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Evaluating the Reliability of Blockchain Based Internet of Things Applications

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***Abstract*—In this paper we describe an evaluation to test the reliability of a blockchain based Internet of Things application using a continuous-time Markov chain model. The factors affecting the reliability in our system include the number of devices, the reliability of individual devices, and the underlying consensus algorithm etc. The effect of some factors on overall system reliability is tested, and we find that the total number of devices has the most significant factor to affect overall system reliability. So that we can improve system reliability according to the affecting factors.**

Keywords—Blockchain based IoT; Reliability; Model checking

I. Introduction

In the present day blockchain technology is becoming increasingly popular for a number of significant applications where there is a need to maintain a secure decentralized ledger of user transactions [1]. These applications include financial services such as online payment and digital currency [2, 3], smart contract systems that preserve privacy [4], networked computer security [5], and secure device communication in Internet of Things (IoT) applications [6]. In each of these applications the security and reliability of the system are significant factors to be considered.

In this paper, we propose the use of a continuous-time Markov chain (CTMC) model and continuous stochastic logic (CSL) to analyze the reliability of a blockchain based IoT. The properties of the model we present are verified using CSL.

The contribution of this paper is to demonstrate the utility of CTMC and CSL to evaluate the reliability of a blockchain based IoT application.

II. Blockchain based edge computing model

For this study we used a BEdge model, which is a type of blockchain based IoT proposed by Sharma et.al. [7]. The main components of this model are a cloud layer, an edge layer and end devices, as shown in Figure 1.

The cloud layer of our model provides a highly -efficient computing service for the whole system including data storage. There is only one cloud service in this model. We do not consider the reliability of cloud service in this study.

The blockchain based edge network consists of a collection of distributed peers including gateways and routers. This layer is responsible for transforming the communication information between end devices and the cloud service, accomplishing the simple computing, and maintaining the ledger via consensus. For the study described in this paper we establish a blockchain network with 7 peers and test the reliability of peers during 2 months. The failure rate of peers is once per month, when failure criteria include power failure, hardware failure, and network down. So, we set the failure rate of peers as once per month.

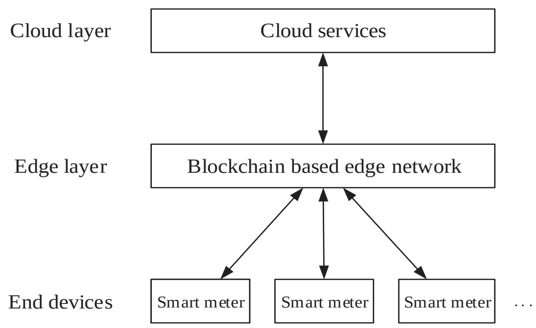

Fig.1. Blockchain based edge computing model.

In this study, where we look at a blockchain network for smart energy transactions, the end-devices layer consists of smart meters which aim to collect data. MTTF (mean time to failure) of single-phase smart meter is greater than or equal to 10 years [8]. We assume that the failure rate of a component is constant λ . MTTF can be defined as described in equation 2.1. Hence, in our further experiments, we set the failure rate of smart meter as once per 10 years.

$$MTTF = \int_0^{\infty} e^{-\lambda t} dt = \frac{1}{\lambda} . \tag{2.1}$$

In this paper, we consider two of the most important factors affecting overall system reliability.

III. Evaluation

The affecting factors will be analyzed in this part. The parameters of each experiment are shown respectively in Table I and II.

In the first experiment to evaluate the reliability of our blockchain model, we adjust the number of edge devices and end devices to evaluate the influence of the device number. The parameters of this experiment are listed in Table I. The

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results of this evaluation are presented in Fig.2 which shows how decreasing the number of devices can improve the reliability in this model.

TABLE I. EXPERIMENT 1 PARAMETERS

Number_ end	rate_end ($year^{-1}$)	Number_ edge	rate_ edge ($month^{-1}$)	T (days)
2	1/10	2	1	60
4	1/10	4	1	
10	1/10	10	1	
30	1/10	30	1	

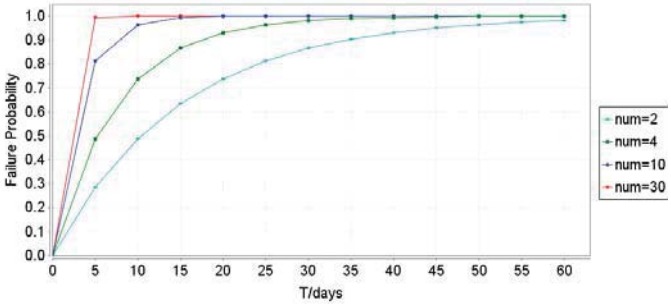

Fig.2. The failure probability up to 60 days when adjusting the number of end devices.

The reliability function R(t) can be written as follows where lambda is a constant representing the failure rate of a component.

$$R(t) = e^{-\lambda t}. \quad (3.1)$$

The corresponding system failure function F(t) can be given as follows.

$$F(t) = 1 - R(t) = 1 - e^{-\lambda t}. \quad (3.2)$$

In this experiment, the peers and end devices can be considered as a series system with multiple independent components, so that the failure rate rises when we increase the number of devices.

Our second experiment involved adjusting the failure rates of edge devices (peers). The parameters of this experiment are shown in Table II. We also check the model performance at regular intervals up to 60 days. Our results are shown in Fig.3.

TABLE II. EXPERIMENT 2 PARAMETER

Number_ end	rate_end ($year^{-1}$)	Number_ edge	rate_ edge ($month^{-1}$)	T (days)
4	1/10	4	1	60
4	1/10	4	1/2	
4	1/10	4	1/3	
4	1/10	4	1/4	

From our experiment we can see that, in Fig.3, the failure probability increases when the failure rate of peer changes from once per 4 months to once per month. Hence, lower failure rate of peer would decrease the failure probability. Another significant result is that, on comparing Fig.2 and Fig.3, we can clearly see that the number of devices is the main factor affecting long term system reliability.

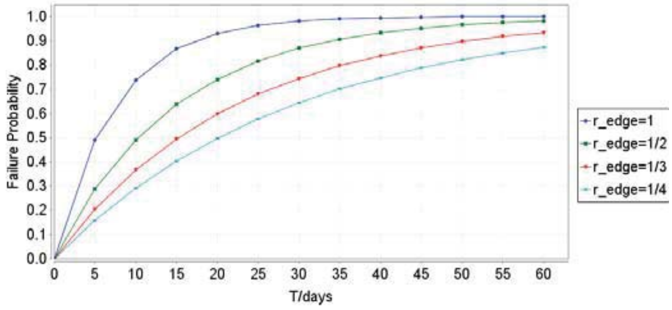

Fig.3. The failure probability up to 60 days when adjusting the failure rates of peers.

IV. CONCLUSION AND FUTURE WORK

In this paper we have designed a CTMC model to evaluate the reliability of a blockchain based edge computing model. Experiment results show that decreasing the number of end and edge devices and decreasing the failure rate of peers will increase the reliability with the number of devices being the principle factor affecting reliability. In future work we plan to consider other factors like underlying consensus algorithm.

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