TOPPERS Project
and
Development of an Open Source OS Based on AUTOSAR Specification

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TOPPERS PROJECT

About TOPPERS Project

TOPPERS = Toyohashi Open Platform for
Embedded and Real-Time Systems

Objectives of the project

- Based on the achievements of ITRON*, to develop various open-source high-quality software for embedded systems including RTOS, and to promote their use

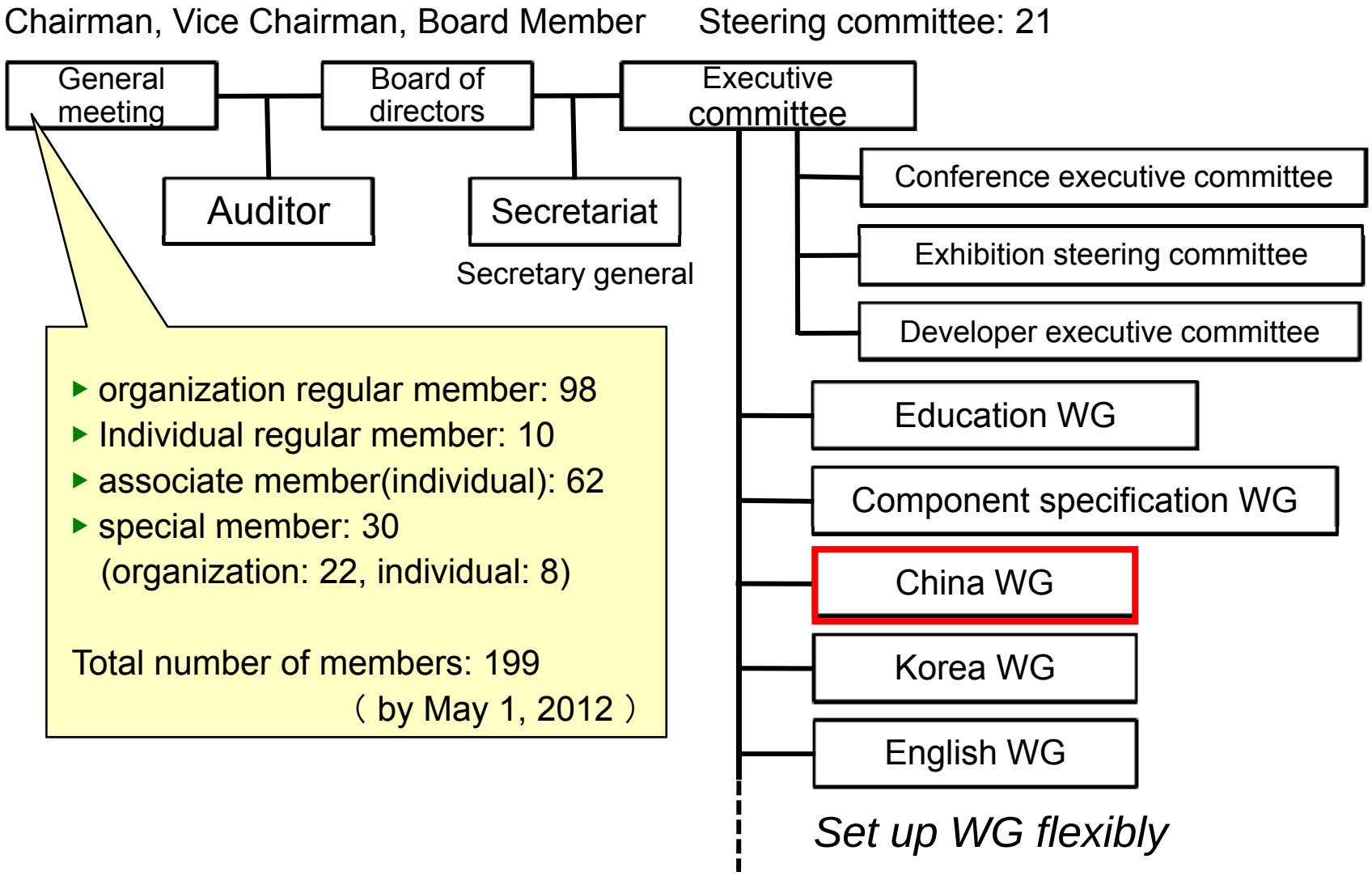
Building a widely used open-source OS as Linux in the area of embedded systems!

