Preliminary Studies on Remote Sensing Images Transmission by BD Short Message System Based on GSG

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Abstract: To transmit remote sensing images by BD short message system, a method that transmits changed images based on subdivision size of global subdivision grid (GSG) is introduced. Combining the facts of BD's short message bandwidth with the features of remote sensing image, it uses some policies, including transmitting remote sensing images based on subdivision cells, transmitting changed images and transmitting codes of objects. It also adopts retransmitting loss packets to increase the reliability of remote sensing images transmission. At last, it is verified by simulation system. The result shows transmitting remote sensing images by BD short message system based on GSG is available and is of theoretical and applied value.

Keywords: global subdivision grid (GSG); BD short message system; subdivision size; subdivision image pyramid

1 Introduction

BD navigation and positioning system is developed independently by China. Comparing with GPS of USA and GLONASS of Russia, not only do BD satellites provide services of navigation and positioning and precision timing, but it has bidirectional communication ability [1]. It plays great role in burst disasters, for example snowstorm and earthquake in 2008, rescue in dessert, and so on. Under those conditions, remote sensing images would be asked and other communications might not be reached, for example all telephones and mobiles could not work in Wenchuan earthquake, so BD short message system would be the most feasible communication method. But BD short message system only can transmit less than 240 bytes once and it is also unsteady. So it will be not very efficient and real time to transmit remote sensing image data by BD short message system. To solve these problems, this paper puts forward some policies and methods based on global subdivision grid (GSG) to transmit remote sensing images by BD short message system.

2. BD Short Message System and GSG

2.1 BD Short Message System

Generally, BD short message system can transmit 72 bytes once. For some users, it may serve them 240 bytes once. In Table 1, the time that BD serves different users is listed [2]. At home, there are a few scholars who do researches on transmitting data by BD short message system. For example, Zhang dong et al [3] transmitted files by BD short message system in 2005. Cheng Fanglin *et al* [4] discussed the communication protocol to transmit massive data by BD short message system in 2008. Because of the limited communication bandwidth of BD short message system, it would take long time to deliver data in real time. For example, if there are no loss packets and it delivers 240 bytes per second, transmitting a 10MB file by BD short message system need almost a half day. If it delivers 240 bytes per 30 seconds, it would take 15 days. Table 2 shows time is spent in transmitting 30MB data at different frequencies by BD short message system. And if there are loss packets when transmitting data, it would take more time to get all data by retransmitting the whole data. So, if user should update data by BD short message system, it would be impossible to do that in time, especially transmitting massive remote sensing images in burst disasters. So, in this paper, it proposes some remote sensing image data transmitting policies and methods based on GSG.

2.2 GSG

In order to divide the global surface into cells with regular shapes and less deformation to store and extract and ana-

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lyze global, multi-level massive data which traditional data models could not deal with, GSG is data model that ensures global geospatial data expression to be global and continuous and hierarchical and dynamic. In the following part, it presents the subdividing methods and code rules based on Octahedral Quaternary Triangular Mesh (QTM or O-QTM) model which is a typical represent of GSG proposed by Dutton.

Table 1. BD users' type and some parameters

Card classes	Users	Intervals	Positioning response time
Ⅰ class	portable	5-10mins	<5secs
Ⅱ class	Vehicles, shipborne and airborne	10-60secs	<2secs
Ⅲ class	Airborne and high-speed moving objects	1-5sces	<1sec

Table 2. Time spent to transmit different files by BD short message system

File size/MB	Packet size/Byte	Interval/second	Time/second
10	240	1	43691
10	240	30	1310730
10	240	45	1966095
10	240	60	2621460

Dutton[5,6] modeled the globe as a polyhedron and got shapes as regular hierarchical triangulations of an octahedron embedded in a planet with its six vertices at cardinal points and its edges coincide with equator, 0°, 90°, 180° and 270° meridians. The process of hierarchically identifying locations begins by dividing any of its eight faces at edge midpoints to define four child triangular facets (Figure 1). So QTM is a global, seamless, regular, approximately uniform and hierarchical grid. From this angle, GSG has polygon-and-point character, i.e. it is made of regular similar cells in macro world and has point characters in micro world. Its polygon-and-point character makes it easy to connect with different resolutions of remote sensing images. So it has an advantage in organizing and managing remote sensing images.

