New Blockchain Adoptation For Automotive Security by Using Systematic Innovation

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***Abstract* — This paper deals with the security matters in automotive by using the Blockchain technology and an innovative thinking skill which has been applied to develop the new prototype design from the initial idea. The Blockchain Governance Game and Fog Computing are adopted to build the new highly secure decentralized service architecture. These relatively new technologies make possible to design the Blockchain based on the automotive security. Although the paper is condensed and does not contain the details, it will be the good guideline for the direction of future research. The thinking skill called Systematic Innovation is the core to solve this problems in the proper Blockchain security network design and well demonstrated in this paper.**

Keywords—Blockchain, automotive service, IoT, warranty, security, authentication, systematic innovation, TRIZ, TIPS.

I. INTRODUCTION

This paper deals with the security matters in automotive by using the Blockchain technology and an innovative thinking skill which has been adopted to develop the new prototype design from the initial idea. One of innovative thinking skill which is called Systematic Innovation [1] is a structured process and a practical toolset for new idea generations and applied to the technical problems. One of techniques in the Systematic Innovation has been applied to make a conceptual solution. Blockchain becomes a strong candidate for solving various problems in the automotive industries. Atypical Blockchain adaptation in the automotive includes supply chain, finance, retail sales and the management of spare parts and warranty [2]. The parts of a car are connected as IoT (Internet-of-Things) and identifying genuine parts of each component becomes vital and these types of technology evolving have faced various security matters in the automotive industries. Blockchain becomes a strong candidate for solving these problems [3-4]. Especially, spare parts and warranty problems are directly related with security matters of cars.

The Blockchain maintains a growing list of blocks which are chained to each other. It is a distributed database and has been proposed by Satoshi as the underlying technology behind the Bitcoin [5]. The Blockchain has been applied in all range of car industries in terms of enhancing the security matters. The process of upgrading the Electronic Control Units (ECU) in a vehicle and the process of fixing a bug in the software installed in ECUs are considered as the security matters. Current security architectures are centralized software updates and these architectures do not address the privacy issues. But software upgrade based on the Blockchain architecture could be applied while maintaining the vehicle the owner privacy [6]. Car insurance companies could offer flexible insurance fees of cars for their customers and a car company could evaluates the driving behavior using data collected from a vehicles. These data could be secured by the decentralized networks (i.e., Blockchain network). Car sharing companies could also adapts the Blockchain technology because of enhancing similar security matters [6]. The number of electric vehicles is constantly growing and all components in a car are connected with smart devices including smartphones and smart home. Again, these kind connection requires high secured architectures and the Blockchain could be one of strong candidates. The owners of home (or cars) could determine the information sharing to protect his privacy when the novel services are enabled for enhancing the smart home (or vehicle) and its functionality. Blockchain based charging service (i.e., Blockcharge) could be used in platforms to pay the charging fees [7].

Many automobile manufacturers concern that false service centers are fitting counterfeit spare parts to their vehicles of customers [8]. The brand reputation could be damaged by counterfeit parts when these parts become a causes of accidents. Even a Blockchain enabled system which means that all IoT sensors, smart devices and service centers are connected makes the car manufacturer and the customer to enable trace the provenance of spare parts back through every step in the supply chain including the information of its original manufacture date and location. But it would be still difficult if a warranty claim has been made against a genuine part in grey market. In addition, most automotive manufacturers are not able to uniquely identify every part in every car sold they need to issue the recall for a specific model and model year. Using another type of Blockchain system in this paper shall make it easy for the warranty team to identify counterfeits quickly [8].

The one of major strength of Blockchain is the decentralized peer-to-peer network and it eliminates a number of security risks that come with data being held centrally [9]. A vital concern in the decentralized network including the Blockchain network is the prevention of the 51 percent attack [9-10]. Decentralized consensus has been claimed with a

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blockchain and we have observed the intensive attacks which are dedicated for decentralized networks.

This research deals with solving the problems for authentication of genuine parts of a cars by using the Blockchain technology. It includes the design development by using one of the Systematic Innovation methods to generate the conceptual solution and also shows the process how the conceptual solution could become an actual prototype solution. The brief summary of the prototype solution by using the Blockchain Governance Game (BGG) is explained after the conceptual design section [9].

II. Conceptual Design By Using Systematic Innovation

The Systematic Innovation tools have been widely used for technical breakthrough and system improvements. Altshuller who is the founder of TRIZ (Theory of Inventive Problem Solving) and his colleagues have studied for identifying 76 standard solutions [1] to improve problematic Su-Field models based on the massive research of existing patents. The Substance-Field (Su-Field) model is designed for analyze the problems related existing technological systems [11] and this analysis is designed for making the complex problems to the form of analytic model which is related to the existing technical system. In other words, the Enhanced Su-Field model makes possible to identify problems in the view point of a technical system and to find innovative solutions to these identified problems [11].

