A Method for Modeling the Virtual Instrument Automatic Test System Based on the Petri Net*

MA Min, CHEN Guang-ju

(School of Automation Engineering, University of Electronic Science and Technology of China, Chengdu 610054, China)

Abstract Virtual instrument is playing an important role in automatic test system. This paper introduces a composition and application of a virtual instrument automatic test system and takes the VXIbus based a test software platform which is developed by CAT lab of the UESTC as an example. Then a method to model this system based on Petri net is proposed. Through this method, we can analyze the test task scheduling to prevent the deadlock or resources conflict. At last, this paper analyzes the feasibility of this method.

Key words virtual instrument; automatic test system; VXIbus; Petri net; model system

Since 1990's, the new testing instrument-virtual instrument’s appearance impels greatly the improvement of testing technologies. Action that most hardware takes on previously in test domain is replaced by software. The idea that “software is also the true instrument” proposed by National Instruments Company in USA changes the situation that test instrument is only defined by the factory but not the consumer. The people begin to recognize that the software frame of virtual instrument is the crucial element that realizes the automation of data sampling and controlling instrument. Virtual instrument is developing rapidly and has become a hot topic in test technology and instrument manufacture domain at home and abroad because of its novelty and the breach of traditional concept. In Refs.[1,2], the applications of virtual instrument in test domain is depicted in detail.

Though the virtual instrument automatic test system (VIATS) has played an important role in the test domain, the performance evaluation and structure optimization to it is a still difficult problem. In this paper, the author firstly introduces the composition and application of VIATS made up with the VXIbus based Test Software Platform that developed by University of Electronic Science and Technology of China (UESTC). Then the author proposes a method to model and analyze ATS in order to study on the static structure and dynamic action of ATS.

1 Composition of VIATS

The core of virtual instrument is to make use of software substituting for hardware to realize some technologies in order to reduce the cost of system’s composition and improve system’s flexibility. So virtual instruments benefit from computer technology. Its exterior characters different from the tradition instruments, the greatest peculiarity of them is called as “software panel”-a virtual panel that consists of graphic environment and helpful function online embedded in computer, but not some physical entities. From characters inside, the complex processor and firmware in intelligent instruments can share the software or hardware resources and realize all the testing functions needed by test instrument by virtue of virtual instrument’s powerful ability to analyze data and process data. So software platform of virtual instrument is considered as the core not hardware.

At the current, some developing tools to virtual instrument like LabView made by NI company and HP VEE by Agilent company have been applied abroad. However, in China only “the VXIbus based Test Software Platform” (VTSP) developed by CAT Lab of UESTC independently fills the blank in this domain[3,4]. This software platform has been applied in many ATS and received much good remark. The composition of the radar receiver in ATS applying the VTSP is shown in Fig.1 and its software panel in VISP is shown Fig.2.

From Fig.2, it can be shown that the testing operators only need to set up the hardware parts of ATS, the users can choose to test the target randomly with software. Moreover, they can arrange the sequence of test tasks by the demand of test. When test begins, the testing operators can control the instruments directly, and observe the testing data and waveform at the same time by the “software panel”. Till the end of test, the test results can be saved in

Received 2004-05-25

* Supported by the Ministry of Education for Ph. D (20030614006)
database or printed by the software platform.

database or printed by the software platform.  

How the software platform does have these functions? It is made up of four layers software. The first is test manager layer. It is a kind of software independent of hardware in order to provide different hierarchy access for the different operators. Its functions include generating test records or reports, accessing the database, communicating data and processing data. The second is functional module layer. It is composed of some software components with universal functions such as data sampling, instrument controlling or instrument interface. The third is instrument driver layer, the very important layer. It is a software layer that can communicate with hardware and manage hardware. In the past, it was written by test developing men, a kind of hardware aimed at a special driver code which made developing period get longer. Now, instrument driver software opens to user independent of hardware. Further more, standard driver programs can repeat to be used. The last layer is I/O interface driver layer. It is mainly used to process the low communication protocol between computer and hardware.

So through the four layers software in virtual instrument, users can operate the computer so that the whole process of test is watched by the friendly graphic interface. It is more convenient, universal and flexible than the tradition test instruments.

Though the composition of VIATS wastes shorter time than the tradition test systems, when the complication of ATS gets more and more deeper, the artificial method to set up the ATS and the method’s validation don’t meet the needs. It is considered too heavy and complicated so that its efficiency is too low, almost cannot be executed. For example, under the sequential task scheduling mode, the ATS only test one product at one time, so the waste time is more than 50%. Therefore, a new method based Petri net will be introduced as follow.

2 Modeling the VIATS Based Petri Net

Petri net theory was proposed in 1962. It is a mathematical representation of systems. Now Petri net has been applied in many domains as a strong modeling tool like artificial intelligence, distributed system, parallel system and communication protocols and so on. So Petri net is also used in ATS to verify the system’s task scheduling or evaluate performance.

Formal definition of a Petri net

A Petri net is a 6-tuple, $PN = (P, T, F, W, K, M)$ where $P = \{p_1, p_2, \ldots, p_n\}$ is a finite set of places, $T = \{t_1, t_2, \ldots, t_n\}$ is a finite set of transitions, $P \cap T = \phi \land P \cup T \neq \phi, F \subseteq (PT) \cup (TP)$ is a set of arcs(flow relation), $W: F \rightarrow \{1, 2, 3, \ldots\}$ is a weight function, $K: P \rightarrow \{1, 2, 3, \ldots\}$ is a capacity function, $M: P \rightarrow \{0, 1, 2, 3, \ldots\}$ is the marking, $M(p) = k$ show there are $k$ tokens in place $p_i$.