Dutton [7] also coded those regular triangles in QTM. Supposing one of triangles in k Level, the triangle's code is $a_0a_1a_2\ldots a_k$, called address code (QTMID). a_0 is a base8 digit numbering from 0 to 7, and a_1, a_2, $\ldots a_k$ are base4 digits numbering 0, 1, 2 or 3. By numbering the original eight faces and their children, each facet, no matter how small it is, may have a unique integer identifier. And then QTM identifiers (QTMIDs) contain geospatial position information [8]. So, not only do QTMIDs encode subdivision cells, but they represent position information in some degree.

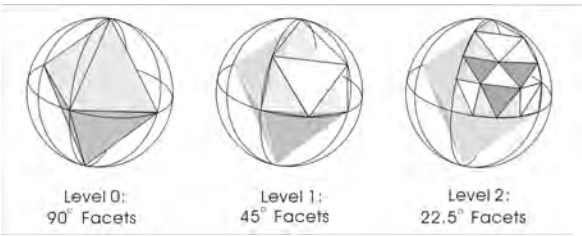

Figure 1. QTM Data Model

Because GSG is composed of regular, little transformed, hierarchical and seamless subdivision cells and each cell's QTMID is unique in the world, different resolutions remote sensing images that allocate the cells in different levels on GSG may be identified by the cells' QTMIDs and images' attribute keys, i.e. global unique geographical identifier, GeoID, which means different resolutions remote sensing images may be managed and indexed by global unique geographical identifiers.

3. Architecture of Remote Sensing Data Transmission Based on GSG

3.1 Architecture of Remote Sensing Image Transmission by BD Short Message System Based on GSG

In real life, regional information on global surface may change greatly, but the whole changes a little. And there is information redundancy between different images about same place, especially images taken in short time. So, when using remote sensing images between short time to update data, we may only update the regions which change greatly or researching target regions and do not update regions whose information is changed little or not researching targets.

It supposes that all remote sensing images are stored in geospatial information storage architecture based on GSG, which means different resolutions remote sensing images are stored in different levels' subdivision cells and indexed with QTMIDs and images' attribute keys. Because the surface of GSG is composed to series of continuous regular standard subdivision cells, it has advantage to update information of small regions. So, when data are updated,

sender could only deliver regions whose information is changed greatly or they contain researching targets on some subdivision cells to receiver. Then receiver updates the subdivision cells' data. Architecture of remote sensing images transmission by BD short message system based on GSG is illuminated in Figure 2.

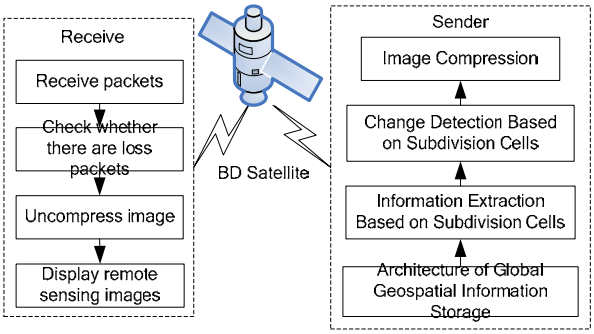

Figure 2. Architecture of remote sensing images transmission by BD based on GSG

In Figure 2, geospatial information subdivision storage architecture is the foundation to remote sensing images transmission. Remote sensing images all are associated with the subdivision cells. First, when transmitting remote sensing images, it analyzes physical features of communication environment, such as the communication bandwidth and data packet size, and researching targets' information. Second, it gets remote sensing images from the database or file system based on GSG. The following step is detecting information on the subdivision cells to make sure whether it is changed or not. If information in subdivision cells' is changed, remote sensing images in the cells are compressed and changed them to BD short message format and transmitted them to receiver. When receiver gets data packets, it decompresses and shows them on some subdivision cells according to QTMIDs. By this means, it achieves the purpose that transmitting as large amount data as possible using little communication resource.

3.2 Remote Sensing Image Transmission Policies

Because the bandwidth of BD short message system is finite but remote sensing images data almost are very large, here it proposes 3 policies to deliver remote sensing images based on the GSG. The policies are as followings.

3.2.1 Transmitting Data Based on Subdivision Cells

To transmit more information by BD short message system, it transmits data based on subdivision cells. When it transmits data, it will analyze communication resource, remote sensing image bit depth and image scale to ensure the level and cells in GSG. The process of calculating subdivision cell is illustrated in Figure 3.

