Approach to Evaluation Technology for Connected Product

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Abstract

Recently, a business which provides various services has been growing along with the popularization of so-called “connected cars” that are the vehicles equipped with communication devices.

Various devices are connected, leading to an increase in the amount of data to be handled and communication frequency in future. On the other hand, service for which reliability is required to function stably even in any environmental change and user usage is being expanded.

In order to meet such market demands, achievement for both short-term development and quality improvement of the connected products is an urgent issue. In addition to improvement of design quality, an approach to improvement of evaluation efficiency and evaluation quality are indispensable.

In this article, cases of evaluation technology development by establishment of a simulation environment and process improvement by front loading of evaluation are introduced.

1. Trend in Connected Product

Recently, a car has advanced in various ways. A business, which analyzes acquired various data such as vehicle conditions and surrounding road conditions on the network via Internet connection or others using mobile data communication and provides appropriate optimal services, has been growing along with the so-called “connected cars” that are the vehicles equipped with communication devices. For example, emergency call, vehicle management, monitoring/operation management, driver assistance/protection, telematics insurance, congestion elimination, entertainment, etc. start to be popularized commonly. In addition, automotive manufacturers are also expanding their service business (vehicle dispatch system/vehicle management, etc.) in collaboration with car sharing and rideshare operators. Changes in environmental surrounding the connected car society is shown in **Fig. 1**.

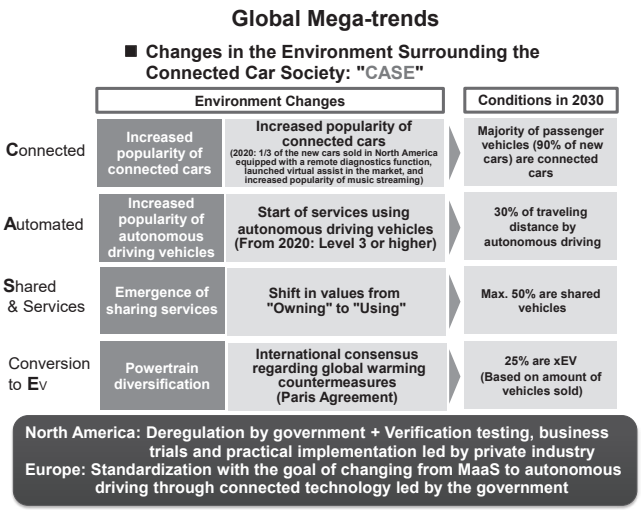

Fig. 1 Changes in the Environment Surrounding the Connected Car Society [1)]

We, DENSO TEN Limited, are also promoting mass production of connected products such as a communication type dashboard camera, an emergency call system, TCU (Telematics Control Unit), and a taxi

dispatch system, and are developing various service businesses such as safe driving management along with hardware. Image of connected car society system is shown in **Fig. 2**.

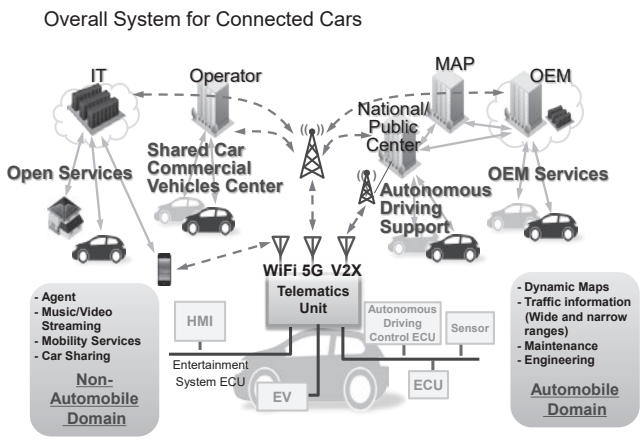

Fig. 2 Image of Connected Car Society System [2)]

2. Increase in Product Reliability Requirement

According to the expansion of services, various devices are connected, leading to an increase in the amount of data to be handled and communication frequency. Also, for data communications such as emergency notification, driving management, and dispatch service, high reliability is required to function stably in any site environment change and user usage. In order to ensure its quality, the expected value of evaluation for systems and products has been increasing.

In site environment, there are various state changes in mobile data communication, GPS reception, or the like depending on location and time. Therefore, implementing a comprehensive evaluation to combine the operating states of each device is necessary. Approaches from both evaluation technology development and evaluation process improvement are important in order to meet the requirements of short-term development and achieve quality improvement with limited resources.

