Computing, Performance and Communication Systems (2022)
Clausius Scientific Press, Canada
DOI: 10.23977/cpcs.2022.060109
ISSN 2371-8889 Vol. 6 Num. 1

Research on Cache Strategy Based on Content Priority in Landslide Monitoring and Early Warning

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Keywords: Landslide warning, Cache, Cache replacement, Content priority, Queuing theory

Abstract: Landslide monitoring and early warning are mostly multi-element monitoring, and each monitoring element has different impact factors on the landslide. If multiple monitoring elements change next to each other, a variety of high-frequency data are transmitted together, and the data transmission is simply carried out according to the transmission time, it will lead to low analysis efficiency and even deadlock. In order to solve this problem, considering the influence factor size of landslide monitoring elements, this paper introduces a caching strategy based on content priority. Firstly, the content priority is divided according to the influence factor size of monitoring elements, and then the content priority is used as the reference factor for cache replacement decision-making. The goal is to improve the hit rate and availability of important content. The simulation results of ndnsim show that this strategy can significantly improve the cache proportion of important content and improve the availability of important content without affecting the global hit rate and response delay, so as to improve the sensitivity and accuracy of landslide monitoring and early warning system.

1. Introduction

In the research of landslide monitoring and early warning system, the detection instruments and monitoring technology have gradually developed from the previous single factor monitoring to comprehensive, systematic and three-dimensional monitoring. However, the optimization of the early warning process of the early warning system itself is rarely involved. The early warning technology of multi-source data cooperation is the development direction of landslide monitoring and early warning system in the future, therefore, it is of great significance to improve the timeliness and accuracy of multi-source high-frequency data transmission. Considering the influence factor size of landslide monitoring elements, this paper introduces a cache strategy based on content priority. Firstly, the priority of content is divided according to the influence factor size of monitoring elements, and then the priority of content is used as the reference factor for cache replacement decision, which improves the hit rate and availability of important content, So as to improve the sensitivity and accuracy of landslide monitoring and early warning system.

2. Related Work

Landslide disaster monitoring and early warning research includes single monitoring, fusion monitoring and essential monitoring. For single monitoring methods, there are bolt (cable) based mechanical monitoring methods, crack meter, GPS, image measurement technology, radar and satellite remote sensing. For fusion monitoring methods, such as ground interference radar (GBIR) monitoring, GPS displacement monitoring, CR-InSAR and GPS technology [1], in this way, the problems caused by the simple use of a single technology can be solved. For the essential monitoring and early warning method, the constant resistance large deformation anchor cable with negative Poisson's ratio effect is developed, the landslide related experimental equipment and instruments are completed, and the early warning of the whole process of landslide disaster is realized.

According to the existing literature, at present, most of them are the Optimization Research on the detection instruments and monitoring technology of landslide monitoring and early warning system, and less is involved in the optimization of the early warning process of the monitoring and early warning system itself [2]. When the detection instruments and monitoring technology have been developed, it is of great significance to optimize the early warning process. At present, the data transmission of landslide disaster monitoring and early warning is simply carried out according to the transmission time, which is still applicable to a single or a small number of monitoring elements, but it is not applicable to the early warning technology of multi-source data collaboration. Considering that if multiple monitoring elements change next to each other, a variety of high-frequency data are transmitted together, and the data transmission is simply carried out according to the transmission time, In order to solve this situation, the early warning process of the system itself is optimized and the cache mechanism is introduced. Therefore, how to effectively ensure the availability of data, improve the hit rate of higher priority content, improve the response speed of requests and reduce data redundancy in the process of high-frequency transmission of multi-source data, It is a key problem in the research of data caching mechanism of early warning system.

Considering the limited cache capacity, unlike the wired environment, which can expand the larger cache capacity, the research on cache replacement strategy is particularly important. At present, cache replacement strategies mainly include first in first out (FIFO), least recently used (LRU) and least frequently used (LFU) [4]. These strategies do not consider the characteristics of the content itself, such as content priority, content access frequency, etc. [5]. Therefore, they are not the most suitable for landslide early warning system. In this paper, a content priority cache replacement strategy is proposed based on the information conveyed by the content itself, such as content priority, content access frequency and so on. The purpose of this scheme is to improve the cache hit rate of important content without affecting the average cache hit rate, so as to improve the availability of important content. The work of this paper is as follows:

A cache replacement strategy is proposed, which takes the influence factor as the index to formulate the content priority;

By adding a new TLV field “priority” to the packet, a decision function is proposed to replace the cached content;

The simulation is carried out on ndnsim simulator, and the performance of the strategy in this paper is compared with the common cache replacement strategy;

Queue theory is introduced to optimize the cache system to further reduce the packet loss rate.

