Research of remote control for Chinese Antarctica telescope based on Iridium satellite communication

Lingzhe Xu[1,2],shihai Yang[1,2]

1.National Astronomical Observatories /Nanjing Institute of Astronomical Optics & Technology，

Chinese Academy of Sciences，Nanjing 210042, China

2 Key Laboratory of Astronomical Optics & Technology, Nanjing Institute of Astronomical Optics & Technology, Chinese Academy of Sciences, Nanjing 210042, China;

ABSTRACT

Astronomers are ever dreaming of sites with best seeing on the Earth surface for celestial observation, and the Antarctica is one of a few such sites only left owing to the global air pollution. However, Antarctica region is largely unaccessible for human being due to lacking of fundamental living conditions, travel facilities and effective ways of communication. Worst of all, the popular internet source as a general way of communication scarcely exists there. Facing such a dilemma and as a solution remote control and data transmission for telescopes through iridium satellite communication has been put forward for the Chinese network Antarctic Schmidt Telescopes 3 (AST3), which is currently under all round research and development. This paper presents iridium satellite-based remote control application adapted to telescope control. The pioneer work in China involves hardware and software configuration utilizing techniques for reliable and secure communication, which is outlined in the paper too.

Keywords: remote control system, Iridium satellite, data transmission

1. INTRODUCTION

The high plateau that covers half of the continent of Antarctica contains the best astronomical observing sites on Earth. The infrared sky background is low, the precipitable water vapor is low, the sub-millimetre sky opacity is low, the winds are low, the atmosphere is exceedingly clear and stable, it never rains, there is no dust, it is geological stable, and the seeing at some sites, notably Dome A, is superb[1].

On 10th, October, 2007, Chinese Small Telescope Array (CSTAR) has been built and accepted in NIAOT. On 16th, October, 2007, CSTAR was transported to Dome A. On 2th, February, 2007, Chinese Antarctic KunLun Station was set up at Dome A. At the end of 2010, Chinese another telescope AST3 will be transported to Dome A. Antarctica region is largely unaccessible for human being due to lacking of fundamental living conditions, travel facilities and effective ways of communication. Worst of all, the popular internet source as a general way of communication is scarcely here. Facing such a dilemma, we propose to realize remote control of telescopes through iridium satellite communication.

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2. Iridium satellite

The Iridium satellite constellation is a large group of satellites used to provide voice and data coverage to satellite phones, pagers and integrated transceivers over Earth's entire surface. Iridium Satellite LLC owns and operates the constellation and sells equipment and access to its services.

The constellation requires 66 active satellites in orbit to complete its constellation and additional spare satellites are kept in-orbit to serve in case of failure. Satellites are in low Earth orbit at a height of approximately 485 mi (781 km) and inclination of 86.4°. Orbital velocity of the satellites is approximately 17,000 mph (27,000 km/h). Satellites communicate with neighboring satellites via K_a band inter-satellite links. Each satellite can have four inter-satellite links: two to neighbors fore and aft in the same orbital plane, and two to satellites in neighboring planes to either side. The satellites orbit from pole to pole with an orbit of roughly 100 minutes. This design means that there is excellent satellite visibility and service coverage at the North and South poles, where there are few customers. The over-the-pole orbital design produces "seams" where satellites in counter-rotating planes next to one another are traveling in opposite directions. Cross-seam inter-satellite link hand-offs would have to happen very rapidly and cope with large Doppler shifts; therefore, Iridium supports inter-satellite links only between satellites orbiting in the same direction[2].

3. Hardware and software configuration for communication system

Communication is realized by an Iridium satellite modem in each supervisor computer. These provide continuous real time status of the instrument, and daily reports and reduced data from the instrument suite. It is possible to use scripted or interactive sessions to update all of the on-board software.

3.1 Hardware configuration for the communication system

The Remote PC (at Antarctic) is connected with an Iridium satellite modem by RS232. The local PC is connected with a common modem. The two PC can communicate with each other by dialing the other's number through the Iridium satellite gateway. Figure 1 shows the hardware configuration.