Organization of the project

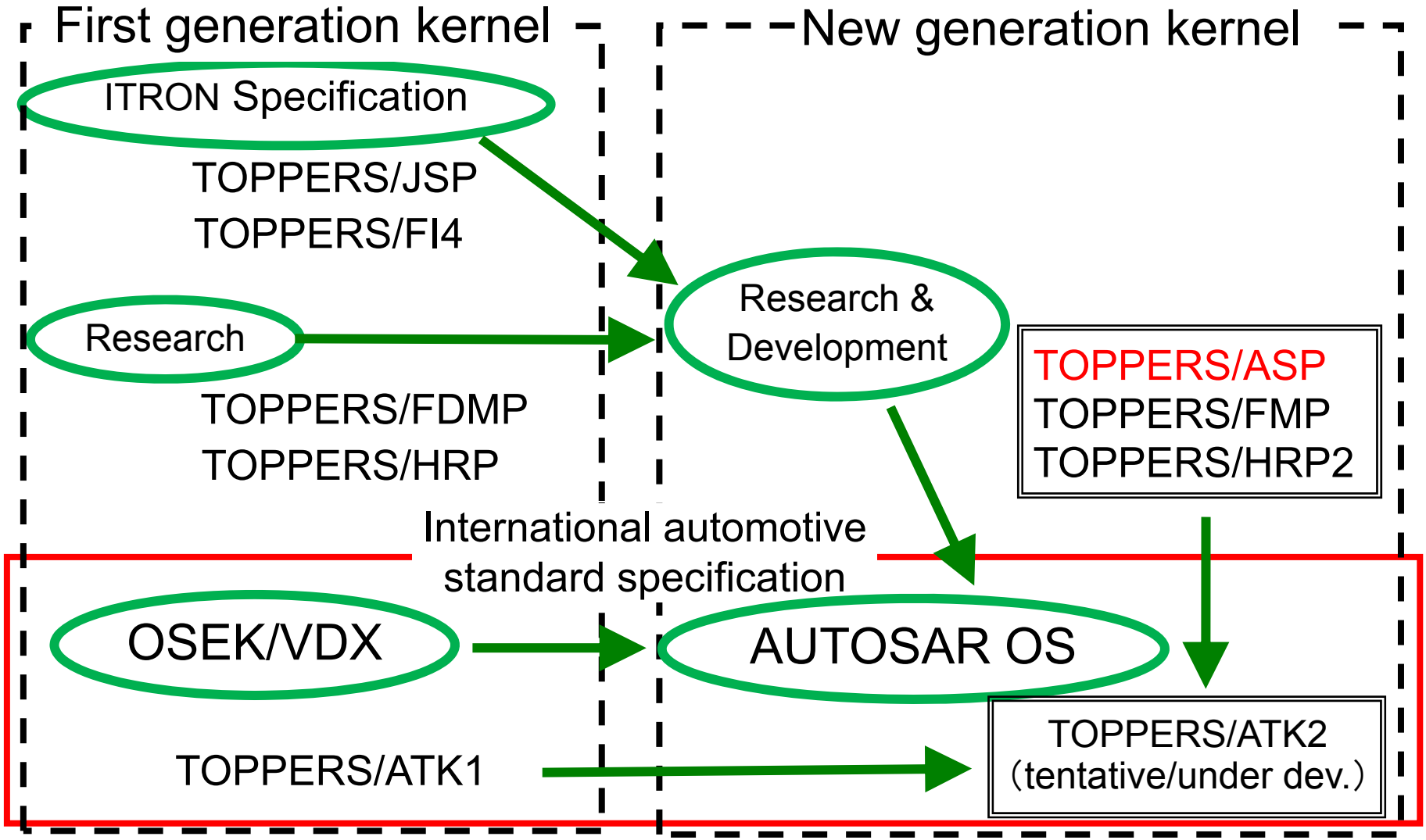
- Chairman: Prof. Hiroaki Takada, executive director and professor, Center for Embedded Computing Systems, Nagoya University
- Project members come from industries, academia, public research institutes, and individual engineers
- The project was incorporated as a non-profit organization (NPO) in 2003

