RESEARCH ON THE WAY OF SHARING GEOGRAPHIC INFORMATION DATA IN DISASTER MANAGEMENT

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ABSTRACT:

In the process of disaster emergency response, how to achieve rapid sharing of geographic information data is still a difficult problem to be solved. Combining the demand for emergency geographic information data in response to emergencies and major natural disasters in China, investigating the current situation of existing emergency geographic information data sharing, and based on the actual emergency geographic information service guarantee work, this paper researches and analyzes the sharing demand, designs the emergency geographic information data sharing model, and studies the emergency geographic information data sharing mechanism from the aspects of sharing platform, data sharing requirements, and service sharing requirements.

1. INTRODUCTION

At present, geographic information has become an important means of guaranteeing China's response to emergencies and major natural disasters. After the occurrence of disasters, many units have established certain capabilities in disaster site information acquisition, geographic information data processing and geographic information services, developed relevant disaster disposal contingency plans and become an indispensable force in the national emergency mapping and security capabilities. (Cao *et al*., 2012; Zhu *et al*., 2014)

The timeliness and urgency of emergency mapping urgently requires the co-ordination of military, inter-departmental and intra-system emergency geographic information data resources, giving full play to and effectively integrating their respective advantages and collaborative services. However, the current emergency mapping lacks task division and unified scheduling and mechanisms, making it difficult to form complementary, synergistic and efficient emergency protection services. In the past emergency response process, each unit mainly relies on its own strength to carry out emergency security work independently, there is insufficient work connection between each other, command and dispatch is not flexible and other problems, it is difficult to form a synergy, and mapping and geographic information system within the emergency mapping and surveying to implement vertical hierarchical security mechanism, there is prevention and disposal in the articulation is not close enough, cross-regional overall linkage is difficult to achieve and other problems. (Wu, 2017; Zhu *et al*., 2014) Therefore, there is an urgent need to give full play to the advantages of the military, inter-departmental and intra-system, build an emergency protection mechanism, clarify the tasks and division of labour of relevant units, establish and improve the sharing and coordination mechanism in terms of airspace application, airport use, on-site information processing, disaster interpretation and data sharing, (Xia, 2018) and form a unified command, fully functional, coordinated and efficient national emergency mapping protection capability.

The scientific and comprehensive nature of emergency mapping urgently requires the integration of information resources from various departments and aspects of society, based on a unified geospatial framework to realize the spatial positioning, visual display, comprehensive query and analysis of various emergency command information, and to realize auxiliary decision-making. However, the current emergency geographic information resources are not rich in types, the information is not highly presentable, and the degree of comprehensive analysis of information is not enough, and the information interchange channels are not convenient enough, the approval procedures for data sharing are complicated, and the relevant systems and standard systems are not sound enough, making it difficult to effectively integrate applications. (Zhu *et al*., 2014)

Therefore, in disaster management, building a national geographic information data sharing system with horizontal interaction and upward and downward linkage between the state, localities and departments is an inevitable way to realise the collection, co-ordination and service of geographic information resources data nationwide. This paper examines the current situation of geographic information data sharing in disaster management, analyses the sharing needs, designs the geographic information data sharing model, and studies and analyses the geographic information data sharing process and sharing mechanism.

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2. DEMAND ANALYSIS

The research investigates the demand for geo-information data, system services, mapping needs and service models of national and provincial geo-information management departments in disaster management, the existing geo-information emergency service capacity of provincial geo-information management departments, the geo-information data that can be shared, the types and forms of geo-information services that can be provided, etc. The research investigates the geo-information data sharing needs of some professional departments in disaster management and the types, scope, data volume, data format and confidentiality level of geo-information data that can be shared by professional departments, and the ways or modes of providing emergency thematic data services. On the basis of this, a cross-level and cross-regional emergency geographic information data sharing service model was designed.