3. Approach to Quality Improvement through Evaluation Technology

Figure 3 shows the V-shape process of product development. With the aim of improving efficiency of evaluation and quality of evaluation, we have approaches to (1) the efficiency improvement of evaluation by establishing a simulation environment and to (2) front loading of issue extraction by evaluating specifications.

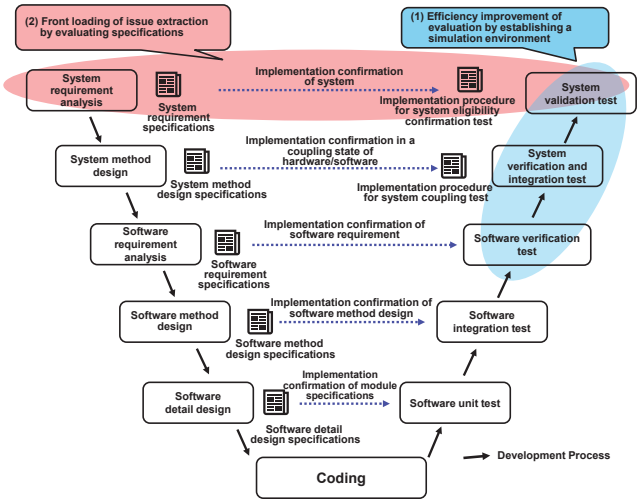

Fig. 3 V-shaped Process of Product Development

(1) Efficiency improvement of evaluation by establishing a simulation environment

The evaluation approach using two cases is introduced in this chapter.

①Automatic evaluation of the emergency notification system

The emergency call system is a device which automatically sends an emergency notification to the center about information such as the location where a collision occurs via TEL communication. Regardless of location and time, European legislation requires normal operation even under radio wave environment which changes with every moment.

Fig. 4 is a functional environment evaluation matrix that covers the functions (logic) to be tested and the radio wave environment (environment parameter). For each step from an alarm activation of emergency call to the call termination, it is necessary to test about 300 patterns and check the operation of about 600 items for confirmation of the function in the case of a change in the communication status such as connected, out of service, and reconnected states. Conventionally, all patterns were tested manually.

This time, an evaluation system which performs automatic execution and automatic judgment for this

test was established, utilizing a simulator (CRAMAS) developed by our company. Full automation enabled the system to operate 24 hours a day, which achieved the efficiency improvement of evaluation and the period shortening.

Radio Wave Environment
(environment parameter)

Function (Logic)

	微弱電波GSM (−90dBm)	電波圏外(無線基地局GSM) (−140dBm)	ネットワーク圏外(無線基地局GSM) (−140dBm)	キャ線基 (−1
【9】自動緊急通報作動	No.1	**No.40**	No.91	
【10】手動緊急通報作動	No.2	**No.41**	No.92	
【11】圏外且つ自動緊急通報作動	−	No.42	No.93	
【12】圏外且つ手動緊急通報作動	−	No.43	No.94	
【13】圏外かつ2分経過	−	No.44	No.95	
【14】圏内	**No.3**	**No.45**	No.96	
【15】PSAP側で受話	No.4	No.46	No.97	
【16】受話せず	**No.5**	**No.47**	No.98	
【17】MSD送信完了(初回送信)	No.6	No.48	No.99	
【18】T5タイムアウト(初回送信)	No.7	No.49	No.100	
【19】T6タイムアウト(初回送信)	No.8	No.50	No.101	
【20】T7タイムアウト(初回送信)	No.9	No.51	No.102	
【21】MSD送信中にPSAPで終話(初回送信)	No.10	**No.52**	No.103	
【22】MSD送信中に電波圏外(初回送信)	−	No.53	No.104	
【23】リダイヤル時間終了	−	−	−	
【24】圏内	**No.11**	**No.54**	No.105	
【25】終話による切断	−	−	−	
【26】CCFT(60分)による切断	−	−	−	
【27】MSD要求	No.12	No.55	No.106	

Fig. 4 Emergency Call System Functional/ Environmental Evaluation Matrix

Fig. 5 shows the evaluation system structure. It consists mainly of a simulator (CRAMAS), which performs test pattern execution and automatic judgment of results, in addition to a base station simulator which simulates a radio wave environment and a call center, a microphone/speaker set for emergency call, and others. CAN information (vehicle speed and crew information), which is a vehicle signal, and an airbag signal at the time of vehicle collision secured the simplification of system and the synchronism of the test timing by generating a pseudo signal with the simulator (CRAMAS).