(*) ITRON is a Japanese open standard for a real-time operating system

Organization and members of TOPPERS project



Development of TOPPERS RTOS（partial）



The first generation kernel

TOPPERS/JSP kernel — *ITRON specification*

- Conform to the standard profile of μITRON4.0 specification

TOPPERS/FI4 kernel — *ITRON specification*

- Conform to the full profile of μITRON4.0 specification

TOPPERS/FDMP kernel — *For multiprocessor*

- Function Distributed MultiProcessor RTOS kernel

TOPPERS/HRP kernel — *Memory protection*

- High Reliable Profile with memory protection function
- Verification by JAXA (Japan aerospace exploration agency)

TOPPERS/ATK1 (Automotive kernel ver.1) — *OSEK/VDX*

- Conform to the international standard of embedded automotive application: OSEK/VDX OS specification

Next generation kernel

TOPPERS/ASP kernel

Basis of next generation kernel

- Improvement of JSP kernel in terms of reliability, safety, and portability
- Support of dynamic object generation by extension package

TOPPERS/FMP kernel

For multiprocessor

- Extension of ASP kernel to multiprocessor

TOPPERS/ATK2 (tentative/under dev.)

AUTOSAR OS

- Conform to AUTOSAR OS specification

Effort toward high quality

TOPPERS next generation specification

- Improvement and extension of µITRON4.0 specification to meet needs in the past decade
- Ongoing development (specifications of ASP, FMP, HRP2 kernels have been completed)

TOPPERS test suit packages (TTSP)

- Test suits for TOPPERS next generation kernel
- Original description of test scenes, and tool for automatic generation of test programs

SafeG

- Dual OS monitor for concurrently running of general-purpose OS and RTOS on a single processor

TLV (TraceLogVisualizer)

- Visual tool for trace logs generated by RTOS

TOPPERS license

- An unique license is applied to software developed by TOPPERS project

Basic concept

- Consider the features of embedded systems, the license conditions should be freer than GNU GPL and BSD license
- Know where and how the software is used will benefit the future development of TOPPERS project

Contents of TOPPERS license

- It is not required to disclose derivative software, and business for selling an improved version of TOPPERS software is permitted
- It is required to notify the TOPPERS Project of where and how the software is used, when TOPPERS software is embedded into an equipment

"Reportware"

Middleware

TOPPERS project provides not only kernels but also middleware as open source software

TINET

- Compact TCP/IP protocol stack compliant with ITRON TCP/IP API specification
- Support both IPv4 and IPv6

FatFs for TOPPERS

- File system supporting FAT12/16/32

RLL（Remote Link Loader）

DLM（Dynamic Loading Manager）

- Middleware for dynamically loading modules
- RLL and DLM have different approaches

CAN/LIN middleware packages

- Communication middleware for CAN and LIN

Application examples of TOPPERS OS
Consumer applications

PM-A970 (EPSON)

DO!KARAOKE
(Panasonic)

945SH
(SHARP)

IPSiO GX e3300 (Ricoh)

GT-541 (Brother)

UA-101 (Roland)

Automobile and aerospace applications

Kizashi (SUZUKI)

H-IIB (JAXA)

〈under development〉

ASTRO-H (JAXA)

〈under development〉

Some reasons for selecting TOPPERS software:
(1) open source (2) high quality (3) unique license
(4) selectable middleware

OPEN SOURCE RTOS BASED ON AUTOSAR SPECIFICATION

Joint research consortium

Joint R&D through cooperation between Nagoya University and companies

- engineer and researcher
- industry experience

- engineer training
- results of R&D

- faculty and researcher
- research knowledge

- results of R&D

Two or more companies

名古屋大学

Center for Embedded Computing Systems, Nagoya University (NCES)

- **The investments per company for development are reduced**
- **Design the specification of next generation automotive RTOS based on AUTOSAR OS specification, and develop RTOS implementation**
- **Disclose the source code of the developed RTOS (tentative: TOPPERS/ATK2, release date TBA)**
- **Education of engineers**

Company members in the joint research consortium :
WITZ Co. Ltd., Eiwa System Management, Inc., OTSL Inc., Sunny Giken Inc., DENSO CORPORATION, Toshiba Corporation, Toyota Motor Corporation, NEC Communication Systems, Ltd., Panasonic Advanced Technology Development Co. Ltd., FUJISOFT INCORPORATED, FUJITSU VLSI LIMITED, Renesas Electronics Corporation

