DESIGN AND IMPLEMENTATION OF A TIME SOURCE SELECTING AND MONITORING SYSTEM FOR THE TELEPHONE SPEAKING CLOCK

Ching-Chiang Lin, Po-Cheng Chang, Jia-Lun Wang, and Shinn-Yan Lin
National Standard Time & Frequency Lab., TL,
Chunghwa Telecom Co., Ltd., Taiwan
12, Lane 551, Min-Tsu Road, Sec. 5, Yang-Mei, Taoyuan, Taiwan 326
Tel: +886-3-424-5471, Fax: +886-3-424-5474, E-mail: *cchlin@cht.com.tw*

Abstract

As an added-on system of the Time Synchronized Speaking Clock (TSSC), the time source selecting and monitoring system (TSMS) together with its design and implementation are major concerns in this paper. The service offered by the TSSC is generally called the "117" time service and the telephone number "117" seems to be a symbol of the national standard time in Taiwan, since it is used frequently by the public to calibrate their time machines. Due to its popularity in daily uses, it is very important to keep the system running smoothly and providing reliable time service.

The paper describes how to construct TSMS, including two sub-systems. One is for multi-time signal source selection and the other for data monitoring and recording, which would strengthen reliability of the TSSC. Considering continuity of future development in TSMS, we chose UML (Unified Modeling Language) to express abstract concepts of the system behaviors and to generate its blueprint.

Finally, TSMS has been successfully implemented according to this blueprint. At the present time, the system is in operation and actual monitoring data are collected and analyzed. Charts of round-trip delays and fluctuations of synchronized time signals could also be plotted. According to these results, we see that the system has indeed brought evident benefits to enhance reliability of the TSSC system.

I. INTRODUCTION

In Taiwan, the "117" time service provides hundreds of thousands of accesses everyday. Its broadcasting center is located in Taipei city, which is about 50 kilometers north from TL. In the center, the Speaking Clock is synchronized with the national standard time by a telephone leased line at all times. Because the accuracy and reliability of the "117" time service has been questioned by some subscribers occasionally, the necessity of establishing a backup time signal source and a data monitoring & recording system was considered. The Time Source Selecting and Monitoring System or in brief, TSMS, was proposed in this situation. The purpose of this plan is to offer our users more reliable and accurate time service. Two major tasks of the plan are as follows. First, set up a multi-time selecting system that can switch to a backup time signal source automatically when the present one is detected to be in error. Second, establish a data monitoring & recording system that helps us check the condition of synchronized time signals and output reports periodically. When the system is detected to be in abnormal condition, a sound alarm may be triggered immediately.

The plan of the TSMS is based on the existing TSSC system. Since hardware and software of the TSSC was set up in different places (they connect to each other via telephone leased line and network), it is difficult to maintain the integrity and continuity of the system if one lacks a complete strategy for performing the plan. Fortunately, UML language with a set of modeling tools could help us design and generate a blueprint to achieve the tasks **[1]**. In the paper, we adopt standard symbols in UML to describe system requirements and components deployment for required functions. The system requirements should include describing interaction between the system and its surrounding environment. Finally, the TSMS has been successfully implemented according to the blueprint. The system collects actual monitoring data and then makes statistical analyses, which include generating a chart of time differences vs. sampling time and a bar chart of probability distribution. From these results, we can further understand the input signal quality of the Speaking Clock and the related transmission delay, which also helps us to keep the TSSC system operating more smoothly and to ensure the quality of the "117" time service.

II. REQUIREMENTS

The primary functions of the TSMS are to enhance the robustness of the input signal of the Speaking Clock and to record related monitoring data for further analyses of system performance. Besides, the system could trigger an alarm to remind the keeper when faulty values from the time signals are detected. The TSMS consists of three sub-systems, which are the Multi-time Selecting System (MTSS), the Data Acquisition System (DAS), and the Data Management System (DMS), as shown in Figure 1. Industrial PCs with Windows XP and a Linux operating system are used to collect and process related monitoring data. Finally, the raw data and some important system information are stored in the National Standard Time and Frequency Laboratory's database at TL. Using the selected date as an index, the authorized personnel could quickly search needed raw data or statistical charts on the screen for reference or study purposes.

Te main considerations for the design of the TSMS are as follows:

- When the input signal of the Speaking Clock is detected to be in abnormal condition, the system could switch to a backup time signal source automatically to avoid signal interruption.