2.1 Data Processing Requirements

A geographic information database with rich content, high presentability and reliable quality is the foundation of emergency security work. China has established a series of basic geographic information databases at scale, including the national basic geographic information database and the provincial basic geographic information database, which have played an important role in successive emergency security, and are important basic data that can be directly used in the construction of the national emergency database. (Wang *et al*., 2019)

At present, the collection and management services of the thematic data required for emergency response in China are respectively undertaken by various professional departments, for example, the geological survey department has data on the distribution of geological hazard points, the earthquake department has established thematic databases on key earthquake hazard areas and emergency shelters, the statistics department has established a database on township-level housing surveys for the sixth population census, and the national production safety supervision and management department has established a nationwide database on major hazard sources. These data provide a reliable source of data for the construction of emergency geographic information databases. However, due to the lack of a unified national standard for the construction of emergency databases, each department constructs its own thematic data according to the standards of its own industry, and the data format, data model, data content and spatial positioning benchmarks are not unified, making it extremely difficult to integrate and apply multi-source thematic data during emergencies. Even within the Ministry of Natural Resources, due to the constraints of the hierarchical management system of mapping, each province separately mapped and managed its own large-scale geographic information data, and the data standards and quality requirements adopted were not uniform, making it difficult to directly integrate and use data of the same type and scale among provinces, and requiring a lot of consistency processing, which affected the efficiency of emergency geographic information data services. (Zhang, 2016; Zhang *et al*., 2017; Zhu *et al*., 2014)

In addition, the emergency geographic information data obtained at the scene of emergencies during the emergency period also needs to be integrated and processed according to the actual needs of emergency services and according to the specification requirements, so as to quickly establish a rich, physically and logically consistent emergency geographic information database, and provide data resources for the efficient and orderly implementation of various emergency protection tasks.

2.2 Shared Functional Requirements

Catalogue management requirements: The shared geographic information data catalogue is the basis for finding and locating shared data. It is necessary to dynamically generate a shareable data catalogue based on the data stored on the shared server, and to associate this catalogue with metadata, quick views, data links, etc. to ensure that users can quickly find the data for their needs.

The need for rapid retrieval: The retrieval of large image data is the basis for rapid visualisation and transmission of shared image data, which requires the rapid construction of a multi-resolution structured image pyramid model.

The need for rapid visualisation: On-demand sharing is also an important means of improving the efficiency of emergency geographic information data sharing, especially for large volumes of image data, so the system is required to support rapid preview of single GB images and other image data, and rapid browsing of vector and thematic data.

The need for rapid fusion: According to the experience of many years of mapping services, one standardised emergency geographic information data can only be applied efficiently, and it is necessary to quickly fuse the multi-type and multi-scale data of shared nodes with the background data to achieve multi-level and consistent fusion processing of data types, data models, data contents and spatial positioning bases.

2.3 Shared Data Requirements

The Ministry of Public Security, the Ministry of Emergency Management, the Ministry of Industry and Information Technology, the Ministry of Civil Affairs, the Ministry of Ecology and Environment and more than ten other units conducted research on the demand for emergency geographic information data. The most demanded data is national aerospace remote sensing image data, followed by basic geographic data, geographic census data, national elevation control network and national geodetic control network data.

2.4 Shared Model Requirements

At present, the frequent occurrence of natural disasters and emergencies in various situations has put forward higher requirements for emergency security work, and there is an urgent need to establish cross-level and cross-regional emergency geographic information resources and sharing mode under the cloud computing mode, based on a unified geographic information spatial framework, (Fan *et al*., 2011) to realize spatial positioning, visual display, comprehensive query and analysis of various emergency command information, and to realize auxiliary decision-making to meet scientific decision-making and command The project is designed to meet the needs of scientific decision-making and command, effective organisation and handling of emergency events.

Based on the National Platform for Common Geospatial Information Services, research on cross-level and cross-field emergency geographic information data sharing, exchange and service technology based on cloud computing, form a cross-level and cross-region data sharing model under the cloud computing environment, realize the collection, coordination and service of national emergency geographic information data, realize data sharing between the national master node and the node of the security detachment and the provincial node, provide technical means for the provincial node to share emergency geographic information data with the provincial departments and bureaus and provides technical means for sharing emergency geographic information data between provincial nodes and provincial departments, municipalities and counties. For the three different stages of emergency response: before, during and after, it realizes the reserve of electronic map data resources at the first level beforehand, rapid sharing, rapid processing, rapid distribution and emergency coordination of emergency geographic information data during the emergency period, and archiving application afterwards, providing data support for the whole process of emergency response. (Cao *et al*., 2012; Fan *et al*., 2011; Wu, 2017)

