Research of TTCN-3 Test Method for Protocol Conformance Verification in GSM-R Interoperability Testing

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Abstract: Protocol testing theory is derived from software testing theory. Protocol conformance testing is the foundation of other protocol testing, such as interoperability testing (IOT) and performance testing; it can test the protocol implementation according to its specification to improve the probability of successful intercommunication between two protocols. The ISO/IEC9646 standard described by ISO is the most mature theory in protocol conformance testing theories. In this paper it summarizes and analyzes the theory in the standard combined with the requirement of the GSM-R IOT. The TTCN-3 (Tree and Tabular Combined Notation-3) based on ISO/IEC 9646 standard is adopted to describe test suite of GSM-R protocol, and it introduces Specification and Description Language (SDL) commonly used for the development of test system.

Keywords: protocol conformance testing; TTCN-3; GSM-R; IOT

1. Introduction

The operational experience of European GSM-R has shown that the precondition is the verification of the interoperability of internetworking devices from different manufacturers to achieve a large-scale group of GSM-R network or complete the dispatching communication, or transport train control data and so on. As the foundation of interoperability testing, protocol test consists of conformance testing, interoperability testing and performance testing. In this paper it focuses on the protocol conformance test in GSM-R IOT（Interoperability Testing）. For the protocol conformance test, the formal SDL as a protocol standard description language is adopted to describe the practical testing method and tool implementation according to the standard in order to simplify test model, improve the efficiency of the test and realize the automatic test of part of GSM-R IOT. TTCN has been developed and is maintained by the Methods for Testing and Specification Technical Committee (TC-MTS) at ETSI [1]. This group is composed of leading testing experts from industry and academia as well as members of ETSI's own Centre for Testing & Interoperability (CTI). TTCN-3 was born out of TTCN-2 which had been maintained by the same group. TTCN testing technology has been applied widely and successfully in European industry, ETSI standardization, and certification for more than a decade.

Project supported by State Key Laboratory of Rail Traffic Control and Safety (Grant No RCS2008ZT004) and the National Natural Science Foundation of China and the National Railway Ministry of China (Grant No.60830001)

2. Protocol Conformance Test for GSM-R

The conformance means the agreement of the formal norm and protocol implementation behavior, that is, whether the protocol can meet the requirements of specification or not.

978-1-935068-15-0

Protocol Conformance Testing refers to check whether implementation of testing (IUT) consistent with protocol specification by testing execution activities. [1]. For GSM-R IOT, it not only ensures the implementation of railway special business, but also takes into account both the reliability and safety, there are the following difficulties:

(1)Complexity: There are a great of standards in GSM-R; each standard includes a large number of technical specifications. And there is more or less relation among the technical specifications. Putting into a lot of energy to master the technical standard before designing test suite.

(2)Flexibility: There are many technical standards such as 3GPP in GSM-R, yet which hasn't been examined in practice, so they still have some shortages. 3GPP and 3GPP2 are still trying to perfect their 3G specifications. Because different manufacturers make different protocols, the design of test suite needs to be continually revised and perfected in the test. Only improving the expansibility of test suite can avoid too many modifications.

(3)Synchronicity: The application of GSM-R in Chinese railway is still in its infancy, which determines the synchronicity of the interoperability testing and project construction, and the design of protocol test suite must proceed with the project construction at the same time. Any design of protocol test suite should improve the efficiency of network devices passing the conformance test.

These factors determine GSM-R interoperability testing is a long-term process, therefore, it becomes a valuable problem to realize the automatic test partly and increase the test efficiency for IOT. The research overseas about test automation begins earlier. As the most common method, TTCN-3 has been widely used in various fields of software testing, also well used in communication software test. IOT can be interpreted as an interoperability testing among the software of different equipments to some extent; therefore, TTCN-3 test methods are suitable for GSM-R IOT.