Furthermore, the confirmation of LED lighting state of the microphone/speaker kit serving as a human interface was performed by voltage monitoring, and the transmission/reception confirmation of voice was performed by judgment of transmission and reception of a specific frequency. Automatic judgement about whether voice transmission to the center and the center recording were success or failure was realized by this method, which led to the achievement of the fully automated test. By establishing this evaluation system, the functional test period was shortened from 30 days to 10 days, and the evaluation man-hours were greatly reduced from 480H to 40H.

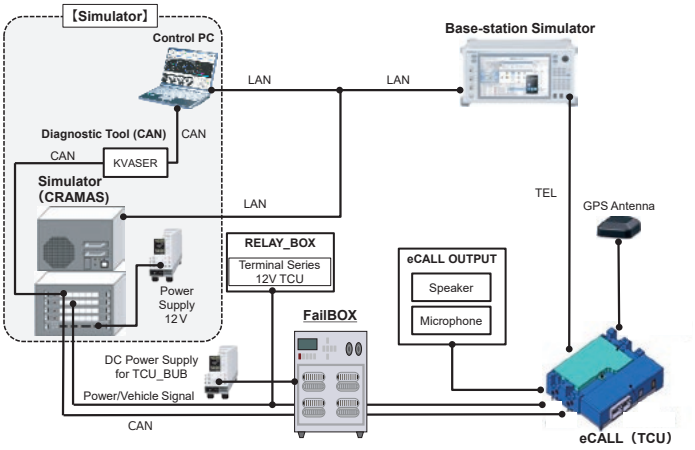

Fig. 5 Evaluation Environment of Emergency Notification System

②Automatic Evaluation of Communication Type Dashboard Camera

The communication type dashboard camera has functions of recording data such as CAN communication, position information, and image in a built-in memory or SD card, and sending it to a server. Depending on the user usage, when the data processing timing overlaps with the time of startup or shutdown of the device, it may result in a problem that data is damaged or wrong data is sent. Since this kind of problem may occur only within a few milliseconds during specific data processing, it is extremely difficult to detect the defect by a normal power supply fluctuation test or a manual operation repetition test. Therefore, we worked on strengthening the evaluation of such power supply systems for establishing the automatic evaluation environment.

Fig. 6 shows the evaluation environment and **Fig. 7** shows the evaluation time chart (case of evaluation patterns) of power supply ON/OFF.

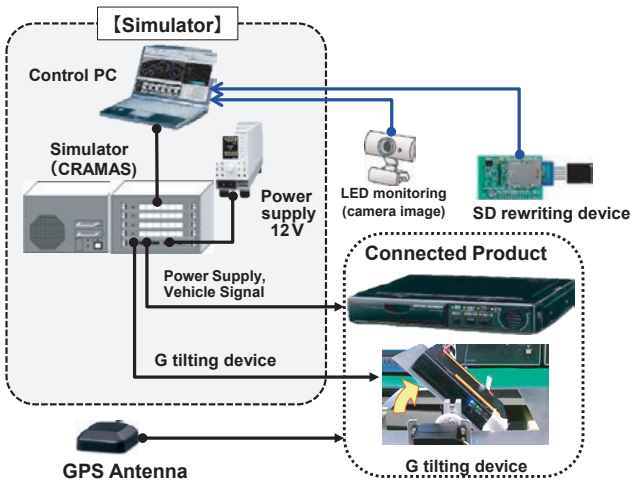

Fig. 6 Evaluation Environment of Communication type Dashboard Camera

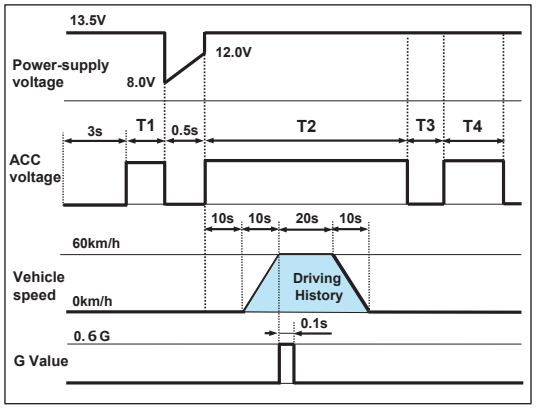

Fig. 7 Evaluation Time Chart of Power Supply On/OFF

Setting the time T1 to T4 shown in **Fig. 7** in detail with a simulator program and executing a large number of patterns enable a defect with low occurrence frequency to be detected. In addition, the reproducible repeated patterns make it easy to analyze the defect and confirm improvement effects, and also enable the frequency of occurrence in the market to be calculated.