When an emergency event occurs, it is necessary to quickly co-ordinate the emergency mapping resources of the state, province, army and various professional departments, and to provide one-stop data sharing and services by converging on demand the basic data on mapping and geographic information provided by the mapping and geographic information department, the on-site image data acquired by the army, and the emergency thematic information data provided by various professional departments of various ministries and commissions through the e-government intranet. (Zhang *et al*., 2017)

2.4.1 Sharing Needs with Ministries: The national master node provides basic and thematic maps for the State Council, emergency command departments, comprehensive and professional rescue departments and other relevant departments to carry out emergency command and rescue, which requires not only basic geographic data and results from the mapping and geographic information departments for integration and processing, but also image data and various types of thematic data obtained from professional departments on site, such as key protection and concern objects, potential by overlaying the thematic information from these professional departments, the national master node can serve the emergency response more quickly and effectively.

When emergency events occur, various professional departments also need the latest data from the competent mapping and geographic information departments as a geographical framework for decision analysis, which usually includes basic base maps of geographic information and on-site geographic information data, etc. Taking the 2013 Ya'an earthquake as an example, after the earthquake, the national mapping and geographic information department provided more than 50 units, including the Central Office, the State Office, the Earthquake Bureau and the Ministry of Water Resources, with basic base maps of about 590 and more than 1,800 pieces of data, amounting to about 740GB, mainly including maps of Sichuan Province, administrative division maps of Ya'an City, topographic maps of Ya'an City, administrative division maps of Lushan County, drone image maps of Taiping Town, image maps of Taiping Town, DEM data of the earthquake area, DOM data of the earthquake area, DLG data, maps of interpretation results, strong seismic intensity maps of the earthquake area, etc. This shows that the demand for data sharing between the Ministry of Natural Resources and various ministries is huge. If a cross-level and cross-regional emergency geographic information data sharing model is established, various types of national emergency geographic information data can achieve the function of rapid sharing and exchange, thus reducing the data exchange and data copy transmission links and greatly improving the efficiency of utilising various types of emergency geographic information data.

2.4.2 Shared Needs with the Province where the Outbreak Occurred: At present, the national mapping and geographic information authorities are under hierarchical management, with national-level mapping and geographic information data centres mainly governing 1:1,000,000, 1:250,000 and 1:50,000 data nationwide, while larger scale data such as 1:10,000 and 1:5,000 are managed by the provincial mapping and geographic information data centre.

When an emergency event occurs, more detailed emergency geographic information data is needed, especially detailed information about the place where the emergency event occurred. The National Emergency Mapping Centre needs provincial mapping and geographic information data centre to share larger scale data on emergency mapping resources, including specifically maps and application systems for leadership work, large scale basic base map data of the place where the emergency event occurred, remote sensing data quickly acquired on site, processed data will be shared with the data centre.

On-site rapid acquisition of remote sensing data is the basic support for understanding the disaster situation, assessing the disaster, rescue deployment and post-disaster reconstruction planning. The implementation of on-site rapid acquisition of geographic information data is mainly carried out by the national emergency mapping security detachment nearest to the incident area and the national aerial emergency mapping base built in each provincial capital city to obtain on-site geographic information of the emergency incident. These on-site fast-acquired remote sensing data need to be provided and served to national-level mapping and geographic information departments and various ministries through the emergency mapping sharing platform. (Fan *et al*., 2011) At the same time, the results processed by the national emergency mapping centre also need to be quickly provided to the province where the emergency is located.

After a disaster occurs, due to the geographical advantage of provincial mapping and geographic information departments will be the first time to go to the scene, to obtain on-site disaster information, and through the disaster interpretation and other means to extract on-site disaster thematic information, these disaster thematic information is the basis for national understanding of the disaster, emergency relief, but also need to provide and service through emergency mapping and sharing mode to the national mapping and geographic information departments, various ministries.