3. Testing Principle of TTCN-3

3.1 TTCN-3 summary

TTCN-3 is a kind of standard language designed by ISO/ITU to illustrate the abstract test suite (ATS), it is recommended as the formal description language of protocol test suite by 3GPP. There are the following advantages of TTCN-3: The representation is easy to understand and learn. It is very convenient and flexible to describe the test suite. It is a description language for ATS, completely independent of any particular system, and can combine with SDL to realize of SDL-TTCN-3, and design the test suite at the same time during developing the communications equipment by the co-simulation.

TTCN-3 designed to describe interactive events between the various entities during the conformance testing, consists of two sections, static description and dynamic behavior description. Its static description section is used to describe the static information of protocol, such as the formats, and parameter values of protocol data unit and abstract service primitives, and so on. And its dynamic behavior description section is used to describe the message receiving and sending, and the associated test decision, timer operation [2]. ISO / IEC 9646-3 mainly defines TTCN-3-GR, the graphical form of TTCN-3, and all the information of TTCN-3-GR is represented in the form of a table. There is also a hidden machine processing format TTCN-3-MP, which is expressed in the extended BNF. TTCN-3-GR makes for easier reading, while TTCN-3-MP can be used to exchange documents between different computers and make a further machine processing of TTCN-3 Test Suite. [3].

3.2 TTCN-3 protocol test model

TTCN-3 test suite consists of four parts: Suite Overview, Declaration Part, Constraints Part and Dynamic Part [4].

The model defines a behavior which is allowed by the protocol entity, according to PDU (protocol data unit) of the Protocol entity and ASP (abstract service primitives). And the behavior of N-layer entity is defined according to (n) ASP and (n-1)ASP. You can implement the observation and control on the behavior among all layers of ASP.

4. Implementation of Conformance Testing for GSM-R

There are six stages for the protocol development

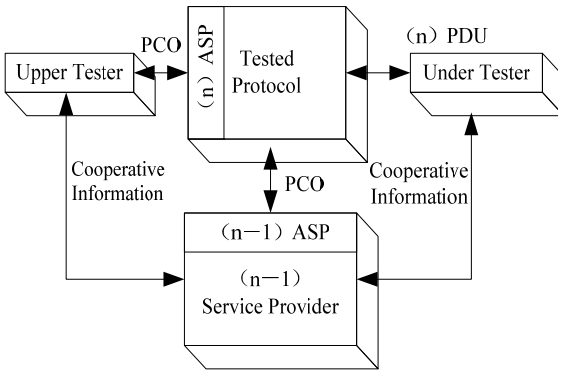

Figure 1. Basic model of protocol conformance testing

process: protocol design, protocol description, protocol verification, protocol performance analysis, protocol implementation, protocol testing and maintenance. Formal model is one of the key technologies in protocol analysis and design. It can realize the formal specification based on the formal model, so as to provide a good basis for the formal analysis and verification for protocols, protocol synthesis, protocol testing and protocol implementtation, also the basis for the formal description language of protocol.

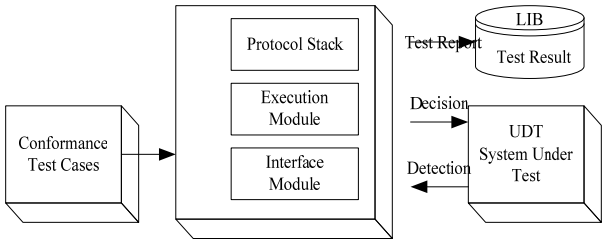

Figure 2. The module of conformance testing system

SDL (Specification and Description Language) is a formal description language defined in the blue book of recommendation Z.100 by ITU-T, and used in specification and description of real-time systems. Specifically it is used to describe the complex event-driven and real-time communication events in object-oriented. It provides the detailed system, data, structure, description of behavior, which makes possible simulation and verification of design. SDL makes use of the concept of the Extended Finite State Machine (EFSM) to describe the object. Large numbers of definition about SDL are expressed by text and graph. In actual application, SDL graphic description is applied, and then converted to C language source code, or CHILL source code by SDL, and finally embedded into the actual development environment [5][6]. Also, SDL adopts multi-layer structure to describe the whole system, which is suitable for the abstract description of GPRS protocol stack. It is ideally suited for describing call processing and protocol process because of such characteristics of SDL. In this paper, it is feasible to use SDL to describe the protocol conformance of GSM-R.