- Establish system function to compare time differences between signals returned from the input of the Speaking Clock and the national standard time. Related data could be collected and stored.

- Establish alarm mechanism that sends an alarm message on the screen when the time difference is beyond ±200 ms.

- Raw data from every previous day could be downloaded to the database at TL automatically. The authorized personnel can perform basic statistical analyses for the data in a selected date interval.

- Establish a system function to show a chart of time differences vs. sampling time and that of probability distribution. Both of them could be stored and printed.

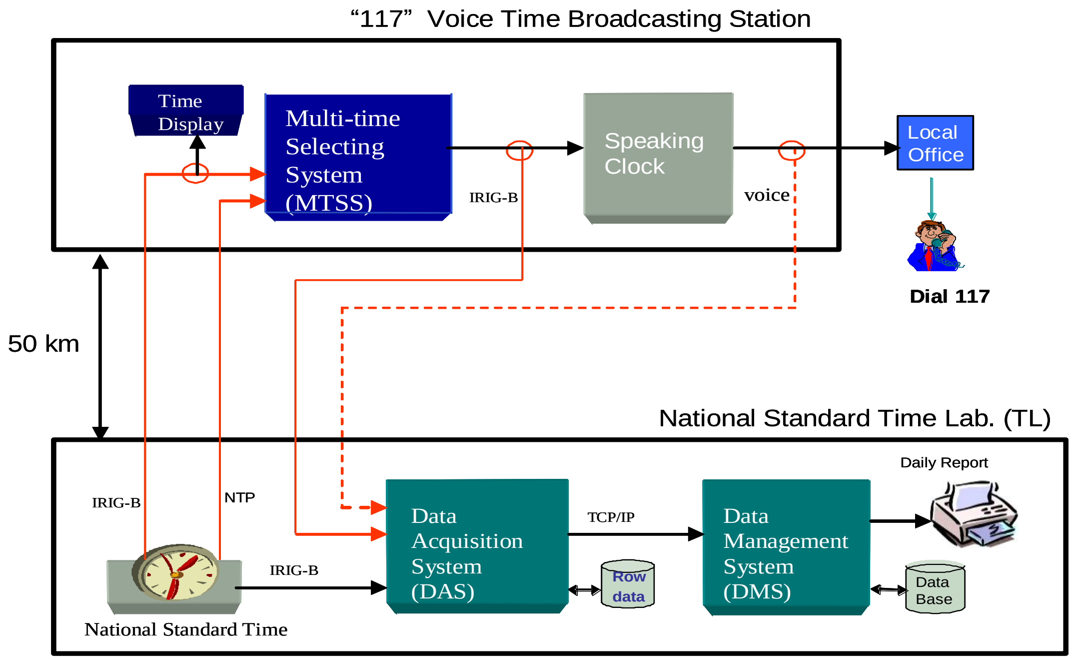


Figure 1. Architecture of the "117" Voice Time Broadcasting Station.

User Cases

User Cases describe the functions that need to be developed from the user's point of view. The user could be a person or a machine that plays the system actor. Each actor has the different way to start the system and then generates the different result **[3]**. We planned three different kinds of User Cases for the TSMS, as shown in Figure 2.