The government version of the disaster service platform established by the provinces is a spatially visual display of disaster information, which is integrated or aggregated with the data and services of the National Emergency Mapping Centre through the emergency geographic information data sharing model in the form of service aggregation to provide and service to the national emergency disaster relief decision-making and professional sectors.

Through the analysis of geographic information data sharing and service model requirements, in the process of emergency event disposal, emergency geographic information data is the core of emergency security, and is the data basis for scientific decision-making and command, effective organization and handling of emergency events. Cloud computing technology supports distributed storage and rapid sharing. Cloud computing technology is used to build a cross-level and cross-regional cloud environment consisting of national master nodes, provincial nodes, ministry nodes, and emergency site nodes, to achieve rapid sharing of emergency resource data between national master nodes and various sharing nodes, and to provide scalable, high-efficiency and highly stable sharing services. (Zhu *et al*., 2014)

3. SHARED MODEL DESIGN

3.1 Basic Ideas

The basic idea of establishing a cross-level and cross-regional emergency geographic information data sharing approach is to adopt a distributed structure and establish a cross-level emergency geographic information data sharing platform from two levels, national and local, relying on the e-government intranet, to realize the collection, coordination and service of national emergency geographic information resource data, and to realize the online sharing of emergency geographic information data from national, ministries, provinces and sites.

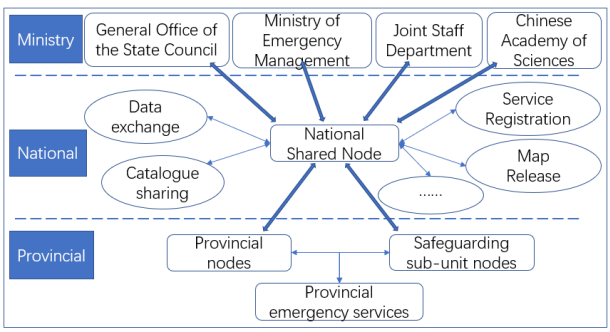

Figure 1. Basic idea of shared model.

At the national level, through the construction of the national master node of the sharing platform and the national emergency mapping on-site remote sensing resources sharing node, the national emergency geographic information resources data channels of multiple departments are integrated to realize the convergence and integration of the pre-, in- and post-emergency geographic information resources data acquired and managed by the Ministry of Natural Resources, the General Office of the State Council, the Ministry of Emergency Management, the Joint Staff Department, the Chinese Academy of Sciences and other departments. For example, the Ministry of Natural Resources collects on-site disaster information through the five-level disaster information reporting mechanism, and provides the General Office of the State Council, the Ministry of Public Security and other departments with physical data, online data services and other emergency geographic information data sharing through the platform.

At the local level, safeguard detachment nodes and provincial district nodes covering 31 provinces, municipalities and directly administered districts across the country have been established to achieve a global reserve of emergency geographic information resource data based on the integration of their relevant emergency geographic information data by each province, and to provide national and provincial emergency departments with timely sharing of provincial and district emergency geographic information data.

On this basis, relying on the e-government intranet, the sharing platform integrates and manages the data and directory services of 38 nodes to meet the application needs of emergency dispatching and command, rapid construction and service of emergency one map through on-demand aggregation, providing reliable and rapid emergency geographic information data service guarantee for emergency decision-making and rescue command.

3.2 Shared Platforms

The national emergency geographic information data sharing platform is the data bus of the national emergency mapping system, and its main role is to realise the collection, co-ordination and service of national emergency geographic information data. The emergency geographic information data sharing service system is an important part of the national emergency geographic information data sharing platform, and its main purpose is to realise data sharing between the national master node, provincial nodes, ministry nodes and emergency sites, and to provide technical means for sharing emergency geographic information data between provincial nodes and provincial departments, cities and counties. In disaster management, it provides data support for the whole process of emergency response by realizing the reserve of emergency electronic map data resources beforehand, the rapid sharing, processing, distribution and emergency coordination of emergency geographic information data during the emergency period, and the archiving application afterwards, for the three different stages of emergency response: before, during and afterwards.

