Model Checking Agent using Formal Method for SMS

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ABSTRACT
Most recently, concerns have been raised regarding the trustworthiness of such systems in many areas. The issue is commonly involved in business and telecommunication industries as the area has potential to contribute income in the Malaysia market. However, based on the general survey and users feedback there are still several unexpected errors arise during the processing system. Therefore, the systems that suppose to give industries a sufficient service has lead to the devastating failures. So, as far as we are concerned, this paper is proposing the model checking agent approach using formal method through Short Message Services (SMS) application as an example. The agent that we design is able to play a role in handling the verification of SMS application. The verification process handled by model checking agent will be shown in automata model using model checking method. It is to verify the correctness of the design to follow the required requirement. Model checking method is able to verify the system thoroughly with the safety and liveness properties and it can be done automatically. Hence, this approach can support the SMS application to be efficient, maintainable and verifiable.

Keywords
Model Checking Agent, Multi Agent System (MAS), SMS Application, Formal Method

1. INTRODUCTION
The development of SMS application has made ubiquitous computing become possible in business and telecommunication industries. The SMS application offers a mobile user-oriented computing environment, where users can freely send and receive SMS at anywhere and at any time. It is a technology which introduces fast, mobile and cost saving for people to communicate and interact worldwide. Therefore, mostly many conventional business and telecommunication industries have used the SMS application in their application as it offers great service to the users [1][2][3]. The users easy to gather all the information in mobile-driven environment and system manages to reduce the human intervention and time. Although the performance of services have increased, but the use of SMS application has become one of the concerned issues that needs to discover. Once the traffic volumes increase, the problems of handling an enormous quantity should be look forward. The real-time sent and received messages can cause the system congested and slightly getting slow [4]. Regardless, the system would be unstable and prone to errors in managing all the messages that interact with the system. As a result, the user information of each messages could be loss during the transaction been made. In identifying and determining the errors, local companies have to invest a very high amount of money to maintain the system. Apart of that, we assume that it is significant for the SMS application to be robust and verifiably correct. In addition, the decision-making has to be performed for the system to satisfy the multiple of tasks. In order to do this, dealing with multi agent system (MAS) to handle the SMS verification is one of our aim focuses in this paper. MAS are famous in distributed nature and goal-oriented as they are able to retrieve, filter and summarize the information for solving complicated problems [5]. Therefore, we specifically design a model checking agent in MAS using formal method to analyze and manage the SMS verification in two conditions: one is the existing of invalid format and syntax. The second condition is identifying the invalid byte transmission. We demonstrate the details for each specification in Section 4. Then, we develop the model specification using formal method, model checking approach to ensure the correctness of the design.

The rest of this paper is organized as follows. In the next section, we review some motivations of this work. We showed the methodology of the propose SMS application in Section 3. Section 4 and 5 respectively, showed the experimental results and discussed on the subject matter. Finally, we conclude our paper with a discussion on our further work in Section 6.

2. MOTIVATION
According to [6] there are billions of messages has been sent worldwide and the number is getting increase every year. The trends today everyone used SMS to send and receive messages to retrieve the information in a fast way. It became one of popular communication technology that offers services to mobile devices including PDAs, all type of mobile phones, computers and any other terminals. It is an easy technology that been created in Europe by Global System for Mobile Communications (GSM) (http://www.etsi.org). However, when the SMS is applied in the application of business industry, we have anticipated several issues in the design challenges which are the limitation of the network bandwidth and network resources for communication between the mobile phones users and the system. Although, the SMS is a low cost consume money with high speed services, but somehow the undesirable congestion can probably effect the system management. Therefore, there is a need to introduce a technique that can facilitate the system management with the increasing of verification at the level of process development.

This paper put forward the issues to the developers to take concerned the risk of the system management so that it will be not in the critical condition. The model checking agent approach addresses issues of verification based on the formal modeling and the specification of SMS management system. By focusing the issues of SMS verification, it attempts to formalize the process of
SMS that is send and receive through the system dual. The approach considers both modeling and property verification using the SPIN and linear temporal logic respectively. Therefore, at the end of this paper, the approach aims to:

i. clearly design a model checking agent that is able to do the process of SMS verification process.

ii. convert the design to formal specification using automation analysis of formal method model checking.

iii. provide an alternative solution to solve the possible unseen errors and unprecedented risks caused by the end-users or system in the development process.

3. METHODOLOGY

To have clear view of this paper, we have showed the methodology of the propose approach in Figure 1. At the first level, we have the case study which is the SMS Management System. Then, we enhance the SMS Management System architecture with a multi agent system (MAS) and create the model checking agent to be as a middleware in the system. From the model, we do the specification of the model checking agent to do the verification process. Next, the model of specification will be verified with model checker SPIN. Finally, we do the result analysis.

![Figure 1: The level view of methodology](image)

SMS Management System is one of e-business system that integrates with SMS for multi level marketing (MLM) services [3]. There are four main modules in this system; registration module, selling product, bonus calculation and group SMS for activities sharing. However, this design architecture has been enhanced for greater performance by using the architecture shows in Figure 2. Actually, this paper has identified that the problems can be occurred in SMS Management System is when they are dealing thousands of user sending the messages to a system. The services became slow and the probability of system to receive an invalid data is greater. As a result, the collision between the messages will increase the system errors. Therefore, the proposed of our model checking agent will be suggested to enhance the quality of services to check the correctness of the system design.