A. Enhanced Su-Field Model

The Enhanced Su-Field model has been introduced and it has been widely applied in the various area [12]. The notation of the model gives the intuitive descriptions of a problem and a solution at once. The conceptual descriptions are based on the Inventive Standards in the conventional TRIZ method. The notation of the Enhanced Su-Field model comes from the queuing model notations and these could describe all types of queuing model. Users who know the rules of the notations would understand the characteristics of the queuing model almost instantly when they see the notation [12]. The notions of the Enhanced Su-Field model has designed not only to cover most of all 76 Inventive Standards but also for someone who does not have the knowledge of the Inventive Standard solutions. Atypical user could recognize the problems and candidate solutions intuitively by using the Enhanced Su-Field model by itself (see Fig. 1).

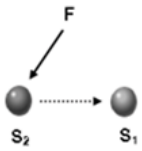
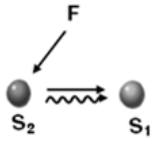
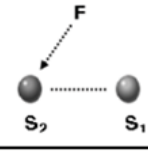
Problem Type	Su-Field Diagram	Solution Guideline
1 (1/S/F)		Enhancing the useful action
2 (2/S/F)		Removing the hamful action
4 (4/S/F)		Mesurement (Same as Group 4 in 76 inventive standards)

Fig. 1. Types of the Problems based on the Su-Field Notation [12]

The basic structure of the Enhanced Su-Field model which is simplified model of the Inventive Standard consists one object (S_1), one tool (S_2) and one field (F) The basic structure could be described as follows:

$$x / s / f\{/0\},\ x = 1,2,4 \tag{1}$$

where x is the problem (or solution) type. The problems in the 76 Inventive Standards could categorized as three types in the Enhanced Su-Field Model. Similarly, the Inventive Standard solutions based on Su-Field notations can be summarized as follows [12]:

$$x/S^{\{y\}}/F^{\{z\}} \rightarrow \begin{cases} 1/S^{\{*\}}/F^{\{*\}}, & x=1, \\ 2/S^{\{*\}}/F^{\{*\}}, & x=2, \\ 4/S^{\{*\}}/F^{\{*\}}, & x=4 \end{cases} \tag{2}$$

The formula (2) is the most abstracted conceptual solutions [12] which gives a brief description but it covers all of Inventive Solutions (Group 1-4). The conceptual solution based on the Enhanced Su-Field model could be not only applied in conventional engineering problems but also flexibly applied in problems of technologies and business.

B. Enhanced Su-Field Model based Conceptual Solution

As it mentioned, the problem in this paper is about improving genuine parts [8]. The problem could be scope down how to generate and store the genuine identification number of each automotive parts. This problem could be categorized into the Type-2 problem and the typical solution for the Type-2 problem is as follows [12]:

$$2/S/F/\{0\} \rightarrow \begin{cases} 2/S^*/F, & S^* = \{S^+, S^n, S^\infty\}, \\ 2/S/F^*, & \\ 2/S/F/a, & 0 < a \leq 1, \end{cases} \quad (3)$$

where the substances S^* and the fields F^* are the optimal attributes for solving the problem. The proposed solution for this particular problem about tracing the genuine part is as follows:

$$2/S/F \rightarrow 2/S^n/F \quad (4)$$

by adding some substances. It indicates that the candidate solution is adding additional factors conceptually. The new idea to compromise the counterfeit problem could be initiated by the Enhanced Su-Field model. The details of the candidate solution will be described on the Section III as the prototyping.

III. Prototyping

This paper tackles the major issues for designing a Blockchain based automotive service that particularly related with handling the geniality of car parts. Two most recent technologies which are the BGG and the Fog Computing are adopted for solving this problem. This section provides the details of both technologies and give the guideline how these could be adopted to build the highly secure decentralized network.

A. Blockchain Governance Game

The Blockchain Governance Game (BGG) is a stochastic game model with the fluctuation and the mixed game strategies for analyzing the network to provide the decision making moment to take the preliminary security actions. This mathematical model could be formulated as the theorem which has been proved by the author [9] and it predicts the moment of one step before the 51 percent attack. The important factors including the marginal means for the number of attackers and the moment of the prior time when it exceeds more than half of total nodes. The portion of the reserved nodes will be the factor of changing the cost function.

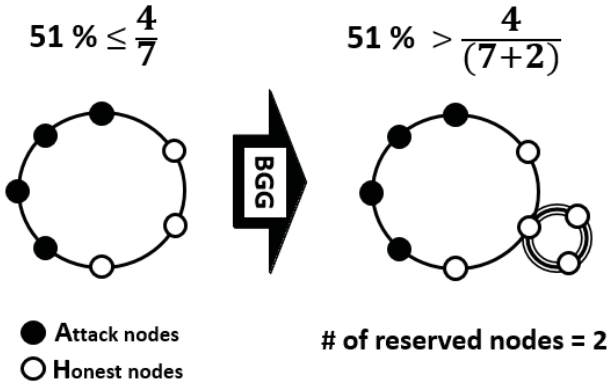


Fig. 2. Blockchain Network based on BGG [10]

This game model is targeted to prevent the 51 percent attack and keeps the network decentralized. The defender only manages the small percentage of nodes which are released prior the attack is happened (Fig. 2). The results are given as a joint functional which gives the predicted time of two players when the first observed threshold is crossing the half of the total nodes along with values of each component upon this time.