3.2.1 National Shared Node: The national main site establishes an emergency geographic information data resource sharing portal, including modules for shared node management, resource data cache management, process data management, service management, catalogue management, data sharing services, system management, etc., to realize the reception of emergency geographic information data, data management, data sharing, online distribution, data services, statistical analysis and rapid construction of one map.

Combined with the National Platform for Common Geospatial Information Services API service, it provides cloud storage data versioning management and data archiving of massive location data (points, lines and surfaces) and images through open server-side storage and computing capabilities, and monitors the processing of all process data throughout, mainly including data tag management, data operation management, data versioning management, data metadata collection and management, data tracking, query statistics and other functions.

It builds emergency geographic information data crowdsourcing processing functions, shares disaster area image data, and provides volunteers with online annotation of disaster geographic information based on image data, extraction of disaster geographic information, online collaborative editing and thematic mapping of vector geographic information data in

the disaster area, as well as volunteer registration, management, task sharing, data cleaning, effect evaluation, credit evaluation and scoring rewards.

3.2.2 Ministry Shared Nodes: The Ministry Shared Node is used for uploading, managing and publishing various types of emergency and disaster relief thematic data or publishing thematic data services of the Ministry, generating and uploading data or service catalogues to the master node, browsing and downloading the required data, etc.

3.2.3 Provincial and Regional Shared Nodes: The provincial and regional emergency geographic information data resource sharing site is a virtual site built on cloud computing technology, providing a virtual space and site for provincial and district users to share their rational information data resources, (Zhang *et al*., 2016) where users can upload, process, manage and publish electronic maps, vector data, emergency remote sensing imagery, population, economy and other thematic data, generate a catalogue of uploaded data in accordance with unified technical requirements; publish emergency geographic information data services and generate a service catalogue. At the same time, it serves as a portal for sharing emergency geographic information data resources in the province and region, with functions such as data catalogue services, data download, data services, data extraction, processing, retrieval, content management and content preview, and can provide technical support for sharing emergency data resources among departments, cities and counties.

3.2.4 On-site Shared Nodes: The Field Sharing Node is used to upload, manage and publish image data, vector data or thematic data collected in the field, generate and upload data or service catalogues to the master node, download data required in the field from the master site, etc.

4. SHARING MECHANISMS

On the basis of research and analysis of geographic information data sharing needs across levels and regions, the mechanism for emergency geographic information sharing and exchange among geographic information management departments at different levels and in different regions is designed, including the division of responsibilities, types of shared data, requirements for shared data quality, requirements for shared data timeliness, and requirements for shared data usage rights.

4.1 Shared Responsibilities

The national emergency geographic information data sharing platform consists of four types of nodes: the national master node of the sharing platform, the node of the national emergency mapping guarantee detachment, the node of the national emergency mapping provincial and regional resource sharing node and the node of the national emergency mapping on-site remote sensing resource sharing node.

The national master node of the sharing platform is deployed in the National Geomatics Center of China, which is responsible for the management, release, transmission and operation and maintenance of national emergency mapping resources, the reception of data from the front site, as well as the coordination and invocation of data from national emergency mapping resources. The national emergency mapping provincial and regional resource sharing nodes are deployed in each provincial mapping and geographic information department, responsible for the management, release, transmission and operation and maintenance of the provincial and regional emergency mapping resources. The national emergency mapping site remote sensing resource sharing nodes are deployed in the Joint Staff Department, Chinese Academy of Sciences, Ministry of Emergency Management, General Office of the State Council, Ministry of Public Security and other ministries and commissions, responsible for the management and sharing of emergency mapping resources of relevant ministries and commissions, and providing emergency geographic information data services for the General Office of the State Council. The national emergency mapping nodes are deployed in each emergency security detachment and are responsible for the acquisition and sharing of on-site data.

4.2 Data Reserves

The design of data organisation and management should follow: different data storage methods should be adopted according to different data types and data formats; data should be managed in a hierarchical manner, taking into account the level of data products (mapping and remote sensing products, digital terrain products, thematic products, etc.); both levels of data management and data application should be taken into account, with practicality and simplicity as the main principles.