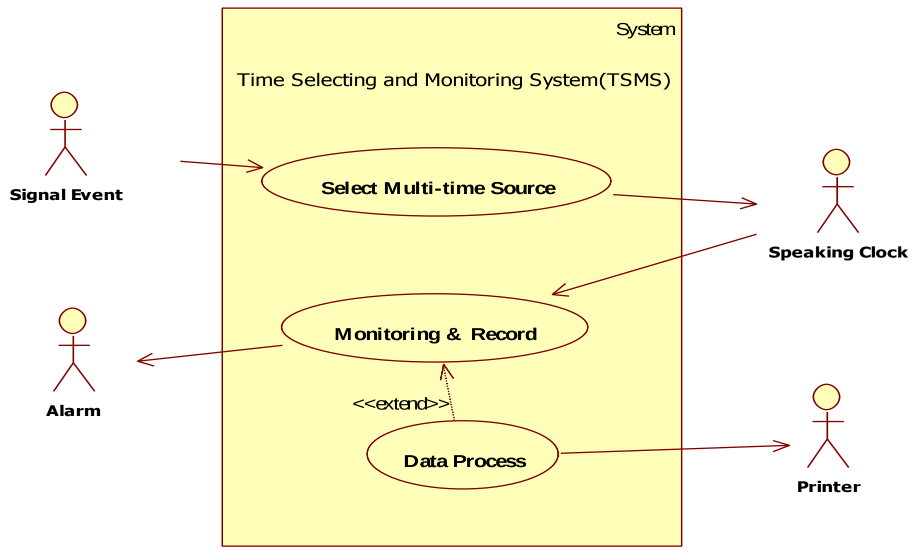


Figure 2. Illustration of User Cases for TSMS.

Select Multi-time Source

Three time signal sources have been designed for the TSMS. They are the external IRIG-B Time, the external NTP Time, and the internal System Time. Generally, the TSMS chooses the IRIG-B Time as its time signal source. If the above source is in a bad condition, the system will switch to select the NTP Time instead. In case the NTP Time doesn't work at that time, the system will take the internal System Time (in holdover state) as its reference.

Monitoring & Record

Assume synchronized time signals from the input of the Speaking Clock return to TL via a telephone leased line and are compared with the national standard time. The generated data of time differences could be stored at TL's database. Moreover, the established alarm mechanism could send out an alarm message when the time difference is beyond ±200 ms.

Data Processing

Raw data from every previous day could be downloaded to the database at TL automatically. The authorized personnel can carry out basic statistical analyses and generate related charts for the data in a selected date interval. For example, a chart of time differences vs. sampling time and that of probability distribution could be shown. Once a synchronized time signal is detected to be in error, the system keeper could determine the status of the time signal transmission, find the causes of the malfunction, and take effective action based on these reports.

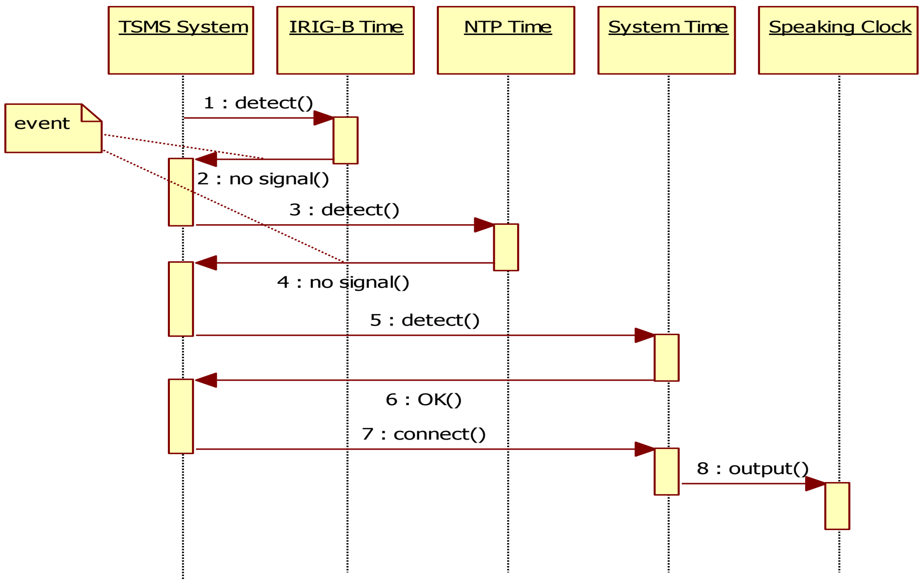
SCENARIOS

Scenarios describe interaction relations between the external actor (which are Event, Speaking Clock, Alarm, and Printer in this system) and the TSMS system. It is not easy to get all possible interaction relations even though each actor's role is very clear **[2]**. For instance, we have to know how to enable a backup time signal source of the NTP Time when the normal synchronized source is broken, and enable the System Time as the reference when the NTP Time fails, too. Furthermore, we also have to know how to collect comparison data of synchronized time signals and how to sift useful information from the data processed. The following UML sequence diagrams illustrate how to deal with the issues above. Figure 3 demonstrates how the system provides synchronized time signal to the back-end speaking clock in a normal situation and then broadcasts an accurate voice time signal via the telephone network.

Figure 4 demonstrates how the system switches to a backup time signal source of the NTP Time when the normal IRIG-B signal is broken.

