Reliability Analysis of Computer Communication Networks Taking into Account Bayesian Network Structure Learning Algorithm

Bixia Wu

{Kengdihg@163.com}

Minbei Vocational and Technical College, Nanping, Fujian, 353000, China

Abstract. With the continuous development of technology and information technology, computer communication networks have also been rapidly enhanced, but the requirements for the reliability and stability of computer communication networks in the process of data transmission have also been gradually increased. Therefore, this paper applies the Bayesian network structure learning algorithm to the process of computer communication network reliability analysis, determines the edges of computer communication network emergence by using the maximum spanning tree algorithm, combined with Bayesian network , which can effectively identify the communication network in the transmission direction, to achieve a multi-objective optimization method for computer communication network under the Bayesian network structure learning algorithm. Finally, the results of example analysis show that the algorithm in this paper can significantly reduce the number and order of independence tests compared with the dependency analysis algorithm, indicating that the algorithm in this paper has better practicality and performance.

Keywords: Bayesian Network Structure Learning Algorithm, Computer Communication Networks, Multi-objective Optimization, Reliability

1 Introduction

The continuous development of computer networks has led to the gradual expansion of the scale of internet networks, but it has also led to the expansion of network link capacity, which also requires higher stability for computer wireless communication networks[1]. In recent years, there has been a gradual increase in the analysis and research on the stability of computer networks in China, and certain achievements and breakthroughs have been made[2]. However, in the actual use process, there is still a certain gap in the expected goals of computer wireless network communication, especially when the computer information network malfunctions, the damage caused will be difficult to remedy[3]. Relatively few studies on the stability of computer wireless communication networks based on intelligent algorithms, most of which mainly focus on the use of a single network communication transformed into a series structure, and traditionally network optimization mainly looks at network cost

ICSETPSD 2023, November 17-18, Coimbatore, India

DOI 10.4108/eai.17-11-2023.2342616

minimization as the loss arising from constraints[4]. Data mining within the communication domain using Bayesian networks has also gradually become a research focus in recent years[5]. However, the NP-Hard problem is optimized using learning Bayesian networks within large-scale databases. Therefore, the structure learning algorithms of Bayesian networks with usability in the present are mainly derived from heuristic learning methods[6]. Dependency analysis-based structure learning algorithms depend on the number and order of independence tests that can be completed under the conditions[7]. Dependency analysis structure learning algorithms perform deterministic cut-set analysis by testing redundant edges in order to determine the direction of the edges in the absence of deterministic edges[8]. Ultimately, it will lead to the calculation of the amount of high-dimensional conditional probabilities, which to some extent seriously affects the performance of the algorithm[9].

In this paper, Applying Bayesian network structure learning algorithms to stability analysis of computer wireless communication networks, which can significantly reduce the number and order of conditional independence tests and improve the efficiency of fault repair and the stability of the communication process by allowing the determination of all hidden trouble points before the redundant edge test[10-11].

2 Bayesian Network Structure Learning Algorithm

By representing the network topology using a weighted undirected graph G=(V,E), using V and E are used in turn to represent the set of network binding points and the set of edges of the Internet communication links. |V| and |E| are used to represent the number of nodes and edges under G, the edge $e_{ij}=\left(v_i,v_j\right)$ of the weighted undirected graph is used to indicate that node v_i which can satisfy the link that achieves v_j, assuming that in $e_{ij}=0$, then it can indicate that the link is not available. c represents the cost matrix of the network link at the node of the computer communication network, and c_{ij} represents the cost link between two nodes near i,j. Then the cost matrix can be expressed as follows.

$$C=\begin{bmatrix} c_{11} & \cdots & c_{1n} \\ \vdots & \cdots & \vdots \\ c_{m1} & \cdots & c_{mn} \end{bmatrix},\left(1\le i\le m,1\le j\le n\right) \tag{1}$$

This expression uses R to represent the corresponding stability matrix between nodes in a computer wireless communication network, and r_{ij} represents the link reliability between two adjacent nodes in i and j. Then for the communication network the reliability matrix is expressed as:

$$R=\begin{bmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \cdots & \vdots \\ r_{m1} & \cdots & r_{mn} \end{bmatrix},\left(1\le i\le m,1\le j\le n\right) \tag{2}$$