Investigation and development of AUTOSAR specification compliant RTOS

Early stage of research (2008 ~ 2010)

- From 2008 to 2010, test implementation and performance evaluation have been conducted at NCES
- Problems extraction
  - Targets of AUTOSAR OS specification
    - R3.0
    - SC1, SC2, SC3
  - AUTOSAR OS specification extension and evaluation for multiprocessor application

Problems in the AUTOSAR OS specification

Large overhead

- Program size and runtime overhead will be great if all functions have been implemented as the specification

Obscure specification

- Configuration method related to memory protection is undecided yet

Difficult to meet real-time requirement

- It is difficult to meet the real-time requirement according to the AUTOSAR 4.0 specification with multiprocessor extension

Poor readability

- The specification is written as the difference between OSEK/VDX OS and AUTOSAR OS

Development and implementation of next generation automotive RTOS specification

Joint research consortium (2011~)

- Clarification and modification of AUTOSAR OS specification
- Creation of an open Japanese specification which can be used freely
- Distribution of developed RTOS implementation as open source software
- Guaranteed quality by thorough test
- Targeted AUTOSAS OS specification: R4.0

Our approach to deal with existing problems

Large overhead

- Addition of sub sets (function level) for protection function
  - Functions with large overhead and low effectiveness are changed to be optional. (e.g., application's ISR catetory2 in an unreliable OS)
- Introduction of dedicated hardware to reduce the overhead caused by RTOS. (e.g., exclusive control among cores)

Obscure specification

- Our specification is added
  - Technologies developed in TOPPERS project are applied

Difficult to meet real-time performance

- Specification for improving real-time performance is proposed based on the experience in developing TOPPERS multiprocessor RTOS

Poor readability

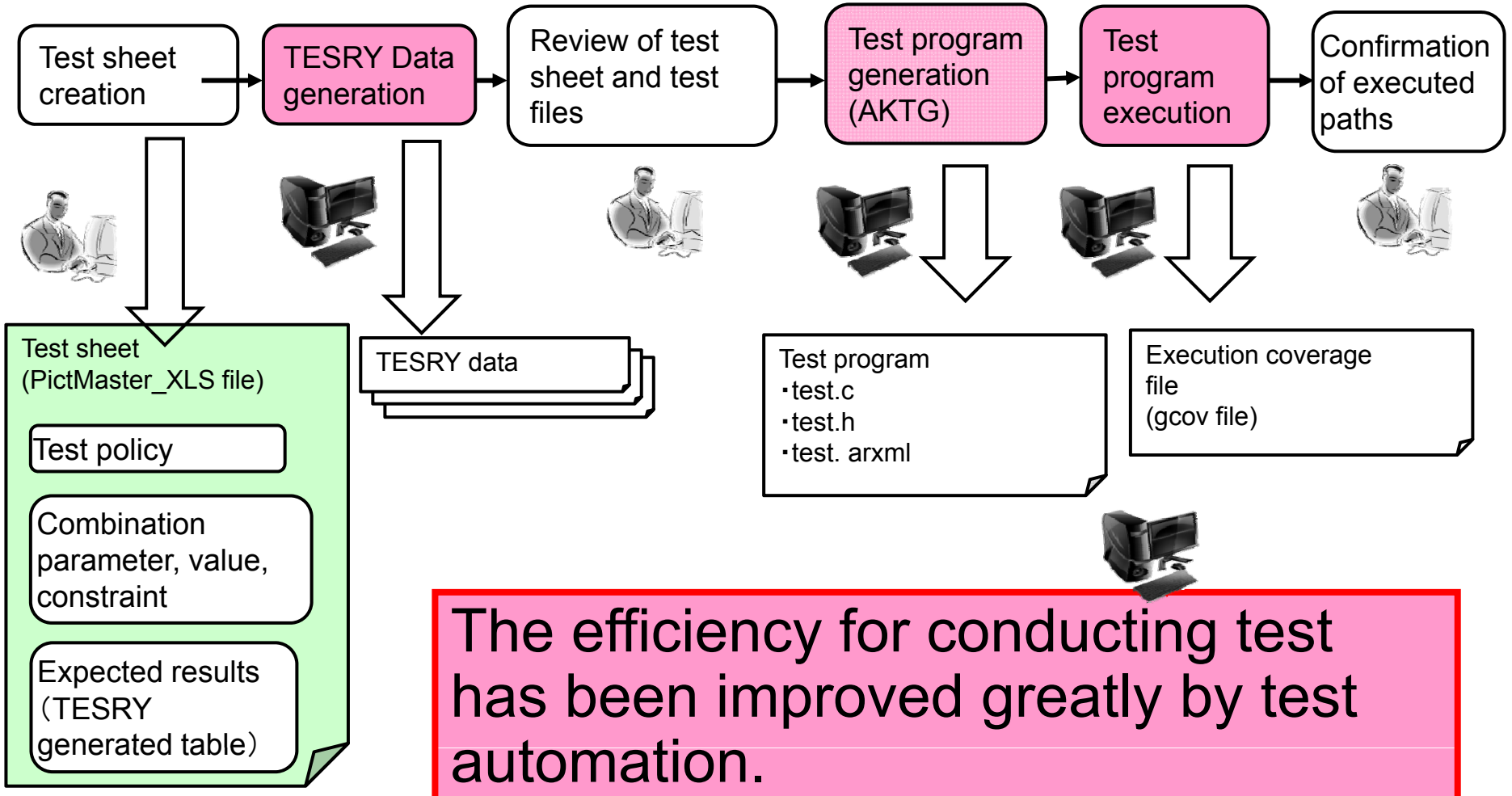
- Specification is rearranged and rewritten in one document by denoting the following contents clearly:
  - (1) OSEK/VDX OS specification, (2) AUTOSAR OS specification (3) NCES's unique specification

