An Algorithm for Discrete-Time Bayesian Network Applied on C⁴ISR with Standby Gates

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1. Introduction

With the development of science and technology, our society has stepped into an era of information nowadays, as the troops have become more and more intelligent and informational, the C⁴ISR [1] (Command, Control, Communication, Computer, Intelligence, Surveillance, Reconnaissance) system has been framed. The essential way to modernize the military communication system is to ensure the reliable operation of the system and transmit the operational information quickly, smoothly and orderly on the battlefield of information warfare. This paper study the reliability evaluation methods for the C⁴ISR system based on the Discrete-time Bayesian Network (DTBN) [2] theory within complex combat environment. Firstly, we propose to take the communication equipment in the C⁴ISR system as the research object, and construct the equipment reliability evaluation index system and the Dynamic Bayesian Network (DBN) [3] model for the corresponding index. Secondly, we will analysis the topological structure of this system and build the DBN for critical missions and performance requirements. Finally we will evaluate the reliability of the C⁴ISR system quantitatively. In this paper, a new algorithm for DTBN will be provided to solve the reliability evaluation problems faced in the multi-level system as the C⁴ISR.

2. Background

The DTBN is an event-based approach defines that the system will failure at most once during the mission time and cannot be repaired [4]. In the DTBN every root node represents the bottom event in the DFT, and the other nodes (intermediate node and leaf node) represent the logic relationship between their parent nodes. The DTBN divides the mission time T into m intervals, the width of each time interval is $\Delta = T / m$. Each interval represents a state of the system or component, so there are m+1 states. Shown as the Fig.1 When the system or part is in the former m states, it is in a state of failure, and it is reliable when in state *m*+1.

3. Conditional probability for Spare Gates

Spare gates have three types, Warm Spare (WSP), Cold Spare (CSP) and Hot Spare (HSP). The WSP gate defines that the standby node can fail before the primary node, before the standby node working, its hazard rate is reduce by a dormancy factor α, $0 < \alpha < 1$ [5]. When $\alpha = 1$, the WSP gate is equivalent to HSP gate, and it's equivalent to CSP gate when $\alpha = 0$.

4. Case study

In this case, we take the radio station in the C⁴ISR system as the study object. Here is the functional structure and hierarchical structure for the radio station, we divide the function into four levels [6], and as shown in Fig.1, each function has its corresponding device.

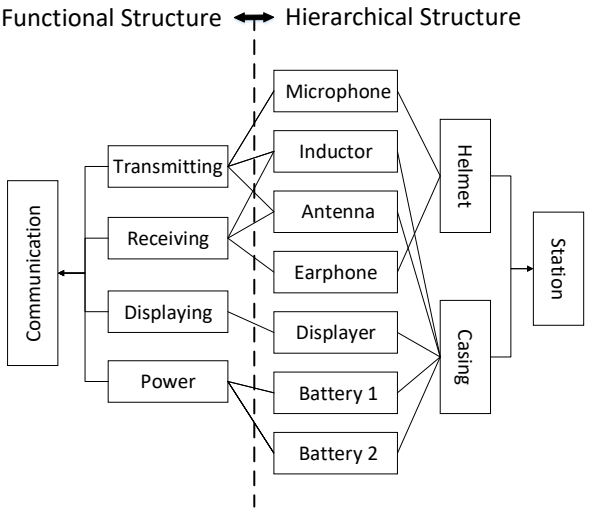

Fig.1 Functional structure

After we analyses the structure of the radio station, we built the DFT for the system, and transform it to DBN [7]. Shown as Fig. 2.

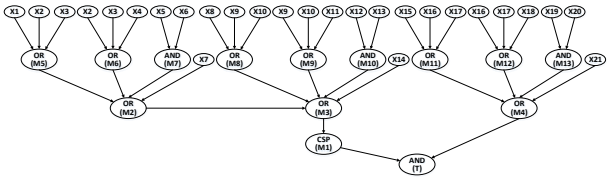

Fig.2 The DBN for the C4ISR

After we built the DBN, we evaluated the reliability for the C4ISR system via the steps shown in Fig. 3.

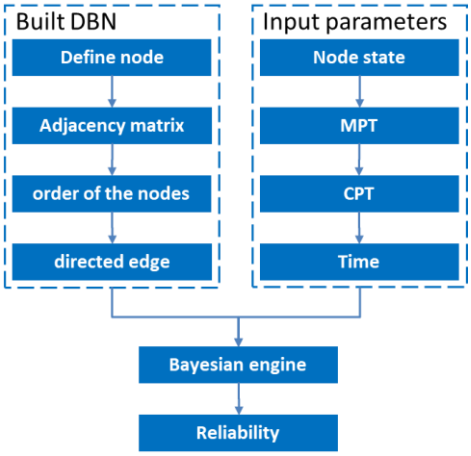

Fig. 3 Evaluate method

5. Conclusion

In this paper, we have introduced the transformation for dynamic fault tree to Bayesian network and the algorithm for the conditional probability table. After that, the dynamic fault tree for the radio station in the C4ISR is established and it is translated into dynamic Bayesian networks. Finally, via discrete time Bayesian network evaluation method, we accurately calculate the reliability for the radio station in the C4ISR.

References

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