3. Cache Replacement Strategy Based on Content Priority

An effective cache replacement strategy can improve the cache hit rate and improve the performance of content distribution. The existing cache only considers the time sequence of the content [7], and ignores the priority of the content itself, which will reduce the availability of important content. In view of the above situation, a cache replacement strategy based on the priority of the content and taking into account the request frequency of the content is proposed. Cache replacement strategy based on content priority. Firstly, the priority of the content is divided according to the influence factor of the landslide monitoring point, and then the priority of the content is used as the reference factor for cache replacement decision-making [8], with the goal of improving the hit rate and availability of important content.

3.1 Buffer Mechanism of Geological Disaster Monitoring and Early Warning System

The communication model of geological disaster monitoring and early warning is driven by the main control unit, which sends instruction packets to request corresponding data packets. After a node receives an instruction packet, if there is an exact match in its data cache DS (date store), the node will return the packet. Otherwise, the node will return the data packet of fuzzy matching (the influence factor is less than the maximum value of the instruction influence factor) until the exact matching is satisfied. At the same time, the node can store the data in the DS according to the appropriate cache decision scheme. If the DS reaches its maximum capacity, the DS will be replaced according to the cache replacement policy.

3.2 Content Availability and Priority

For the geological disaster monitoring and early warning system, the availability of content refers to whether it can respond to the request of the main control unit and achieve the effect of early warning after the failure of some nodes in the network. Due to the complexity of the environment, nodes may often leave the network. If the node caches important content, it may lead to the unavailability of important content. Therefore, availability is no less important for geological disaster monitoring and early warning system than hit rate, response delay and other indicators [9]. The conventional way to ensure availability is to keep multiple copies of the content, which is based on a large enough cache capacity. In mobile scenarios, large cache means reduced mobility. Therefore, high availability needs to be combined with cache replacement strategy. We can't improve the availability of all content, so our goal is to improve the availability of important content. According to the availability requirements of the content produced by the node, we divide the priority of the content. That is, if a content is very important and needs high availability in the network, its priority will be the corresponding high point. In our model, we distinguish the priority of content by adding a new TLV field “priority” to the packet. The greater the value of priority, the higher the priority of content [10].

3.3 Cache Replacement Policy

Table 1 symbol description

$P(k)$:Indicates the priority of the content k
$F(k)$:Indicates the request frequency of content K in the current DS
$S(k)$:Represents the size of the content K
C_f :Normalized coefficient of $F(k)$
C_s :Normalized coefficient of $S(k)$

Next, we analyze which parameters should be included in the decision function of cache replacement. Firstly, according to the previous description, content priority must be considered; Secondly, we expect that the introduction of content priority will not have much impact on the global average hit rate. If only the priority is considered, it is bound to have some impact on the global performance. Some monitoring data with large change rate may be replaced because it is not marked as important. Therefore, we want to introduce the request frequency of the node [11]. The request frequency measures the number of times the content is requested in the DS of the current node. To some extent, the request frequency can reflect whether a content is a content with a large change rate. If it is a content with a large change rate, the request frequency of the content will be relatively large, and vice versa. In addition, considering the limitation of node cache capacity, the size of content should also be used as a measure. According to the above analysis, we need to calculate a function such as formula (1) for each content reaching ds:

$$R(k) = P(k) \times \frac{C_f F(k)}{C_s S(k)} \tag{1}$$

However, by carefully observing the formula, it can be found that it increases linearly. When the same content K is requested many times, it may become very large. However, if the content K is requested in the next period of time, it will always be cached in the DS, because there is no large to replace it. In order to solve this problem, we take the generation cycle of content into account in the replacement strategy. Every time a new content arrives, DS will detect whether any content in the cache is expired. If so, delete the content to free up cache space. The pseudo code of cache replacement strategy based on content priority is shown in Table 1. When a content K reaches the DS, it will first check whether the content is already in the cache. If it is already cached, the value will be updated. Otherwise, check whether the cache space is full. If the cache is not full, cache the content. If the cache is full, calculate the value and compare it with the R value of other contents of DS to eliminate the content with the smallest r value. Finally, empty the expired content.