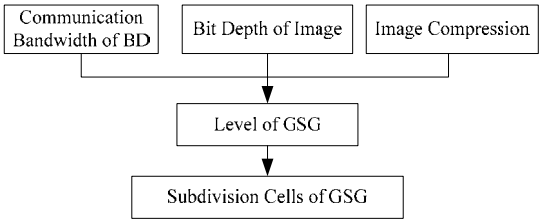

Figure 3. Process of calculating subdivision size

3.2.2 Transmitting Changed Remote Sensing Data

In real life, there are little changed between two remote sensing images about one place. There is redundant information between them. So it is not necessary to update all the data about the place. To update changed information may reduce the data redundancy and improve data transmission efficiency. Figure 4 is the process of changed remote sensing data storage and transmission.

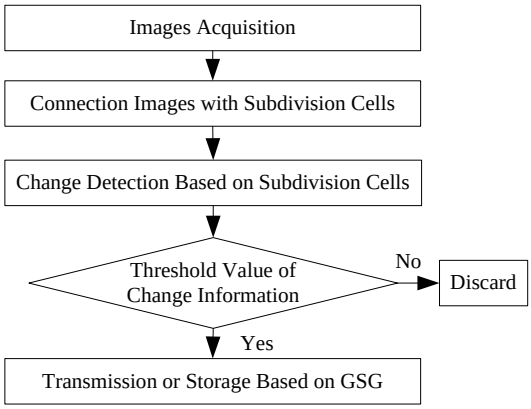

Figure 4. Architecture of data storage and change information transmission based on GSG

3.2.3 Transmitting Object's Codes

To some objects in remote sensing images, it transmits their codes substitute for their images' data to reduce the load of network. The objects' codes may include whether road is blocked or not and bridge is destroyed or not. We may design some icons to express those objects information and encode the icons. When those objects' information

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should be told, it may only give the objects' codes to receiver. After receiver gets objects' codes, it will transfer codes to objects' icons and show them. Transmitting the objects' codes may reduce data quantity and times during the course of transmission and improve transmission efficiency.

4. Key Technologies and Process

4.1 Key Technologies

4.1.1 Subdivision Image Pyramid

Subdivision image pyramid is a multi-resolution image data model. It organizes high-resolution remote sensing image according to subdivision cells in GSG and indexes different resolution remote sensing image by the cells' QTMIDs. By creating remote sensing image subdivision image pyramid, it may organize, manage and show rapidly the remote sensing images in subdivision cells in GSG [9].

When remote sensing images are transmitted by BD short message system, data got from subdivision image pyramid of a special level in GSG will be rapidly because data are indexed by the subdivision cells' QTMIDs.

4.1.2 Remote Sensing Image Compression

JPEG2000, which was drafted by Joint Photographic Experts Group(JPEG)in 2000, is one of image compression standards. The standard number is ISO 15444. It uses discrete wavelet transform (DWT) block code substitute for discrete cosine transform (DCT) multi-formula code to compress image [10]. The improved JPEG2000 may truncate the embedded blocks of image. It may also get block code stream randomly, transmit progressively, get region of interest, have a greater fault tolerance and safety, and so on [11].

In order to reduce the packets counts and time of data transmission to improve efficiency, images are compressed to JPEG2000 in sender. Then receiver decompresses the JPEG2000 to original data after receiver gets packets. Because of the progressive feature of JPEG2000, the receiver may see what figure is firstly and may get clearer and clearer figure with getting more and more data.

4.1.3 Packet loss detection and retransmission

Because BD short message system is not steady, there are packets lost when massive data are transmitted. And there are intervals which may be from 1 second to 10 minutes between two BD short message packets. If some packets are lost and the whole file should be transmitted, it would take long to transmit a large file. So it is necessary to design to detect packets loss and retransmit those. In the paper, it designs a packet header structure, which is as followings.

```
struct tagBDPACKETHEADER{
DWORD dwdBDSourceID;
DWORD dwdBDDestID;
BYTE btPacketID;
WORD wdPacketNo;
BYTE btPacketType;
DWORD dwdPacketLength;
};
```

In packet header structure, the item of *dwdBDSourceID* is sender BD card ID, and *dwdBDDestID* is receiver BD card ID. *btPacketID* means data types transmitted in the packet, such as message, file, image or icon, and so on. *wdPacketNo* means the order number in all packets, and help receiver make sure whether packets are lost or not. *btPacketType* presents that the packets of a file or image are first transmitted or retransmitted. And *dwdPacketLength* presents the length of packet.