Figure 5 illustrates how the system switches to a backup time signal source of the System Time when both the IRIG-B and NTP Time fail at the same time.

Figure 6 illustrates operating procedures of data collecting and processing. Let time signals from the output of the MTSS system (input of the speaking clock) return to TL via a telephone leased line and be compared with the national standard time. Collected raw data of time differences are stored in the system's database and could be used to determine the performance of the system after further analyses. While the time difference of raw data is detected better than ±200 ms, the system could trigger a sound alarm to draw the system keeper's attention, which is beneficial for us in solving the problem as soon as possible and reducing possibility of sending an inaccurate time signal to the public. Besides, related statistical charts could be obtained, saved, and printed while raw data were being analyzed.



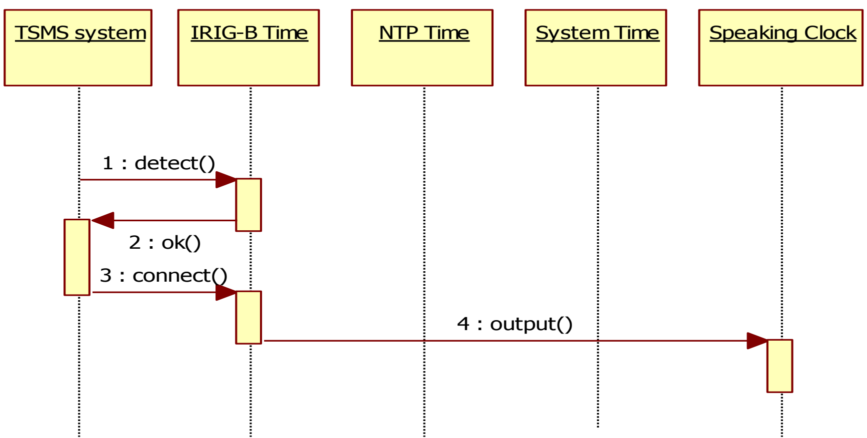


Figure 3. In a normal situation, the IRIG-B Time is chosen as the time signal source.

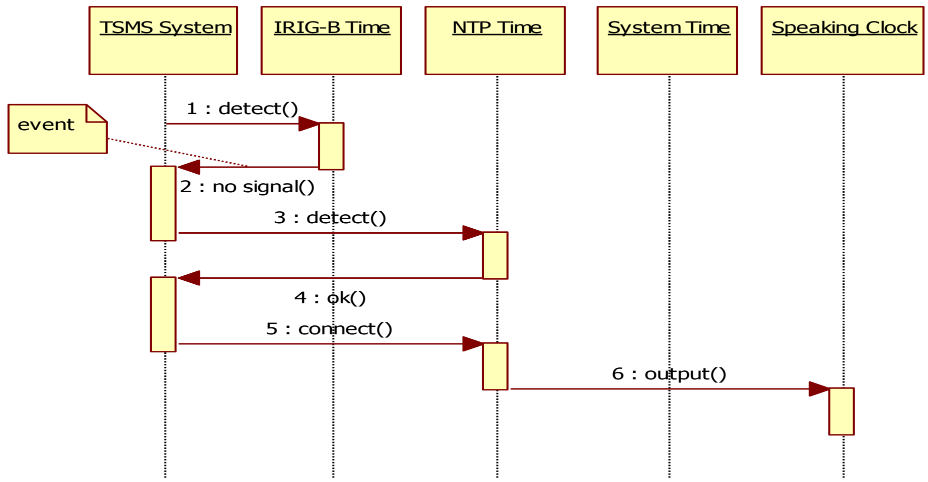


Figure 4. When the IRIG-B signal is in error, the system will choose the NTP Time.

