VLBI “Quasar” Network.

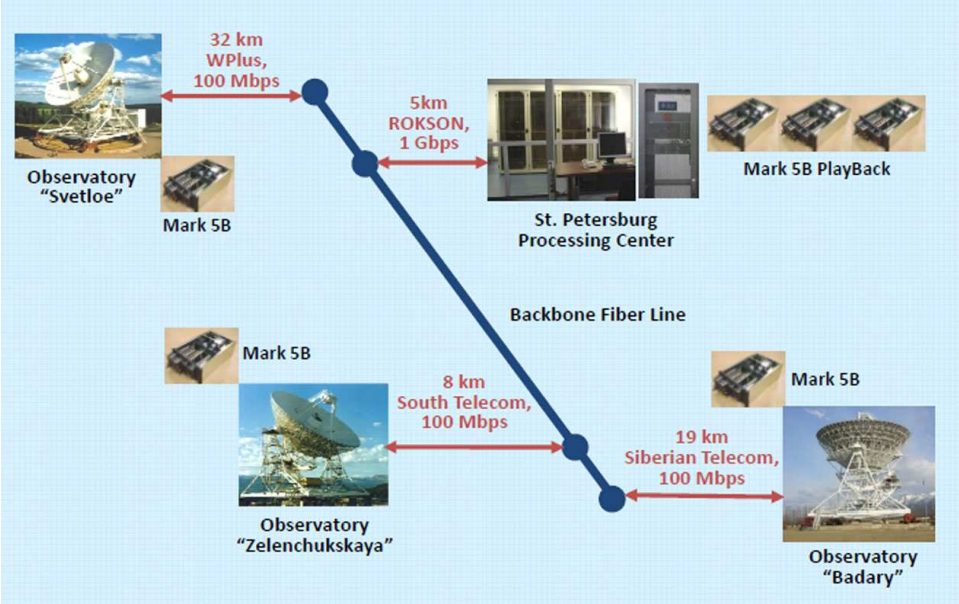

Figure 2. Optical Fiber Lines.

Regular observational sessions for UT1 determination in e-VLBI mode within “Quasar” Network on baselines Svetloe–Badary and Zelenchukskaya–Badary have been carried out since 2009.

The scheme for the data transfer is presented in Figure 3. The data copying from the Mark 5B recorder is performed in breaks between scans while the antenna is slewing to the next source. The "disk2net" function of the Mark 5B software is used for this purpose. Typical 1-hour sessions recorded at 256 Mbps rate contain 20–22 scans with a total data size of about 40 GB. A session may be transmitted at 40–50 Mbps rate over shared networks using the Tsunami-UDP protocol.

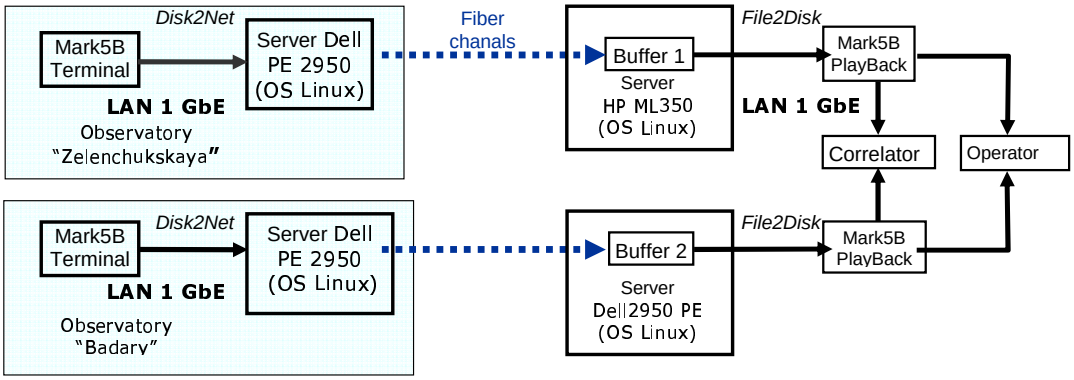

Figure 3. Block scheme of data transmission within e-VLBI mode with buffering: Mark 5B, LAN, Buffering Server, Internet, Buffering Server, LAN, Mark 5B, Correlator. Network testing was realized with iperf (end-to-end).

Time diagrams of single scan transmission via the Internet are presented in Figures 4, 5, and 6.

To date, 22 e-VLBI Intensive sessions have been transmitted from the Zelenchukskaya and Badary observatories and two sessions from the Svetloe and Badary observatories to the IAA Control and Processing Center. These sessions were processed at the IAA Analysis Center to obtain corrections to UT1. The values of the UT1 corrections obtained from all sessions are in the 1–160 μs range with an RMS deviation of about 61 μs.