Table 2 Cache Replacement Strategy Based on Content Priority

Algorithm:
1: while incoming data D(k) reach DS do
2: if Cache hit for D(k) then
3: Update R(k)
4: else if DS has enough space for D(k)
5: Cache the data D(k) in DS
6: else if $R(k) \leq \min\{R(j), j \in DS\}$
7: No replacement happens
8: else
9: Find $\min_j\{R(j)\}$
10: Replace data D(k) with D(j)
11: end if
12: Discard the data which out of time
13: end while

4. Distributed Scheme

(1) Elimination algorithm: basically FIFO (first in first out), and content priority is adopted for special nodes.

(2) Expiration policy: TTI (time to idle)

(3) Cache policy: cache side

Cache side is the most commonly used cache strategy. Under this strategy, the application will communicate with the cache and data source, and the application will check the cache before hitting the data source.

Systems using cache side policy can resist cache failure to a certain extent. If the cache service fails, the system can still operate through direct access to the database.

5. Conclusion

This paper studies the cache replacement strategy of landslide monitoring and early warning system, and proposes a cache replacement strategy based on content priority, which can improve the cache hit rate of important content without affecting the global average hit rate, so as to improve the availability of important content. For landslide monitoring and early warning system, it not only improves the early warning performance, including the hit rate, Response time also improves the availability of important content. At present, this paper simply prioritizes the content, and then determines the priority of the content through a more accurate method. The specific way is to determine the priority of the content based on the expected value of the content through the game between the producer nodes, so as to be closer to the actual production and life, so as to make our proposed strategy more reliable

References

[1] Yulin Bao and Quan Zheng. "Research on cache joint deployment strategy based on deep learning training platform." electronic technique 50.07(2021):61-67. doi:CNKI:SUN:DZJS.0.2021-07-022.

[2] Xian Zhou, et al. "Research on file block cache strategy of D2D cluster based on auxiliary equipment." Journal of South China Normal University (NATURAL SCIENCE EDITION) 53.03 (2021):106-112. doi: CNKI:SUN:HNSF.0.2021-03-014.

[3] Huan Zhang, Fan Jiang and Changyin Sun. "Cooperative content caching strategy based on Q-Learning in fog wireless access network" signal processing .
[4] Lanhua Luo, Shudan Yuan and Qiaoping He. "An ICN Cooperative Cache Strategy Based on node centrality approximation algorithm." Computer and modernization .04(2021):85-90+97. doi:CNKI:SUN:JYXH.0.2021-04-015.
[5] Pan Wenwen, Liu Bei and Song Zhiliang. "Edge Computing-Induced Caching Strategy for National Traditional Sports Video Resources by Considering Unusual Items." International Journal of Distributed Systems and Technologies (IJDST) 12.2(2021): doi:10.4018/IJDST.2021040101.
[6] Bang Tang, et al. "Cache replacement strategy of web proxy server based on Gaussian mixture model." Computer measurement and control 29.02(2021):166-170+175. doi:10.16526/j.cnki.11-4762/tp.2021.02.033.
[7] Xueyan Tian, Mengya Wang and Ershun Pan. "Imperfect maintenance strategy of dual computer system with cache based on Markov decision process." Journal of Shanghai Jiaotong University 55.04(2021):480-488. doi:10.16183/j.cnki.jsjtu.2019.270.
[8] Quan Guocong, et al. "Prefetching and caching for minimizing service costs: Optimal and approximation strategies." Performance Evaluation 145.(2021): doi:10.1016/J.PEVA.2020.102149.
[9] Min Hu, Yuming Chen and Hongcheng Huang. "Edge network caching strategy based on social relationship perception." Computer application research 38.06(2021):1825-1829. doi:10.19734/j.issn.1001-3695.2020.09.0247.
[10] Yachao Xu. Research on cache strategy and wireless resource allocation method in c-ran.2020.Nanjing University of Posts and Telecommunications,MA thesis.
[11] Wang Weiguang, et al. "Caching deployment based on energy efficiency in device-to-device cooperative networks." International Journal of Distributed Sensor Networks 16.12(2020): doi:10.1177/1550147720984659.