Modernisation of cosmic ray stations of the Institute of Solar-Terrestrial Physics of Siberian Branch of the Russian Academy of Sciences in order to do work in the real-time mode

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Abstract. Modernisation of the hardware-software complexes of CR stations worldwide in order to work in the real-time mode is a topical problem. Solution to this problem will promote diagnostics of solar-terrestrial relations and space weather forecast. Complex and online analysis of data on CR variations requires full automation of primary data processing, timely data entry into databases with online update, and free access to data. The paper presents characteristics of CR stations of ISTP SB RAS. We describe the hardware-software registration complex which was updated in order to do work in the real time mode. Detailed consideration is given to transmission systems of data from CR stations of ISTP SB RAS and to antenna systems. We give examples of creating databases on the server of CR station Irkutsk and remote CR stations of ISTP SB RAS, and their synchronisation. We also present the existing international projects, which deal with database development, and the participation of CR stations of ISTP SB RAS in these projects (Irkutsk, Irkutsk 2, Irrutsk 3, Norilsk).

1. Introduction
The worldwide network comprises not only neutron monitors but also meson telescopes and ion chambers. The ground-based worldwide network can thus be considered as a unique instrument with resolution in arrival direction of particles and energy. Using all stations as a united multidetector allows us to improve significantly quality and amount of data as compared with a single instrument. There are 50 operating stations at the moment. Russia has 13 cosmic ray (CR) stations. The worldwide network includes 4 CR stations of the Institute of Solar-Terrestrial Physics of Siberian Branch of the Russian Academy of Sciences (ISTP SB RAS) [1], each of them is equipped with a NM64 supermonitor: IRKUTSK (IRKT, Irkutsk), IRKUTSK 2 (IRK2, 2000 m, the Eastern Sayan), IRKUTSK 3 (IRK3, 3000 m, the Eastern Sayan), and NORILSK (NRLK).

2. Data recording systems
PCI - 1780 [2] records data on the CR neutron component. PCI - 1780 is a general-purpose multi-channel counter/timer card for the PCI bus. It uses the AM 9513 Counter Chip and provides eight 16-
bit counter channels, 8 digital outputs and 8 digital inputs; frequency is up to 20 MHz. Data is recorded onto the hard disc minutely.

The BU-353 GPS receiver is used to perform time synchronization.

To record atmospheric pressure, the recording computers are equipped with barometers BRS - 1M. Measuring range of BRS - 1M is 600-1100 hPa; maximum permissible error is ±33 (20 for BRS-1M-2) Pa; data is displayed on the screen and is recorded onto the hard disc using RS-232 interface unit.

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3. Data transmission systems

All stations have local area networks (LANs) and access to the Internet. Data is transmitted to server through the radio channel, using networking devices operating in the 2.4 GHz range (access points DWL - 2100 AP+ and DWL-2700AP); the devices are designed to operate at different distances under different environmental conditions. Access points DWL - 2100 AP+ are used to transmit data at CR stations IRKUTSK and NORILSK.

Data from the CR station IRKUTSK 2 is transmitted using DWL - 2100 AP+ at the transmitting end and DWL - 2700 AP at the receiving end; both ends are connected to antennas GRAD 2483M. The major directional lobe of antenna PAR - 35S, which is connected to access point DWL - 2700 too, is directed to CR station IRKUTSK 3. Data from CR stations IRKUTSK 2 and IRKUTSK 3 is transmitted in the real-time mode to server in Irkutsk through the satellite link.

DWL-2100AP+ is a multi-purpose wireless access point. It establishes a stable connection with 802.11g wireless devices at a rate of up to 54 Mbit/s. The access point supports WEP (Wired Equivalent Privacy) - 64/128 bit data encryption - and WPA (Wi-Fi Protected Access)/WPA2, provides the access control of users due to the MAC address filtration; besides, it inhibits the SSID broadcast to prevent access to the internal network. The transmitter power is 100 mW.

Outdoor wireless access point DWL-2700AP that conforms to IEEE 802.11b/g standards covers a large operating distance, providing wireless Internet access with transfer speeds of up to 54Mbps. DWL-2700AP is ideal for adverse climatic conditions: with its solid, watertight housing and built-in heater with a temperature sensor, this AP is environment-proof. Power supply over Ethernet cable enables an access point to be installed at places with no AC power sockets available. With a variety of high-gain outdoor antennas, DWL-2700AP provides good wireless connection in mountains. DWL-2700AP supports 152-bit WEP encryption and AES (Advanced Encryption Standard). Besides, IEEE 802.1X port-based network access control for user authentication with MAC addresses helps to provide optimal security.

CR stations IRKUTSK and NORILSK are equipped with ASUS WL - 500g Premium Router that has a built-in firewall and NAT functionality, thus providing an independent internal network and, along with an antivirus program, a reliable protection against any external action on recording computer. The following antennas are installed at CR stations of ISTP SB RAS: PAR-35S (antenna power gain is 30 dBi), GRAD 2483M (antenna power gain is 15 dBi), RA-2.3-01 (antenna power gain is 18 dBi).

4. Data transfer software to databases and server

Primary and processed data is transferred to FTP server of CR station IRKUTSK (ftp://84.237.21.4). Here, information is checked and data on CR variations is presented at [3].

ActivePerl script is used to transfer data from remote stations. The script synchronizes state of subdirectories when it is impossible to install database on a computer. Data on each station (primary and processed data, service information) is stored separately on the server.
5. Databases of CR stations of ISTP SB RAS
Creation of a database of CR stations of ISTP SB RAS has been determined by the necessity to collect data from CR stations IRKUTSK, IRKUTSK 2, IRKUTSK 3 and NORILSK at a united center in order to perform on-line control of data quality, fault diagnosis and program failures.
Free version of Oracle Express Edition is used at CR stations of ISTP SB RAS. This edition has the following constraints: its RAM is 1 GB, it uses no more than one operating CPU, maximum database size of Oracle Database XE is 12 GB. This includes between 0.5 and 0.9 GB for the data dictionary, internal schemas, and temporary space, which leaves just 11.0 GB for user data. When database is installed on a remote computer, PL/SQL is used for data synchronization.

6. Conclusion
A software and hardware complex enabling CR stations of ISTP SB RAS (IRKUTSK, IRKUTSK 2, IRKUTSK 3, NORILSK) to work in real-time mode has been developed. The database of CR stations of ISTP SB RAS is now used to accelerate and optimize preprocessing, to present data in the Internet. Databases of all CR stations of ISTP SB RAS are synchronized with the central database [3].

[1]  Aleshkov V, Dvornikov V, Lukovnikova A, Sdobnov V 2007 The ISTP SB RAS Sayan mountain spectrographic complex of neutron monitors International Symposium: fundamental Science & Applied Aspect (Athens, Greece, 2007) p 396
[2]  Kartyshov V, Klepach E, Eroshenko E, Smirnov D, Yanke V 2008 Universal Recording System for the Stations of Cosmic Rays 21st ECRS ( Košice, 2008) pp 119–122
[3]  http://cgm.iszf.irk.ru