The differences between the UT1 values obtained from all real-time IAA Ru-U sessions and those of the EOP 05 C04 series are given in Figure 7.

The results achieved show the possibility of successful periodic e-VLBI observations via shared Internet channels from all observatories of the "Quasar" Network.

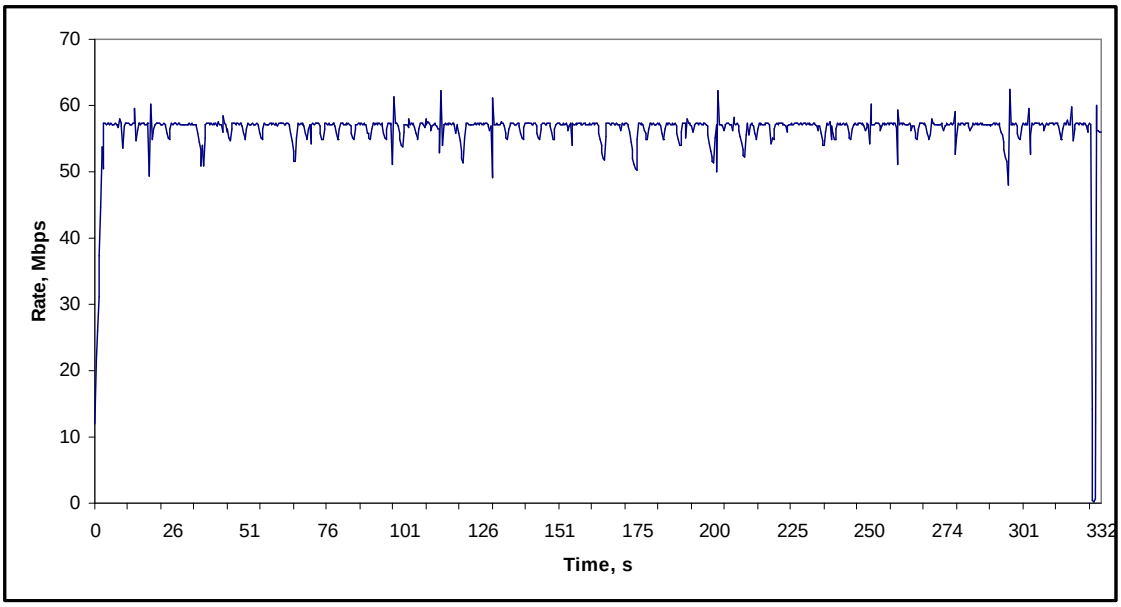

Figure 4. Time diagram of single scan transmission through ISP "South Telecom" at a rate of 100 Mbps from the Zelenchukskaya Observatory to the IAA Control and Processing Center in St. Petersburg. Rate 50 Mbps. Scan size 2 Gbytes. Tsunami-UDP protocol.