There are some rules in receiver when it processes loss packets about remote sensing images. The rules are as followings.

Rule 1 If the first image data packet is loss, receiver gives up receiving following other data packets from same file or image. This means the file or image transmission fails.

Rule 2 For one file or image, receiver feeds back loss packets information to sender less than twice. If receiver does not get the wanted loss packets after 2 times intervals, it gives up feeding back information and destroys all the data what it had gotten. This also means the file or image transmission fails.

Rule 3 If there are some loss packets in retransmitted packets, receiver also feeds back the loss packets information. But if there are also loss packets after 2nd feedback, receiver will give up feeding back information and destroy all the data what it had gotten. In this case, it means the file or image transmission fails.

4.2 Data Transmission Process

4.2.1 Sender

The main jobs of sender are compressing remote sensing images into JPEG2000, adding the packet header and packaging data into standard BD short message packets, and delivering the standard packets by BD short message system. The other job is retransmitting the loss packets according to feedback information. Figure 5 presents the procession of sender.

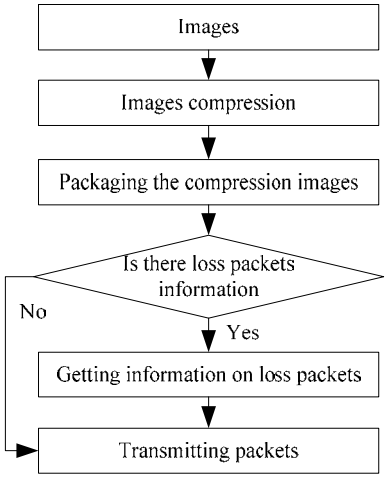

Figure 5. Process of Sender

4.2.2 Receiver

After getting packets by BD short message system, receiver analyses packets to judge that the packets are transmitted firstly or retransmitted. If packets are transmitted at first time, data are appended into data buffer. If the packets are retransmitted, data are inserted into data buffer according to packet's order number. If there are loss packets according packet's order number, it counts loss packets information and feeds them back to sender by BD short message system. Then it decompresses data of buffer into original images and displays them. Figure 6 presents the procession in receiver.

5. Experiments and Analysis

Pointing to usage of BD terminal in Wenchuan earthquake, we develop a remote sensing images transmission simulation system by BD short message system under Microsoft embedded Visual C++4.0. Because of the limits of terminal resources and BD short message system communication bandwidth, those methods based on GSG are used. And there are some rules when data transmitted. To think over the features of BD short message system and the limits of terminal computing resources, it adopts some methods. i.e. to express roads which are blocked or not and bridges are destroyed or not, those information is updated by objects' icons. The objects' icons and codes of icons are illustrated in table 3. And to give information about mountains landslides and barrier lakes, their images are transmitted.

At last, the simulation system is tested by 10888 × 9960

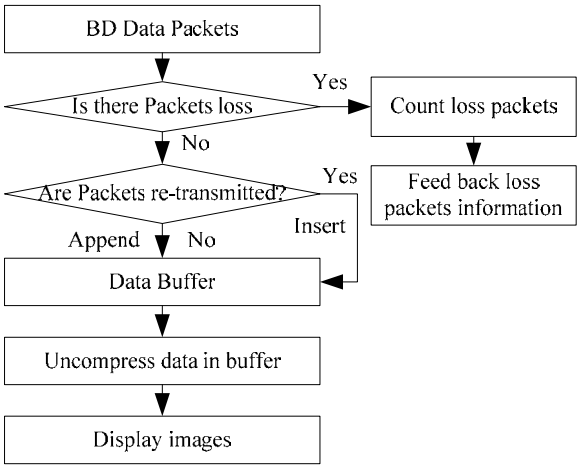

Figure 6. Process of Receiver

Table 3. Icons and codes of different road status and bridge status

Object	Object Code	Icon	Status	Icon Code
Road	100		Ok	1001
			Blocked	1002
Bridge	200		Ok	2001
			Destroyed	2002