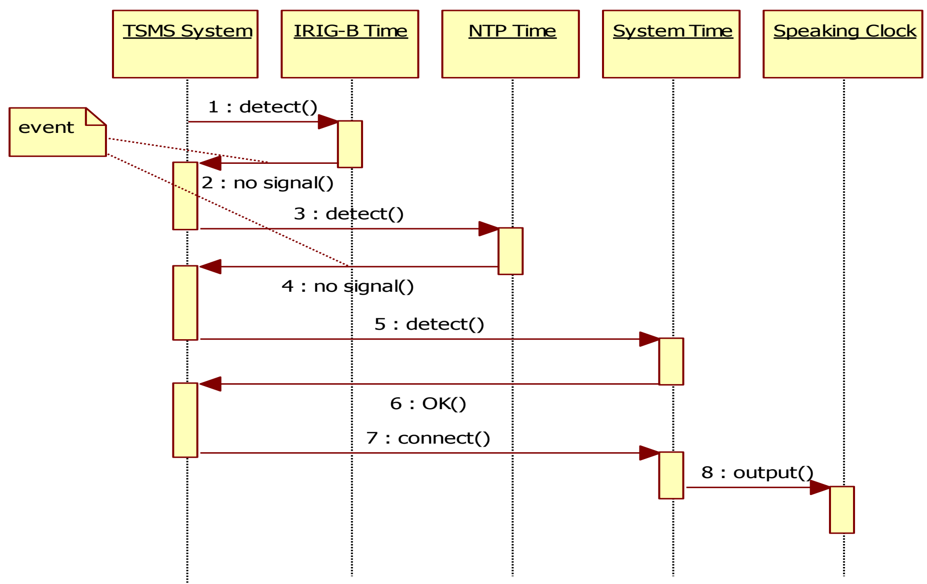


Figure 5. When both the IRIG-B and NTP Time fail, the system will choose the System Time.

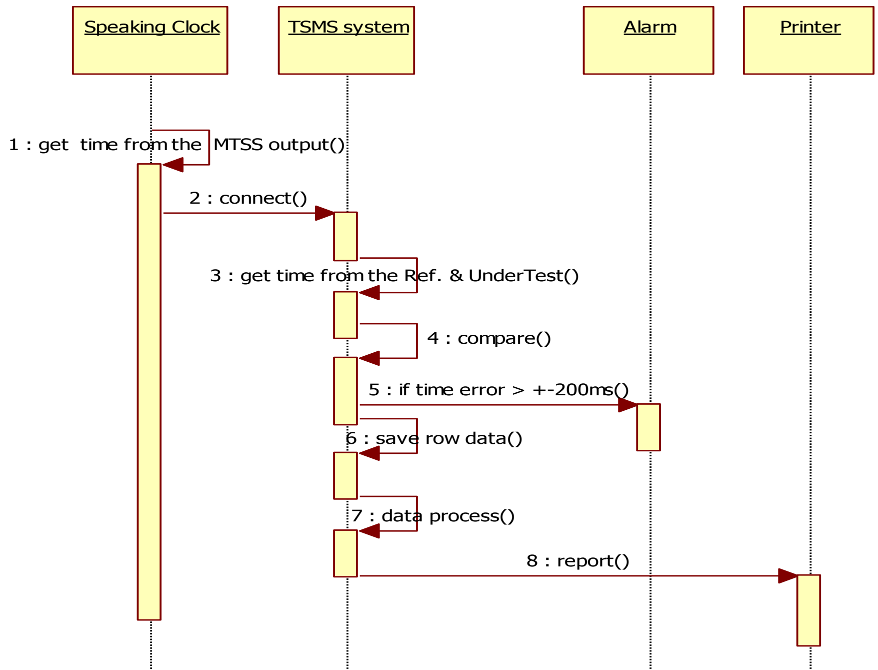


Figure 6. Operating procedures of data collecting and processing.

III. IMPLEMENTATION

In the UML, both the component diagram and the deployment diagram are used to show models of the system implementation. The component diagram demonstrates structural relationship among components and the deployment diagram shows the arrangement of each node and allocations of related components physically **[3]**. Figure 7 illustrates interrelations of the three major blocks in our system and deployment of each node with respect to the outer environment, which is used to express concepts on the abstract level of our system. For the MTSS and DAS sub-systems, we focused on the deployment of the internal hardware modules, but for the DMS sub-system, we were concerned with deployment of the internal software components.

The MTSS sub-system adopts an internal selector to choose the time signal among IRIG-B Time, NTP Time, and the System Time (OCXO oscillator), depending on their signal status, and its regenerator then uses the chosen one to generate the "new" IRIG-B Time output. The DAS sub-system operates in the Linux operating system and includes two pieces of IRIG-B AM interface cards for receiving both the standard time signal and the returned one to be tested, one communication voice card for receiving a voice signal from the output of the Speaking Clock and one alarm module. The DMS sub-system operates in the Windows XP operating system and contains the software ANALYSIS.EXE and GRAPHICS.EXE to process daily raw data and generate related reports.