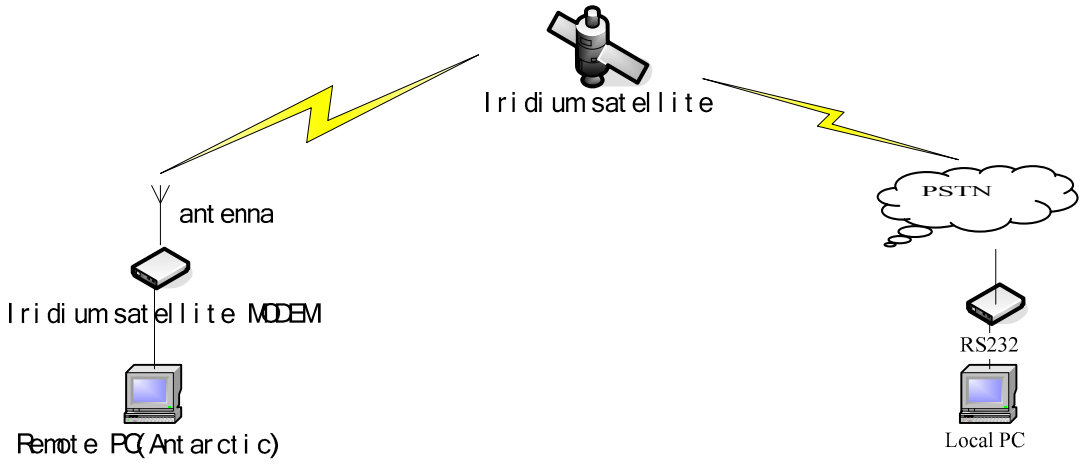

Figure 1: Hardware configuration

- The modem serves as the DCE (Data Communications Equipment) at the remote site.
- The remote control application serves as the DTE (Data Terminating Equipment) at the remote site, communicating with software in the modem through AT commands sent to either the modem's Control or Data ports.
- Data flows to and from the modem over-the-air, using the Iridium satellites and Gateways connected to the Internet (for packet data) or to the PSTN (for asynchronous data).
- A host application (server) manages remote sites (DTEs).

3.2 Software configuration for the communication system

Iridium satellite modem supports AT command. AT Command is the protocol between modem and computer, which is developed by Siemens, Motorola and HP. Every AT Command is with a prefix AT+. There is a feedback for every command. There are three modes to send mobile notes, BLOCK mode, TEXT mode and PDU mode. PDU mode is widely used now. The process of communication is shown below:

- Set up a communication link between remote PC and Local PC. The receiver sets the Iridium satellite to monitor mode using "ATS0=1" command.
- Set baud rate to 2400bps.
- The sender sends "ATDT xxx" command to the receiver. If the sender receives "CONNECT 2400", it means success. If the sender receives "NO CARRIER", it means failure. If the sender receives "BUSY", it means the line is busy. If the sender receives "NO ANSWER", it means the line is no answer.
- The receiver receives "RING". If the receiver receives "CONNECT 2400", it means the link is established. If the receiver receives "NO CARRIER", it means the link is not established.
- When the link is established, the data can be sent by each PC.
- When communication is over, the receiver sends "+++" to stop communication.
- The receiver sends "ATH" to hang up.