As an assumption, there are five tasks in an ATS, every task needs some equipments to accomplish. Then let the transitions set represent the test tasks set, such as equipment initialization, testing frequency or power and so on. The input place set is corresponding to the beginning of test belong to a task, the output place set

![Fig.1 The composition of the radar receiver in ATS](image)

![Fig.2 Interface of this ATS in the VTSP](image)
shows the end of test task; the tokens represent the equipments such as oscillograph and cymometer, which test tasks use. At this time, we can describe the structure of task scheduling of ATS, as shown in Fig.3.

Fig.3 Model of ATS based Petri net

From Fig.3 we can know the sequence of tasks being executed. At first, the task $t_1$, such as system initialization, is executed, then there are two groups of tasks being executed in parallel, one group is test task $t_1$ and $t_4$; another is test task $t_1$ and $t_2$. At the same time, the sum of tokens in places is four in the initial marking $M_0[2 001 001]$. They distribute in $p_1$, $p_4$, $p_7$ respectively and indicate that there are four test equipments ready for this ATS. Every test task needs different instrument, so the four tokens are put in four different places. In this ATS, if the task needs two equipments to complete, the corresponding weight is two in the arc such as test task $t_1$ and $t_2$. Otherwise, the weight is one in default. After one test is completed, the equipments resource represented by tokens will be set free to ready for next test.

The reachability tree is a good tool applied to analyze and verify the Pet net’s performance. Therefore, Fig.4 is the reachability tree of this ATS’s Petri net model from which we can draw some conclusions for this ATS’s task scheduling structure.

1) Boundedness. The tokens included by all places in every marking are not more than four, so this Petri net is bounded. Boundedness reflects the situation that system needs the resource in run. In the design of ATS in practicality, the tokens in Petri net must be less than the capacity of places in any marking which can sure system runs in order without overflow.

2) Liveness. In the reachability tree, every transition fires once at least and no transition does not fire which indicate the Petri net is live based on the definition of liveness that in the reachability set $R(M_0)$, to every $M' (M' \in R(M_0))$, there is a transition path from $M_0$ to $M'$ represented by $\exists \beta: M_0(\beta > M')$. Then it sure the petri net live and deadlock will not take place. The property shows in the system run, every task will be accomplished without missing one.

3) It is also seen that before any transition takes place, the other transitions only took place finite times. Then we can say that the Petri net has fairness, the system has no hunger when the tasks compete in the resources.

4) After all transitions take place, the Petri net reaches the $M_0$ in repeat. It represents the Petri net has the reversibleness. This property is every important to the ATS, because in the ATS, many tasks need repeat test in order to get the most accurate result from plenty of datum. Therefore, the reversibleness makes sure the rotative tests of ATS.

5) From the reachability tree, we can know there are only four tokens in any node, so the Petri net is strictly conservative. It is corresponding to the conservative of the total sum of test equipments in test.

Through the analysis to the reachability tree, the system has the liveness, boundedness, reversibleness and so on. These peculiarities prove the ATS has a sound configuration. Moreover, it has the reliability and stability.

3 Concluding Remarks

The proposed method that models the ATS based on Petri Net can optimize the architecture of system, improve the utilization rate of the test equipment, prevent the deadlock and conflict of resources and make great brief of the compositive course of system.
References


Brief Introduction to Author(s)

MA Min (马敏) is currently a Ph.D. candidate in University of Electronic Science and Technology of China. Her research interests include automatic test systems, formal methods and Petri nets.

CHEN Guang-ju (陈光琥) is presently a professor of automation engineering at University of Electronic Science and Technology of China. His research interests include modern measurement and instrumentation, computer-aided test and system integration, integrated circuit test and intelligent computation. He is an editor for the Chinese Journal of Scientific Instrument, a fellow of IEE and a member of CIE.

5 Conclusions

In this paper, we first analyze the theory of color space transform, then give an secret communicating algorithm of video. Algorithm first transforme a intra frame of video to three gray image firstly, then compute the Lth-level discrete wavelet decomposition of the gray images, with which the watermark was embedded simultaneously into and do invert wavelet transform to obtain the gray images which contains the secret information. Changing the intra frame of video based the three gray images to make the intra frame contain the secret information. While extracting the secret information, transforming the intra frame to three gray image and do Lth-level discrete wavelet transform to the gray images, distill the watermark $W_1$ from the wavelet coefficients of the three gray images. Experimental results demonstrate that the method had superior performance and potential for the secret communicating of video.

References


Brief Introduction to Author(s)

WANG Feng-bi (王凤碧) was born in 1974. She received the M.S degree in electrical engineering from UESTC in 2002. Her research interests include embedded system and communication test.

HUANG Jun-cai (黄均才) was born in 1973. He received the M.S degree in computer software from UESTC in 2004. His research interests include netcomputing, information security, bioinformatics.

ZHOU Ming-tian (周明天) is now a professor and Ph.D. supervisor in UESTC, Fellow of Chinese Institute of Electronics (CIE), Editorial Member of Acta Electronica Sinica and Chinese Journal of Electronics. His current interests include netcomputing, information security, distributed computing, parallel computing and mobile computing.