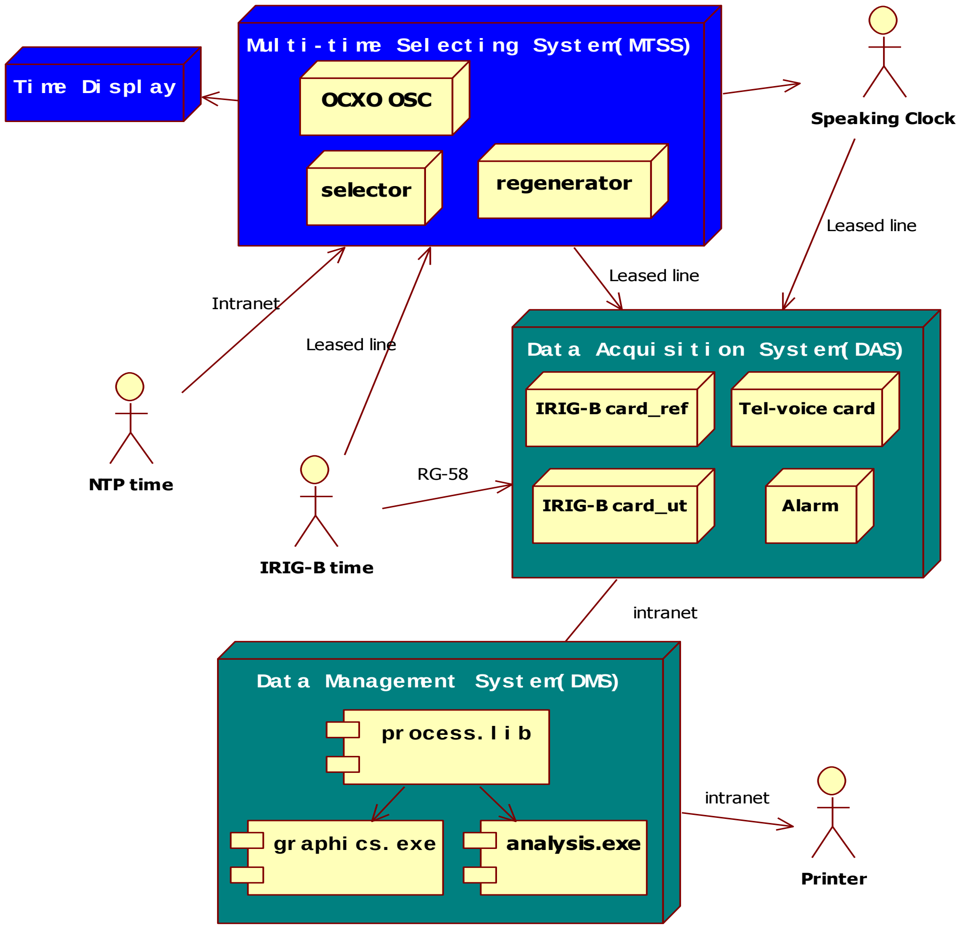


Figure 7. Component and deployment diagrams illustrating the main functions of TSMS.

IV. RESULTS

READINGS

The DAS sub-system is in charge of collecting raw data of time differences in the Linux OS. When in normal operation, there is a display as shown in Figure 8. The item "Reference" shows the reading from the reference time signal, while the item "UnderTest" shows the reading from the time signal that is returned from the input of the Speaking Clock in the "117" broadcasting station to the National Standard Time and Frequency Laboratory at TL. The item "UnderTest-Reference" is their time difference shown once per second and "Mean(10s)" is the average value for 10 seconds. The latter is also recorded and saved in a local hard disk. The total delay (including the delay from path and equipment) of the signal transmission from TL to the "117" broadcasting station and then back to TL could be obtained from the above readings, which lets us know how the system works and its possible errors due to signal transmission.