According to the expression weighted undirected graph G within different nodes and links, all can use the metric to represent their state, then the corresponding communication network e_{ij} state by the communication network propagation when the reliability can be expressed as $delay\left(e_{ij}\right)$, $E\rightarrow R_{+}$, communication network cost can be used as X3 $cost\left(e_{ij}\right)$: $E\rightarrow R_{+}$ then the communication network reliability can be expressed by $rel\left(e_{ij}\right):E\rightarrow R^{+}$ 3 metric. Also combining the communication volume matrix between the nodes, the values that can be obtained for the link capacity, the communication cost expression and the reliability of the nodes, the probability expression that can be used is:

$$\begin{cases} Gen\_sat\left(G\right)=W_{c}Sat\_\cos t\left(G\right)+ \\ W_{d}Sat\_delay\left(G\right)+W_{r}Sat\_rel\left(G\right) \\ Sat\_\cos t\left(G\right)=g\left(Z\left(G\right)\right) \\ Sat\_delay\left(G\right)=h\left(D\left(G\right)\right) \\ d_{i}a_{ij}\le\alpha \\ \sum_{j=1,j\ne i}^{N} g_{ij}\ge\beta \end{cases} \tag{3}$$

Computer communication network reliability analysis, using diversity and accuracy for definition, comprehensive assessment in order to complete the computer communication network reliability analysis selectivity, through in computer communication network reliability analysis through in the search space particle swarm composition computer communication network reliability analysis composition, the corresponding computer communication network reliability analysis data information feature vector χ_{i} is expressed as follows:

$$l_{\varepsilon}\left(g\right)=\left(1-\rho\right)l_{\varepsilon}\left(g-1\right)+\gamma f\left(\chi_{i}\left(g\right)\right) \tag{4}$$

In the above expression, f denotes the adaptive function corresponding to the feature data feature vector χ_{i} of the computer communication network reliability analysis. $\gamma\chi_i(g)$ denotes the εth quick fix corresponding to the computer communication network reliability analysis in the practical application process.

The expression for the quick fix π_p in the computer communication network reliability analysis II is:

$$Acu(\pi_p) = NMI(\pi_p, \pi^*) \tag{5}$$

Bayesian networks can be used to represent the probabilities among the variables in the formula, and the corresponding reliability can be used as a knowledge base using the standard combined probability distribution[12-13]. Based on the independence and conditional independence that exists among the variables within the communication network structure, the combined probability distribution is transformed into a product of local distributions using Bayesian networks, with the expression:

$$P(V) = \prod_{i=1}^{n} P(X_i | Par(X_i)) \tag{6}$$

Where V in the expression denotes the set of network nodes $\{X_1, X_2, \cdots, X_n\}$, $Par(X_i)$ denotes the set of parent nodes of node X3. The learning algorithm using Bayesian network structure is an effective combination of dependency analysis learning method and dependency scoring-search learning method.

The length of the computer communication network structure is mainly used to represent the complexity of the network structure, and the data expression length can be used to evaluate the similarity between the candidate model and the true model. The network structure description length expression is.

$$\sum_{i=1}^{n}\left[|Par(X_i)| \log_2(n) + d(r_i - 1) \prod_{X_j \in Par(X_i)} r_j \right] \tag{7}$$

Where, $Par(X_i)$ is used to denote the set of parent nodes of X_i and d is used as a constant in the expression, corresponding to the storage unit required for each variable value within the storage. The data description length expression is:

$$\sum_{i=1}^{n} \sum_{X_r, Par(X_i)} M(X_i, Par(X_i)) \log_2 \frac{M(Par(X_i))}{M(X_i, Par(X_i))} \tag{8}$$

Where $M(\bullet)$ can be used to indicate the frequency of occurrence of each variable in the brackets within the constructed database. The specific expression of the form is.

$$MDL(G)=\sum_{i=1}^{n}MDL\left(X_i,Par\left(X_i\right)\right) \tag{9}$$

If there is less information shared with the base cluster of computer communication network reliability analysis, the accuracy of that base cluster is lower. Otherwise, vice versa. Based on the characteristics of accuracy and diversity of clusters for computer communication network reliability analysis, the comprehensive evaluation criteria for defining clusters based on computer communication network reliability analysis are expressed to include[14].

$$Eval\left(\pi_p\right)=\lambda Acu\left(\pi_p\right)+\left(1-\lambda\right)Div\left(\pi_p\right) \tag{10}$$

In equation $\lambda\in[0,1]$, the correctness and diversity of Stability Analysis of Computer Wireless Communication Networks important degrees in the comprehensive assessment criteria.