×3 remote sensing image, whose resolution is 0.6m. The BD card used in the system may only transmit 106 bytes per 45 seconds. When the length of packet is larger than 106 bytes, it is wrong for receiver to uncompress packet data to original image. The result is showed in table 4 and figure 7 illustrates the relationship between packet size and loss packet counts (LPC) and result field. In table 4, the "wrong" in result field means simulation system can not uncompress data rightly and nulls are right. During the transmitting, sender only transmits 16×16 pixels images by BD short message system. Table 5 shows the results using

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retransmission. Table 6 illustrates times by transmitting different size images. From Table 6, it takes only 270 seconds and 1 second in

Table 4. Results about different sizes of a packet of BD short message system

No	Packets number of a file	Packet size/Byte	Times /times	Loss packets Counts	Loss packets percent / %	Result
1	4	240	10	3	7.5	wrong
2	4	200	4	2	12.5	wrong
3	5	150	4	0	0	wrong
4	6	120	5	2	6.7	wrong
5	6	115	4	0	0	wrong
6	6	110	4	1	4.2	wrong
7	6	109	4	0	0	wrong
8	6	108	2	0	0	wrong
9	6	107	7	1	2.4	wrong
10	7	106	10	0	0	
11	7	105	8	1	1.8	
12	7	104	5	0	0	

Table 5. Results using retransmission

No	Packets number	Packet size/Byte	Test Times /times	Loss packets percent/%	Result
1	7	106	5	0	
2	8	106	5	1	Success by retransmission
3	7	106	5	0	
4	7	106	5	0	
5	7	106	5	1	Success by retransmission
6	6	106	10	4	Fails twice in losing first packet and successes once by retransmitting 2 packets
7	7	106	3	2	All Fail for losing first packet

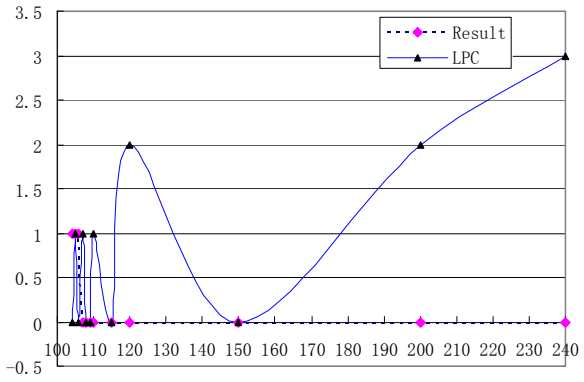

Figure 7. Relationship between packet size and loss packet counts (LPC) and result

Table 6. Time transmitting different sizes images

Transmission Mode	Size/Byte	Time/second
part image	78K	33930
Image on subdivision cell	822	270
Code of icon	4	1

transmitting cell' images and icons' codes, which is too much less than transmit the whole images. Figure 8 is the result in which the No.1 presents the cell' images and No.2 and No.3 are icons.

The configurations of simulation system are as followings.

Sender is a PC, whose CPU is Inter(R) Core(Tm)2 Duo CPU E4600 whose frequencies are 2.4GHz and2.4GHz, and memory is 2GB and hard disk is 240GB.

Receiver is a PDA, whose CPU is Intel(R) PXA263 whose frequency is 400MHz and its memory is 64 MB and flash is 32MB.

6. Conclusions

Using methods of transmitting remote sensing images by BD short message system based on GSG and embedded

system development, it realizes updating images for terminal by BD short message system. In a word, the technology of transmitting remote sensing images by short message system based on GSG has such advantages.

First, it is easy to adapt environment. It analyses the bandwidth of BD short message system and feathers of images and selects a best size of cell, which make it is possible to transmit remote sensing images by narrow bandwidth.

(a) Images before updated

(b) Images updated

Figure 8. Results between images in receiver

Second, it improves data transmission efficiency of BD short message system. Because it only transmits changed images indexed by address code in subdivision image pyramid based GSG and transmits objects' icons, it avoids transmitting the whole images and objects' image information and coordinates.

Third, it is successfully to transmit massive data. To some extent, it improves the success rate of data transmission for using retransmission.

Fourth, it is more efficient for data to be used. Because data are organized by GSG and it uses JPEG2000 to compress image to transmit progressively, receiver may see what data are even through some packets of a file or image are lose, which avoids data that receiver has gotten is useless and wasted. In some degree, the utilization ratio of data is improved.

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