![Figure 2: The SMS Management System and the propose architecture](image)

Based on Figure 2, the architecture is enhanced into agent-based system with the role of all agents as the following below:

i. **Input Agent (Ia)**

Input Agent is a user interface in mobile phone has used as a medium for a users to interact with the SMS management system. The Ia will receive the request from user and assist the MCa to get the input from the user.

ii. **Model Checking Agent (MCa)**

The Model Checking Agent role as a manager of the whole system that will check and verify the SMS request whether does it satisfies the system requirement or could be otherwise. The requirement is verify based on the properties that we mentioned before. This process is done in order to ensure the system get a correct and valid message.

iii. **Output Agent (Oa)**

Output Agent will be reacted if the messages successfully verified from the MCa. Then the Oa will accept the messages and sent it to the system server. The status of the user request will automatically send in back propagation to the user for acknowledgment.
iv. **Refine Agent (Ra)**

However, if the messages are identified as failure, the refine agent or Ra will handle to do the refinement of any errors in the user request by sending 'failure status'. It means that the user has to send back their request again for new process. Otherwise, the message will be considered as violated and terminate automatically.

### 3.1 Automata Model

As for process verification, we have designed the automata model. This model shows the clear process for each state that occurred in verification process. In formal method, the automata model is used to formalize the verification process. In format and syntax checking, the MCa is responsible to check and verify the format and syntax once the user (sender) request to send message to a system (receiver). The message can be depends on the application. As for the case study example, it can be the case of input string only or in the syntax of "PUR<UserID>#<ItemID>*<Quantity>#<BankRefNum>". The automata process is shows in Figure 3 to provide a trustworthiness system in SMS Management System.

![Figure 3: The automata of format and syntax checking](image)

In byte transmission checking, MCa is responsible to check the text character length once the user (sender) request to send message to a system (receiver). Basically, the SMS message can contain text or binary data. A single short message can contain up to 160 characters when we use Latin alphabets. 70 characters when non-Latin alphabets such as Arabic and Chinese are used. In this paper, it discussed a scenario that may possible happened if the network busy and has limited bandwidth, then the transmission of messages could be failed to achieve. Therefore, we request to check and verify the correctness of message that send and receive by the user to SMS Management System.

### 3.2 Specification of Model Checking Agent

For properties verification, we have designed the agents to communicate based on the protocol. To confirm the properties such as liveness we have to convert the flow into a linear temporal logic (LTL). The LTL is a mathematical formulae for statements on a linear time [10]. The properties of the linear temporal logic (LTL) is defined as follows:

1. **Y**
2. **B**
3. **E**

#### 4. RESULTS

We showed the result of verifying the model using Spin based on PROMELA translation. When the search depth reached at state 32, the model checker Spin has successfully found an attack to the verification model. The attack needs to verify the three properties as follows: never-claim, assertion violations and acceptance cycles. The result is simulated using XSpin and has been exported in Figure 5.
In XSPIN, errors are displayed in a graphical transition where all the process specified. When an error condition occurs, it generates a trace file used to identify the position that has been attacked by the error. Therefore, we have demonstrated the analysis of the output result using Spin in Figure 6 with the number of depth reached, state and transition explored. However, we also have investigated and analyzed the design to find the reason why the result performs in the simulation. We assume that the source code and specification that we specified from informal language to PROMELA does not perform as well as the automata model that we designed. Therefore, the search process is incomplete.

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5. DISCUSSION
In SMS Management System (case study), our proposed model checking agent will verify the process of SMS transmission based on the property, as mentioned in the previous section. The verification starts at the initial state and try to satisfy the requirement for each . If the model checking agent accepts the requirement of messages, then the is considerably satisfies the system requirement. Otherwise, the model checking agent will need to ask the refine agent to do the refinement process. The process will be repeated until all states are satisfied by the requirements as shows in the Figure 3 and Figure 4.

In the above case, we have tested our model using Spin (http://www.spinroot.com/spin) [8] model checker to verify the system to conforms the requirements. The Spin accepts design specification written in formal language Promela (Process Meta Language) which it is appropriate for complex and distributed systems. This method has assured to prove the correctness of systems using temporal logics to specify the properties [9]. The Spin returns the result in expeditiously when the counterexample shows a quick analysis on how the requirement can be violated. The counterexample analysis of model checking agent of format and syntax checking is shows in the Figure 5. In addition, it has shown that the Spin model checker has found an invalid format failure that violates the requirement format and syntax at state 9. Therefore, the sending message is aborted by model checking agent and must finally be refined back to the user for proceed to other states.

6. CONCLUSION AND FURTHER WORK
Previously, there are many researchers have claimed that model checking is one of good proving method for distributed system. It can allow agents to verify at run-time based on certain requirements [7]. However, in our example, we have presented a mechanism of model checking agent to specify and verify the SMS properties; syntax and format and the number of byte transmission. The verification is done to determine the information in SMS Management System is verifiable and can be trusted. This is, when millions of messages are sent and receive at the lower bandwidth and busy network.

Moreover, we have shown the potential of SMS properties to enhance the SMS verification in SMS Management System to be more efficient and maintainable. Spin provides counterexamples that define sequences of processes that may lead to failure. This study purpose is to give an alternative verification approach to increase the trustworthiness of user towards the distributed SMS application system. Thus, the proposed model checking agent will be one of solution to be as a middle manager in order to overcome the verification issues. As future research, we try to explore the logic and meaning of the related issues by using other model checkers to ensure the effectiveness of SMS application. A comparative performance and empirical testing might also be conducted to support the theories.

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8. REFERENCES