The national emergency geographic information data is divided into image data, vector/raster data, document data and table data. Document data mainly includes quality inspection reports, calibration documents, etc., which are stored in the form of system files and managed in the form of cataloguing; table data mainly refers to all kinds of auxiliary data, and table data belonging to data products are stored in the form of system files. Both storage modes are managed by cataloguing.

Data storage is divided into an online, nearline and offline multi-level system with off-site backups and follows an appropriate data storage strategy.

4.3 Data Update

To achieve synchronous update of emergency geographic information data of provincial nodes with the national emergency geographic information basic base map database and the basic database of frontline emergency services of the mobile workcube.

4.4 Shared Exchange

The establishment of an emergency data exchange system for different levels and departments to share nodes, including the scope of emergency geographic information data sharing and exchange between different levels and departments, the sharing and exchange methods and mutual authority settings.

4.4.1 User Management: Data sharing with provinces and ministries is done through the national master node, and a unified portal is established to achieve single sign-on and one-stop service. A significant portion of the data shared during emergencies is classified data, and in accordance with the requirements for the provision of national mapping results in emergencies, a green channel is used during emergencies, which can be provided first, but various application acceptance procedures must be completed as required, (Wang *et al*., 2019) so a strict and reliable user rights management system must be established, with all nodes publishing a catalogue of shareable data through the national master node, and logging in through the national master node and setting strict. All nodes publish their shareable data catalogues through the national master node, log in through the national master node and set strict rules for data downloading, defining data scope, access quantity, accuracy, download speed, priority, etc.

4.4.2 Node Control: To achieve the integrated management of the entire national emergency geographic information data resources, it is necessary to unify and control the data resource sharing process of each node, including the control of node access, node deletion, node authority control, and the control of the sharing authority and scope of data resources within the node, etc.

4.4.3 Audit and Monitoring: The shared emergency geographic information data resources contain a large amount of confidential geographic information data. The source and flow of the confidential geographic information data must be tracked and monitored throughout the whole process, and detailed operation logs must be recorded.

4.4.4 Load Balancing: Under the restricted bandwidth of the national e-government intranet network, in addition to measures such as reducing data volume and sharing on demand, the access requests of each shared node are regulated through node access scheduling to achieve load balancing of shared node access networks, thereby realizing efficient network sharing and transmission of emergency mapping resources.

4.5 Copyright Protection

To maintain the copyright of shared data, the scope of sharing should be limited. Emergency data sharing is shared within a certain scope, at a certain time and under certain conditions. (Zhang *et al*., 2017) Through user rights management, the scope of use of emergency data is limited to the emergency period, the units or personnel involved in emergency response, the use in handling emergency events, and not for work unrelated to the emergency.

Encourage the addition of traceable information such as invisible watermarks to emergency geographic information data, and mark the source of the data prominently on emergency security products made by users using the data again. For the use of emergency geographic information data found to be ultra vires or infringing, the user should be promptly reminded of the use of the unit and the shared data use authority level of the unit should be lowered.

4.6 Shared Incentives

In addition to policies to ensure that each node shares emergency geographic information data in a timely manner according to emergency needs, an evaluation and incentive system for data sharing should be established, (Fan *et al*., 2011) and an evaluation system for data content, data quality, data presentability, sharing efficiency, data utilization rate and data contribution rate of each node should be established and corresponding technical means should be used.

5. CONCLUSION

This paper designs a cross-level emergency geographic information data sharing platform and sharing methods, and builds a national emergency geographic information data sharing system with "horizontal interaction and upward and downward linkage" among national, local and departmental levels, and applies it to the actual emergency security work. The next step is to further refine the sharing requirements, optimise the sharing process and improve the sharing mechanism.

Combining blockchain, shared value network and other new technical means, the "tamper-evident and traceable" characteristics of blockchain are used to supervise and evaluate the authorization and final flow of emergency shared data resources at all levels. The consensus algorithm of blockchain and shared service contribution is used to comprehensively evaluate the quantifiable contributions of each sharing node in data resources, computing and storage resources and crowdsourcing volunteers, forming a national emergency geographic information data resource sharing mechanism that takes into account sharing and security, coordinates demand and application, and encourages resource sharing and result services.

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