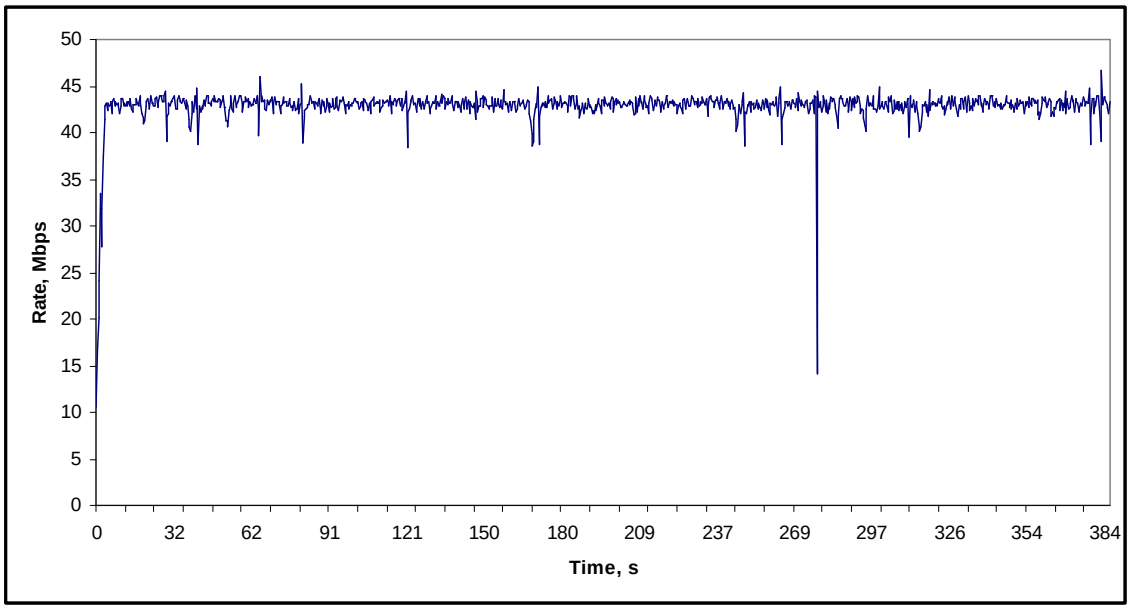

Figure 5. Time diagram of single scan transmission through ISP "Siberian Telecom" at a rate of 100 Mbps from the Badary Observatory to the IAA Control and Processing Center in St. Petersburg. Rate 40 Mbps. Scan size 2 Gbytes. Tsunami-UDP protocol.

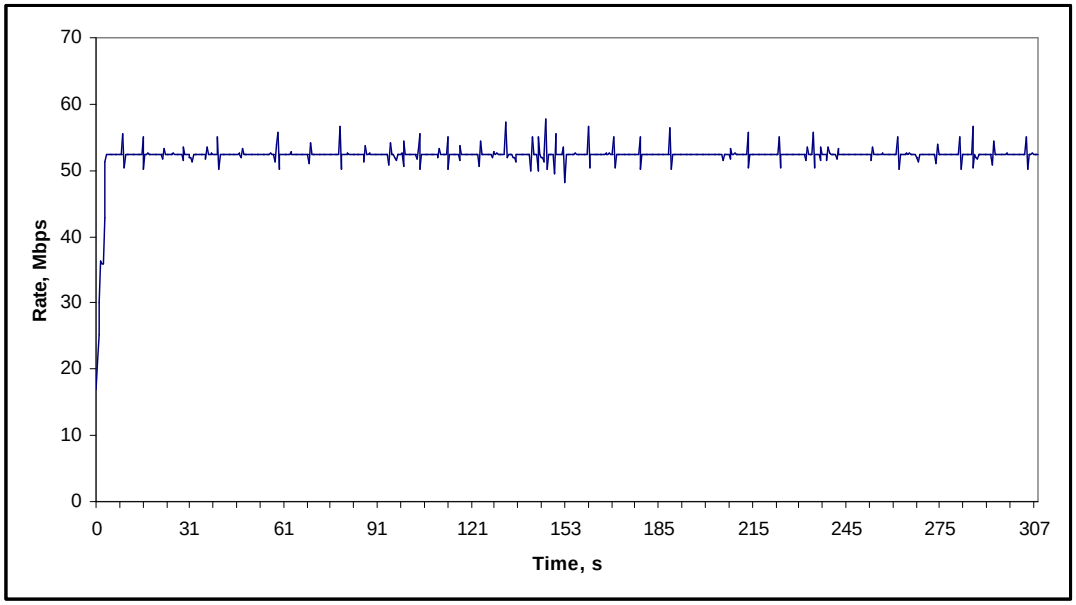

Figure 6. Time diagram of single scan transmission through ISP "WebPlus" (100 Mbps) from Svetloe Observatory to the IAA Control and Processing Center St. Petersburg. Rate 50 Mbps. Scan size 2 Gbytes. Tsunami-UDP protocol.

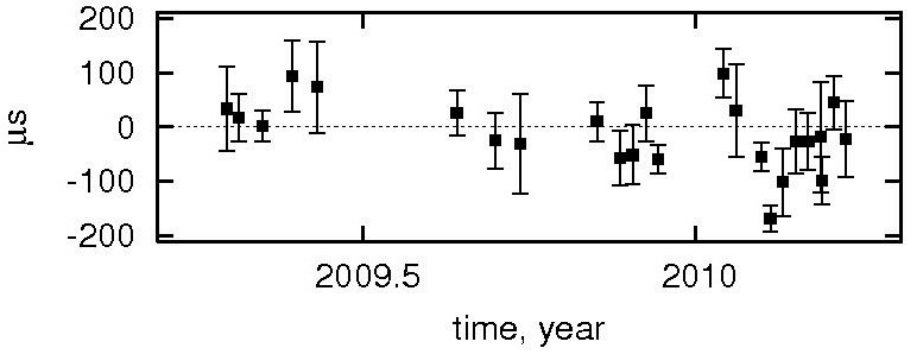

Figure 7. UT1(IAA)–UT1(EOP 05 C04) for 24 e-VLBI sessions.