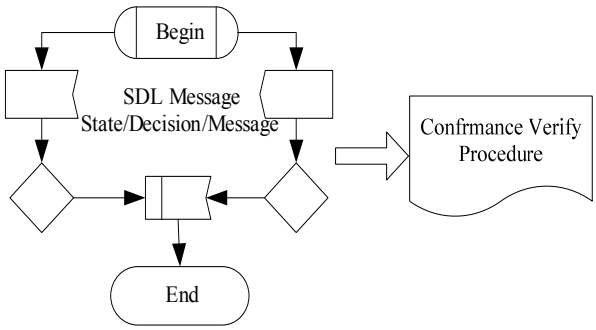

Figure 3. Description of SDL protocol testing

According to the test purposes, corners can test by choosing the interface of IUT and testing environment in order to achieve the goal of testing and verifying IUT[7]. They can also generate Message Sequence Chart (MSC) by combined use of SDL (collaborative simulation), and then observe message sequence and data flow inner IUT and between IUT and environment (testing system) to find errors [8][9][10]. The test step and test case of GSM-R system verification are given in table and table2.

Here we also give an example of the encoding test rules for a signal parameter by defining an ASN.1 (Abstract Syntax Notation.1) module as shown as following. The Translation of the ASN.1 parameterized definition is always too complex to give all detail information, in particular when information objects are involved. At the same time, the conformance test of location updating procedure using ASN.1 types in the SDL could be expressed as[11][12]:

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Table 1.The Test Step of GSM-R Location-Update Procedure

Test step name	Location-Update(Send Identification: Boolean, Update-Location: String)
Description	MS update location successful in new VLR
Label	description, Conformance Verdict
1	Location update Insert Subscriber Data Pass

Table 2.The Test Case of GSM-R Location-Update with Key Component Parameters

Test case name	Location-Update
Configuration	SubscriberDataInsertConfig1
Description	Send Identification and update location
Label	Behaviour description, Conformance Verdict
1	BEGIN(Send Identification)
2	END(Send Identification)
3	BEGIN(Cancel Location)
4	CONTINUE(Insert Subscriber Data)
5	END(Insert Subscriber Data, Update Location)

SIGNAL Subscriber-DataReq(
CellidAddrType,
LocDataType,
Subscriber-Data (ENCODED BY INTEGER),;
The next is an example of SDL specification codes:
Use moduleLocationUp1;
process NetworkRegister;
Data Type Definition
Subscriber-Data-ackmsg IASString,
LocString IASString,
IMSInum Integer,
NetCode Integer,
ConformVerify Boolean;
start;
task Subscriber-Data-ackmsg := (AK, 1, "Send Identification");
task AuthenticationParaGroup1 := subscirberstring!msgData;
task LocString := makeMsg(1,1,'4216');
task ConformVerify := IMSInum!NetCode;
...
nextstate s1;
state s1;
provided true;...
nextstate s1;
state s1;
provided true;
stop;
endprocess NetworkRegister;

By means of the above test method of TTCN-3, it is feasible to find an effective way for realizing test automation. On basis of SDL, protocol conformance testing can prompt and generate the standard protocol testing program as quickly as possible, so as to find if the protocol realization conforms to conformance or not in time. This way will greatly improve the efficiency of GSM-R IOT, and reduce the test cost [13][14].

5. Conclusions

From the above analysis, it can be judged preliminarily that protocol conformance testing based on formal description of SDL can prompt and generate the standard protocol testing program at a faster rate, so as to verify if GSM-R protocols of all manufactures are in agreement with each other. The advantages of formal description includes flexible design, capable to ensure conformance of test description in each layer, and helpful to realize the test automation. This paper mainly discusses the conformance testing method which, however, is also of some reference significance for interoperability testing and performance testing due to the same testing principle.

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978-1-935068-15-0