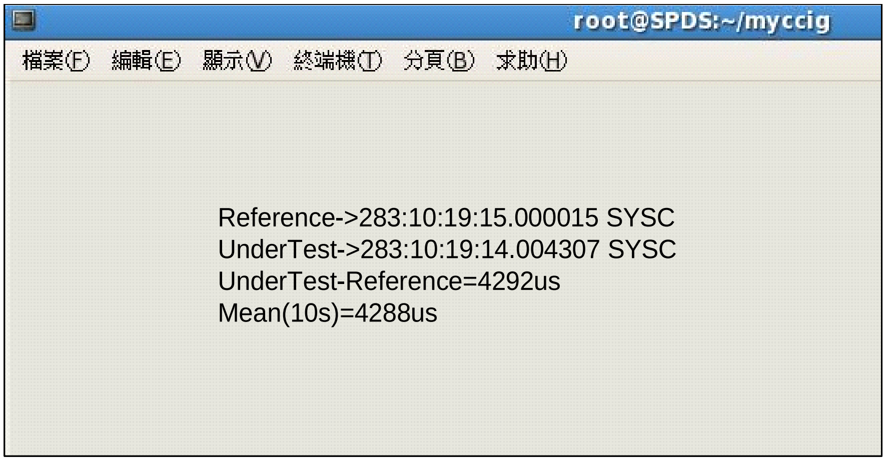


Figure 8. Display of the DAS sub-system in normal operation.

ALARM

In addition to collecting raw time difference data, the DAS sub-system checks whether the time difference is within limits (±200 ms) or not at the same time. When the time difference is beyond the limits, an alarm appears on the screen, as shown in Figure 9. In the example, the item "Mean(10s)" is 416776us (416.776ms), which is beyond the acceptable limits (±200 ms), and a "TIME SIGNAL ERROR !!" warning message appears on the screen to draw the attention of the relevant personnel.

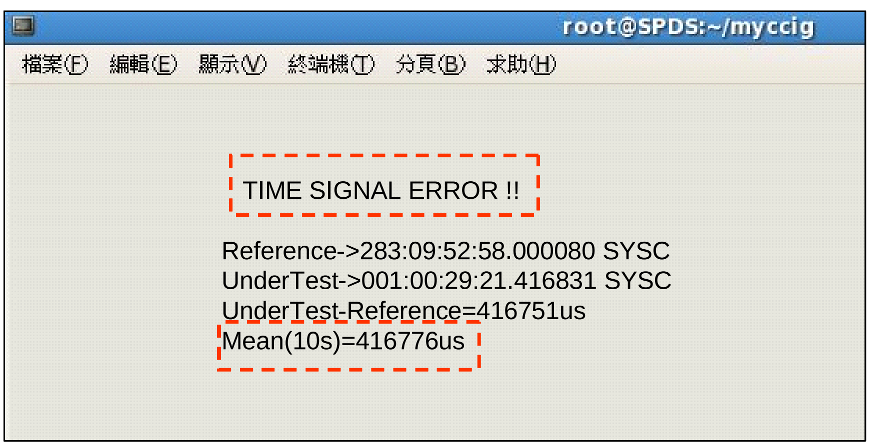


Figure 9. An alarm appears while time signal is in error.

STATISTICAL CHART

The raw data saved above could be analyzed by the DMS sub-system manually or automatically. Basic functions like performing statistical calculations, plotting a chart of time differences vs. sampling time and that of probability distribution, etc., could be carried out easily in the manual mode. In the automatic mode, the DMS sub-system is set to perform those functions for raw data from the previous day and save the generated charts by itself. Figure 10 illustrates a chart of time differences vs. sampling time with the average value (Round-Trip Delay) equal to 4290.33 (μs) and the standard deviation equal to 25.33 (μs). The above values are from the actual measurement results of the system. In Figure 11, probability distribution from the raw data in Figure 10 is shown. It is quite similar to a normal distribution, which means the signal transmission is in a normal condition.