3 Experiment and Result Analysis

By using the algorithm of this paper In the stability analysis process of computer wireless communication networks the time complexity of the algorithm used within phases I and III can be expressed using $O\left(n^2\right)$, but in phase II of the reliability analysis, the corresponding time complexity is expressed using $O\left(k^2n^2\right)$, and the initial length of C is calculated under the conditional independence test $I\left(X_i,X_j\left|C\right.\right)$ using k. which is the length under the initial set of conditional variables. The time complexity of the function in this paper's algorithm is close to $O\left(n^2\right)$ without accounting for the order of the network nodes, but the time complexity calculated under the use of the Bayesian network structure learning algorithm is at least $O\left(n^4\right)$.

The computational flowchart of the Bayesian network structure learning algorithm and the design process can be used to achieve an optimal solution for the variables. The experiment will be concluded when the number of test iterations is 100. Using the algorithm proposed In this article the optimal solution this computer communication network, the minimum value of link cost of computer communication network that can be calculated is 44, then the maximum value of reliability of the algorithm in this paper in computer communication network can be guaranteed to be equal to 0.875, and the corresponding simulation curves of link cost and reliability of computer communication network are shown in Figure 1 and Figure 2.

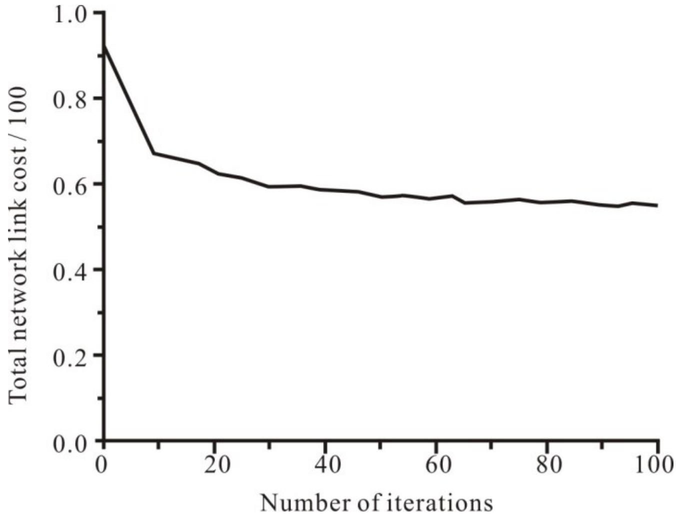

Fig.1 Computer communication network link cost curve

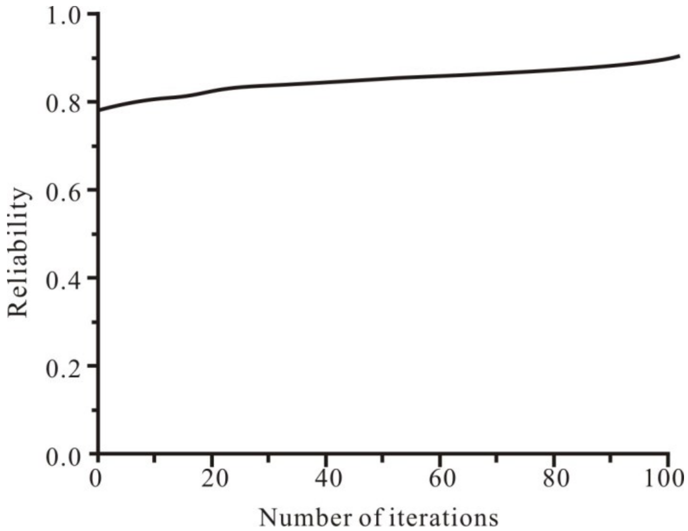

Fig.2 Reliability curve of computer communication network

The performance of the computer communication network can be verified using the Bayesian network structure learning algorithm. 376 nodes and 46 communication networks exist in this computer network. The constructed communication database uses dataset1, dataset2, dataset3 and dataset4 in that order. the size of the calculated values is 3000, 5000, 7000 and 10000 entries in that order. It can be seen from Table 1. Compared with the ISR algorithm, the algorithm in this paper can effectively reduce the number of times that can be tested for independence under different conditions, and according to the test results in Table 1, it can be seen that the algorithm in this paper has higher learning accuracy, which indicates that the algorithm proposed in this paper has plus good time performance and high reliability.

Table 1. Comparison Results of this Paper's Algorithm and ISR Algorithm in Dataset4 Experimental Results

	Stage	Experimental results within different stages			Number and total of conditional independence tests of each order					
		Total number of communication networks	Number of lost communication networks	Number of redundant communication networks	0	1	2	3	≥4	Total
Algorithms in this paper	I	35	12	2	777	0	0	0	0	666
	II	48	2	5	0	151	77	27	7	262
	IV	44		1	0	26	12	1	1	40
ISR algorithm	I	35	12	2	777	0	0	0	0	666
	II	48	3	5	0	217	133	34	11	395
	III	44	3	1	0	517	304	114	17	952

According to the conclusion in Figure 3, it can be seen that Chtaset1, dataset 2, dataset3 and dataset4 in the construction of the database, in the use of Bayesian network structure on the identified database size, effectively combined with the algorithm running time. According to the test results in Figure 3 it can be derived from the algorithm running time and database size linear relationship that the algorithm of this paper is more suitable for large-scale database.