Figure 2 and figure3 shows the process of communication

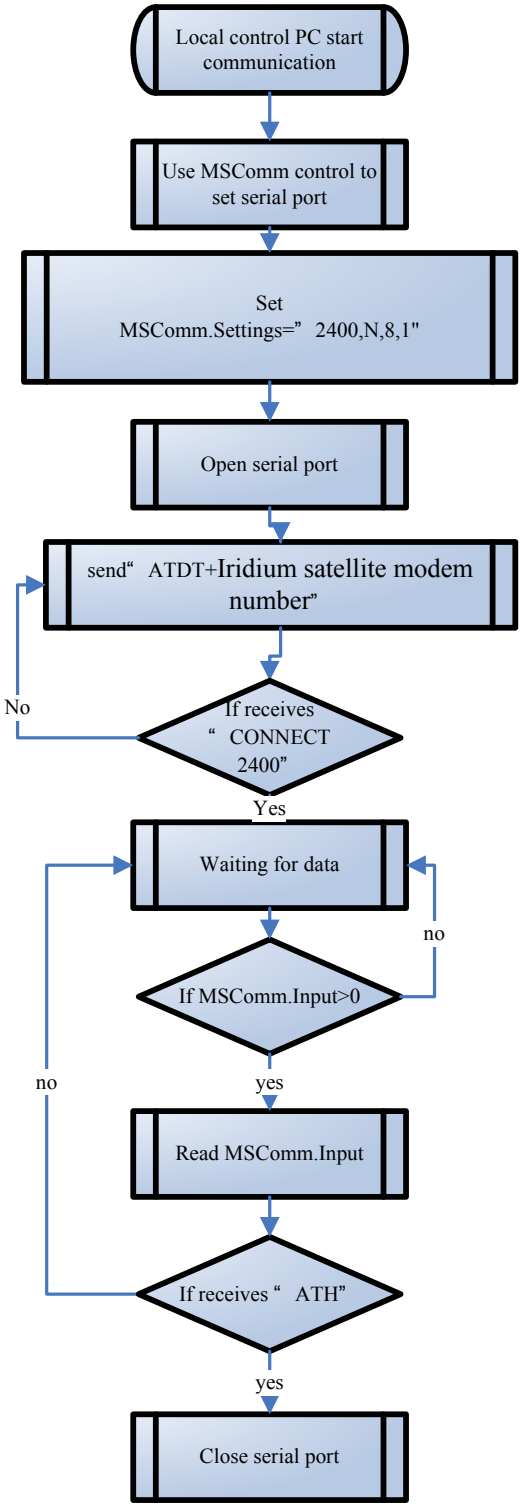

Figure 2: local control PC software configuration

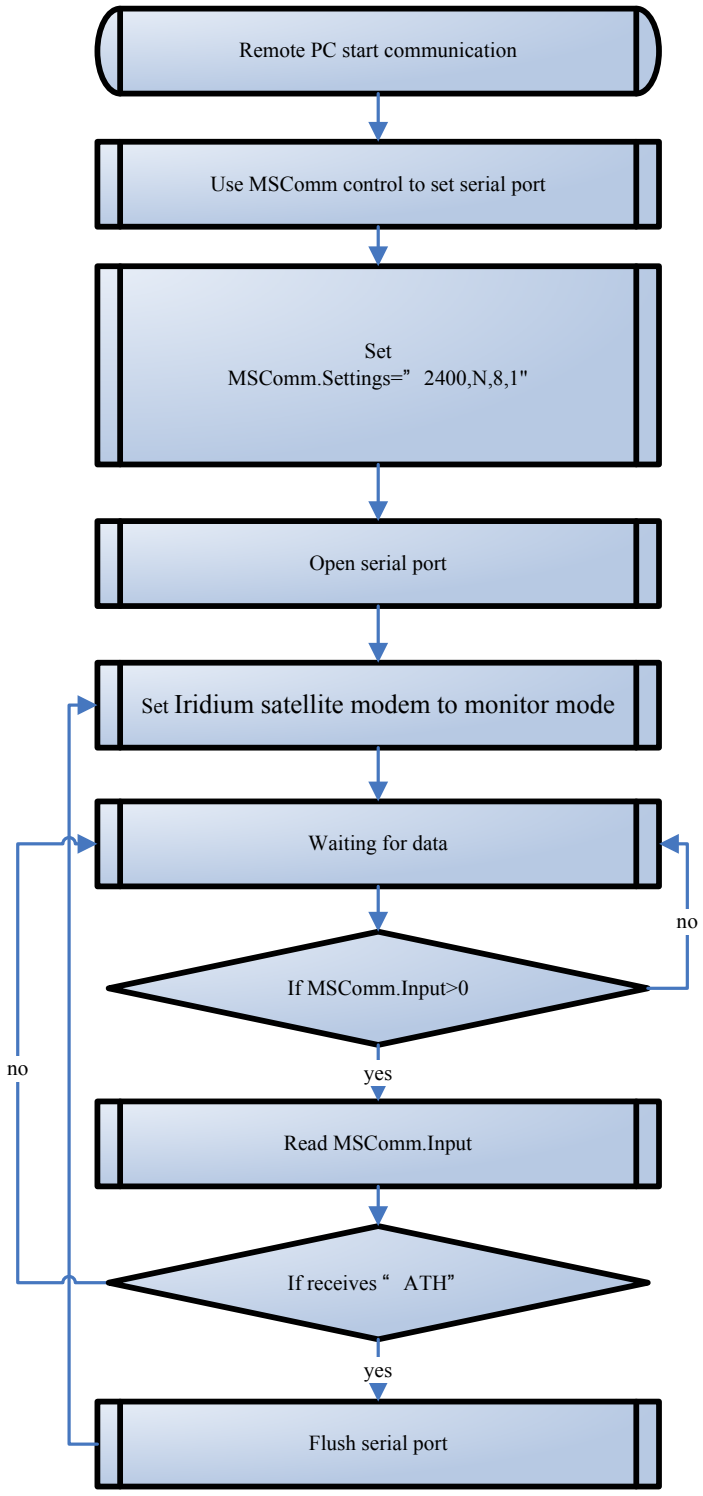

Figure 3: Remote control PC software configuration

4. Some important issues

The Communication system is designed to run autonomously for up to a year, so it must be very credible and self-resume.

- Remote wakeup function: First the remote PC must connect to the power, Second the remote PC's motherboard must support remote wakeup function. At the CMOS setting of the remote PC, set 'modem ring resume' or 'POWER ON BY RING' to enable. When the local PC calls the remote PC modem it can wake up the remote PC.
- Data Verification: At Antarctica, the signal of Iridium satellite is weak. So, we must use data verification technique. The remote PC compresses the data and joins the CRC parity bit and sends the data frame by frame. The local PC receives the data and checks the data frame by frame.
- Ftp services: Because of the expensive communication fee, the data must be compressed before communication. Some big file need to be transmitted by FTP. First the remote PC connects to the local PC. The local PC gets the file name from the remote PC. The local PC gets the file from remote PC through FTP server.
- Watch dogs: A robotic telescope needs to have a well thought-out strategy for coping with system failures. Hardware and software watchdogs need to be carefully constructed. One of the major issues is restarting a system that has been allowed to cool down to ambient, perhaps through a power failure[3].

5. Conclusion

Owing to extremely awful weather condition and without fundamental living environment on the Antarctic region for human being it is necessary for any astronomical telescope to be remotely mobilized. In the long run robotically operation mode is a must for efficient observation with high scientific output. The way to communicate productively with astronomical telescopes in operation from every corner of the Earth is the first important issue. Normally this could be solved effectively by nowadays popular Internet if it is not on the Antarctic region where there is scarce Internet access. This is how and why we initiate the research on iridium satellite based communication a couple of years ago. Since then through R & D stages we have learnt the mechanism in the data transmission through iridium satellite and its hardware, software and interface. A number of lab simulation tests were conducted. This paper presents some of our progressive research results. And eventually Chinese AST3 telescope based on Iridium satellite communication will be put in place and remotely operated.

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