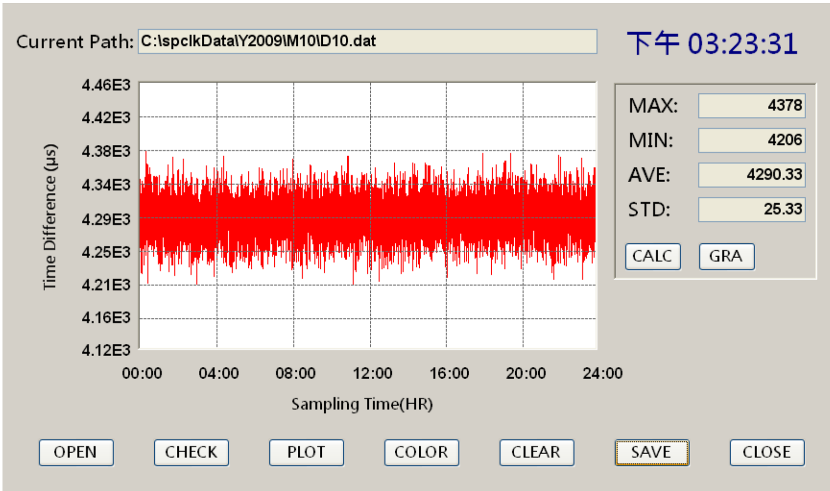


Figure 10. Chart of time differences vs. sampling time and statistical calculations.

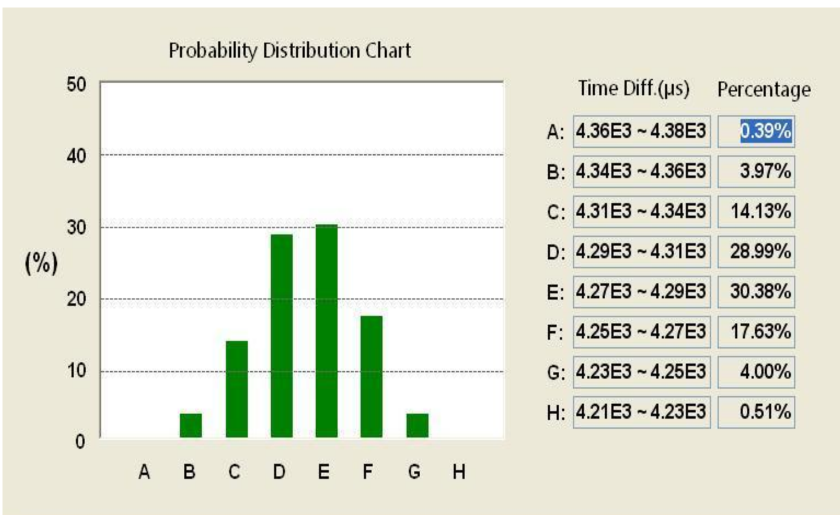


Figure 11. Probability distribution chart.

V. CONCLUSION

Because the TSMS was mainly designed to strengthen the reliability of the "117" public voice time service, two objectives have been focused on, which consisted of enhancing robustness of "117" synchronized signals and establishing related monitoring and recording functions. In order to develop the system continuously and express concepts of the system design concisely, we adopted graphical notations of the object-oriented language UML in the whole research and development process, which reduced uses of textual descriptions. In this paper, especially at stages of necessary analyses and system implementation, we used sequence diagrams to express dynamic interaction and static deployment of objects, which helped us clarify interrelations among sub-systems and their surrounding environments. At any rate, object-oriented analysis is a kind of iterative processes, so our system has experienced several modifications during its research and development period without exception.

In the past, performance of time signals (synchronized with the national standard time) from the input of the Speaking Clock was not monitored and recorded, so there were no immediate actions if any error occurred. After initiation of formal operation of TSMS, not only multiple sources of time signals have been added, but sub-systems for data collection and analysis have also been included to periodically output related reports, which enhances the reliability of the "117" public voice time service, provides information of synchronized signals like total delays and variations, and promotes our confidence in the service system. Nevertheless, the TSMS still has room for improvement. In the next stage, functions of recording voice signals from the output of the Speaking Clock and sending an alarm to the mobile phone of a system keeper will be proposed, which will make the TSMS more efficient and user-friendly in the near future.

REFERENCES

[1] F. Armour, S. Kaisler, J. Getter, and D. Pippin, 2002, "*A UML-driven Enterprise Architecture Case Study*," in Proceedings of the 36th Hawaii International Conference on System Sciences, 6-9 January 2002, Big Island, Hawaii, USA.

[2] I. P. Paltor and J. Lilius, 1999, "*Digital Sound Recorder: A case study on designing embedded systems using the UML notation*," Turku Centre for Computer Science TUCS Technical Report No. 234.

[3] G. Booch, R. A. Maksimchuk, and M. W. Engle, 2007, **Object-Oriented Analysis and Design with Applications** (3rd ed.; Addison-Wesley, Reading, Massachusetts).