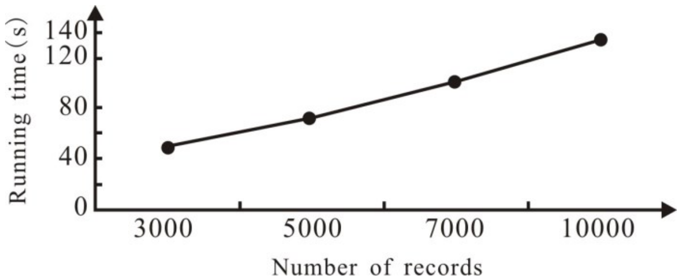

Fig.3 Correspondence between the running time of the algorithm and the database size

4 Conclusions

The Bayesian network structure learning algorithm is mainly based on ensuring the stability of computer wireless communication networks, which can significantly reduce the cost of link media required for wireless network communication. In practical use, it has high theoretical and practical value. In this paper, the Bayesian network structure learning algorithm in computer network communication, in determining the content of redundant communication network detection, combined with the existing Bayesian network algorithm for the dynamic development of communication networks, significantly reduces the number of independence tests and orders, greatly improving the efficiency and reliability of the proposed algorithm. The focus of future research is on how to optimize the algorithm and how to apply the algorithm to computer communication network reliability research topics.

References

[1] Ji, W. (2019). Research on reliability design technology of computer communication network. China Computer & Communication, 10(4), 261-271.

[2] Xiong, Y. (2019). Discussion on reliability design technology of computer communication network. China Computer & Communication., 447, 52-71.

[3] Peethala, D., Kaiser, T., & Vinck, A.(2019). Reliability analysis of centralized radio access networks in non-line-of-sight and line-of-sight scenarios. IEEE Access, 7, 18311-18318.

[4] Jia, H. D., Li, Q., Zhou, G. J., & Zuo, R.(2020). Reliability analysis of highway network in china based on complex network theory. IOP Conference Series: Materials Science and Engineering, 792(1), 1329-1352..

[5] Yan, L., Zhang, T., Gao, Y., Wang, R., & Ding, S.(2021). Reliability analysis of station autonomous computer system based on fuzzy dynamic fault tree and markov model. Engineering Reports, 66(1), 196-224.

[6] Yeh, W. C. (2021). Novel binary addition tree algorithm (bat) for calculating the direct lower-bound of the highly reliable binary-state network reliability, 51(22), 1740-1742..

[7] Liu, B. (2019). Pergamon topological optimization models for communication network with multiple reliability goals, 36(12), 2499-2509..

[8] Ye, J., Dang, S., Shihada, B., & Alouini, M. S.(2020). Space-air-ground integrated networks: outage performance analysis. IEEE Transactions on Wireless Communications, 26(3), 485-489.

[9] Lakhel, N. B., Nasri, O., Adouane, L., & Slama, J.(2020). Controller area network reliability: overview of design challenges and safety related perspectives of future transportation systems. IET Intelligent Transport Systems, 14(7), 1-1.

[10] Xue, W. T., Wang, N., Yang, L. I., Chen, L., Huang, J. H., & Yang, X. L.(2019). Operating performance and situation analysis of power communication network. Computer Engineering & Software,8(3), 65-81..

[11] Jia, G., Zhu, Y., Li, Y., Zhu, Z., & Zhou, L.(2019). Analysis of the effect of the reliability of the nb-iot network on the intelligent system. IEEE Access, 175(3), 139-140.

[12] Maldonado, R., Rosa, C., & Pedersen, K. I.(2020). Latency and reliability analysis of cellular networks in unlicensed spectrum. IEEE Access, 6(3), 8-20.

[13] Benmansour, T., Ahmed, T., Moussaoui, S., & Doukha, Z.(2020). Performance analyses of the ieee 802.15.6 wireless body area network with heterogeneous traffic. Journal of Network and Computer Applications, 163(2), 1-1.

[14] Nethravathi, B., & Kamalesh, V. N.(2020). Fault isolation technique for decentralized survivable communication network systems via regions and paths. Indonesian Journal of Electrical Engineering and Computer Science, 17(1), 1-6.