Data such as driving history is required for defect detection. Vehicle data such as vehicle speed and engine speed can be generated by the simulator program. Furthermore, pseudo rapid acceleration/deceleration and collision conditions were entered into the product by using a tilting device capable of program control. The operation check of a device was realized by automatically checking the LED lighting state with a sensor and leaving the timestamp when an image data was obtained as data. The storage of these driving histories and the verification of data which is uploaded to the server made the quality confirmation of products more efficient.

(2) Front loading of issue extraction by evaluating specifications

Normally, all functions are evaluated after designing the application/viewer software. However, more than 80% of defects and improvements are operation screen transitions, wrong indications related to the display, and difficulties to see. These contents are incorporated at the time when the design specifications are created and can be confirmed before completing the software design. Therefore, front loading was performed to extract defects and improvements by “usability evaluation for specifications” in the design phase of application/viewer specifications. **(Fig. 8)**

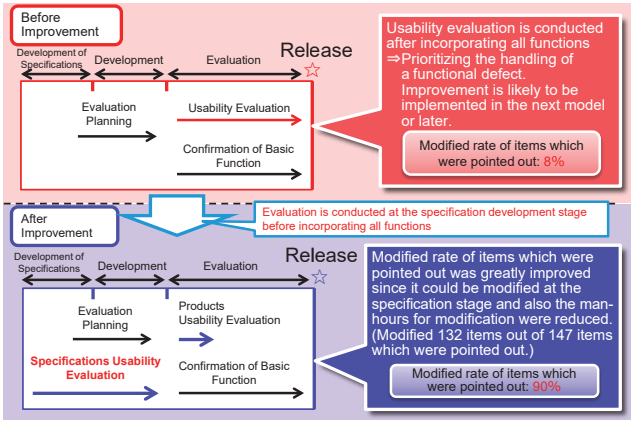

Fig. 8 Front Loading of Usability Evaluation

Two new methods of “heuristic evaluation method” and “cognitive walkthrough” were adopted for “usability evaluation for specifications.”

Each function of the Web application was checked for 47 items from 17 viewpoints with “heuristic evaluation method,” and the operation/screen transition, etc. of all functions were confirmed with the “cognitive walkthrough” method.

As a result, improvement can be made in the design phase. Although the modified rate of the items which were pointed out at the time of release was 8% with the conventional method, 90% of the items which were pointed out in the overall evaluation could be improved by introducing “Usability Evaluation for Specifications,”

resulting in the improvement of the completion rate at the time of release.

Figure 9 shows the improvement case in the "Usability Evaluation for Specifications."

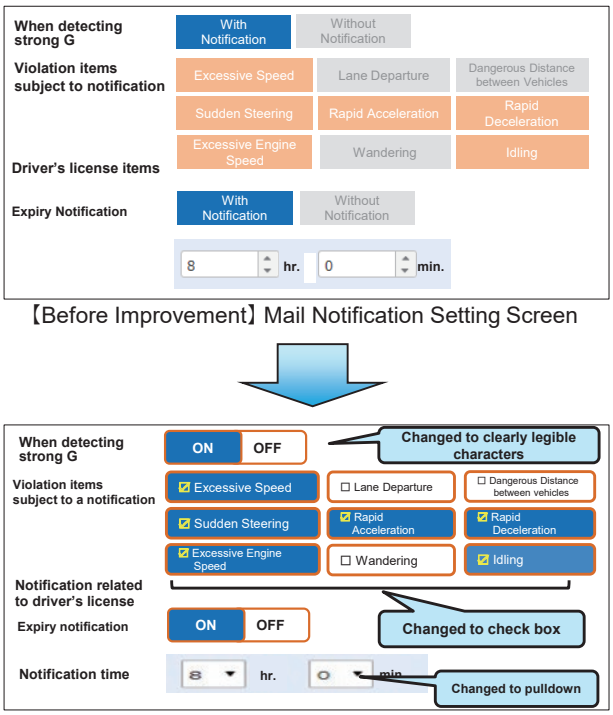

Fig. 9 Improvement cases in Usability Evaluation for Specifications

4. Conclusion

In order to meet the high-quality requirements of connected products, technology development such as automatic evaluation which simulates actual environment of automobile and network is indispensable.

In addition to the evaluation technology development described above, we would like to contribute to the development of connected products capable of being used safely and comfortably through an approach of developing evaluation technologies related to human interfaces such as gesture operation and voice recognition.

Lastly, we would like to express our sincere appreciation to the relevant people inside and outside the company for their cooperation and guidance in developing this evaluation technology.

Reference

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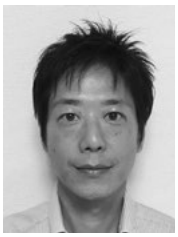

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