B. Fog and Edge Computing

Fog computing is closed to end users and bigger geographical distribution. Fog computing is the terms created by Cisco and it refers to extending cloud computing to the edge of an enterprise network. Its computing facilitates operates for computing, storage, and networking services between end devices and cloud computing data centers. Edge computing is targeted to optimize cloud computing systems by performing data processing at the edge of the network, near the source of the data [13]. Although edge computing is conventionally referred to the location of services, fog computing implies distribution of the services which close to devices and systems in the control of end-users. Fog computing requires a medium weight and intermediate level of computational power. It often serves as a complement to cloud computing rather than a substitute.

Basically, fog computing pushes information to the neighborhood area network amount of community knowledge at a fog node or even an IoT gateway [14]. The fog computing could be combined with the Blockchain technology for enhancing the security matters.

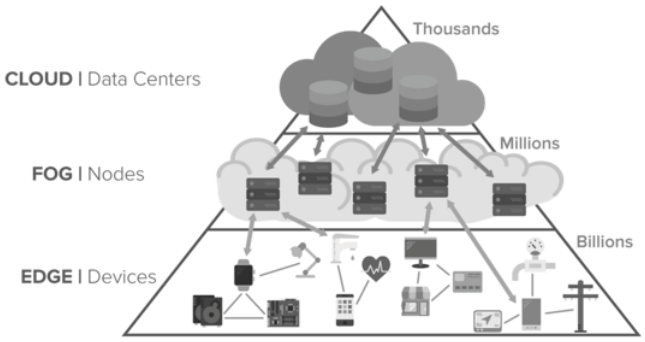


Fig. 3. Fog and Edge Computing [14]

C. Blockchain Connected Smart Automotive Parts

The Blockchain within IoT (i.e., components of a car) is considered for a secure network architecture. It is assumed that the car components in the Blockchain are "smart" which means that each component contains a sensor and capable to connected with other IoT. The car components are connected as the Edge network and the monitoring equipment in car service centers are Fog level (see Fig. 4). Additionally, the database in the headquarter is considered as the cloud network. The components in the car and the equipment of a service center are connected as single Blockchain (see Fig 5).

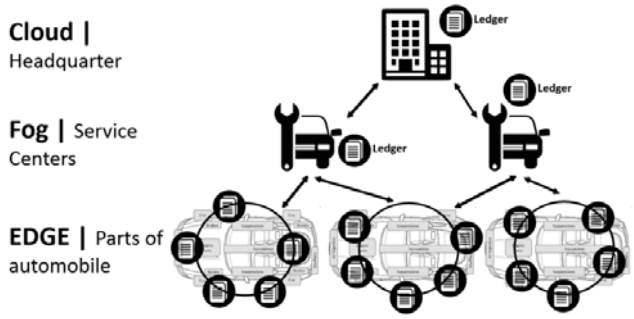


Fig. 4. Edge and Fog Computings in Auto Services by Using Blockchain

Service centers and/or a headquarter have the additional nodes to avoid the 51 percent attack in the Blockchain Governance Game [9-10]. It is noted that another technologies for handling the isolated Blockchain within the Fog computing may be required to design the system.

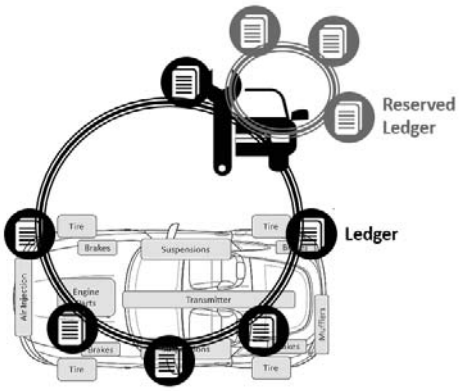


Fig. 5. Adopting BGG for Auto Services in Blockchain

Each car component generates the value based on its mechanical action and the generated value is the transaction value in the Blockchain. The car components and one or more (logical) equipment in a service center are the nodes of the Blockchain. The miner is selected based on VRF (Verifiable Random Function) which could be used for selecting the node for the ledge generation [15] without heavy computational powers. Unlike atypical Blockchain services (i.e., cyber currencies), there is no reward mechanisms in the system rather the VRF has been applied for proper node selection to generate a new ledger. Comparison between Fig. 2 and Fig. 4. shows how the framework of BGG is applied into the Blockchain based automotive services especially handling the genuine car parts.

IV. Conclusion

This paper tackles the major issue for designing a Blockchain based automotive service network. The security perspective provides the Blockchain network protection to avoid the 51 percent attack by using a hybrid stochastic model. In addition, relatively new IoT network is considered for build the new architecture to support the Blockchain network based automotive services. The unique innovative thinking skill has been applied to adopting the Fog computing and the *Blockchain Governance Game* techniques are applied into the automotive services especially for handling genuine car parts. This thinking skill called Systematic Innovation is the core to solve this problems in the proper Blockchain security network design and well demonstrated in this paper.

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