Current results in the end of 2011

- Modified and improved specification of AUTOSAR OS
- Implementation of specification based on AUTOSAR OS R4.0
  - SC1
    - Specification related to the shutdownOS has been modified in the implementation
  - Parts of SC3
    - Forced termination of OS application and ISR catetory2, as well as memory protection of ISR catetory2 are excluded
- Design documents about the implementation
- Development of test suits
- Conduct of test

} with partial automation

Development of test suits and test implementation



The efficiency for conducting test has been improved greatly by test automation.

Guaranteed quality via automatic extensive test

Test target: system service

Type of system services	Number
SC1 system service	34
SC3 system service	52

From thousands to tens of thousands tests are carried out for only tens of system services

List of test cases

Type of test	Normal case (Num.)	Abnormal case (Num.)
SC1 system service test	8,305	601
SC3 system service test	49,569	1,248
Ref: MODISTARC verification*	50	16

(*) Far more than MODISTARC verifications

PROPOSAL: APPLICATION OF TOPPERS SOFTWARE IN CHINA

The advantages of adopting TOPPERS software

(1) Open source

- Learn via reading source code
- Easy to port them on various MCU
- Customization is possible

(2) High quality

High Quality Open Source

- Extensive application records in Japan, including automobile and aerospace (under development)

(3) Business-friendly license with great flexibility

- Source code of derivative software need not to be disclosed
- Business for selling an improved version of TOPPERS software is permitted
- Only obligation of report is required in case that TOPPERS software is embedded into an equipment

(4) Development services provided by related companies

- Porting on different MCU, development of middleware, etc.

Various materials for study

Seminar materials for beginner *With English and Chinese versions*

- Learn the basic method for constructing an embedded software on RTOS through training seminars

Seminar materials for senior *With Chinese version*

- Learn network programming and system design

Basic level 1 seminar materials

- Learn development of small-scale embedded system and basic knowledge of RTOS

Basic level 2 seminar materials

- Commentary of RTOS and service calls

Support multi-languages（ongoing）

- Translate the comments of TOPPERS/ASP kernel source code into English
- Translate Japanese documents into Chinese

Invitation of product use and project participation

- Welcome to use TOPPERS software that can be downloaded freely from the websites below
- Welcome all who supports the aims of the organization to join us via TOPPERS membership
- Working group (WG) for promotion in China
  - Supported by Chinese-speaking members

Website:

http://www.toppers.jp/ （Japanese）
http://www.toppers.jp/en/index.html （English）
http://www.toppers.jp/cn/index.html （Chinese）
http://www.toppers.jp/kr/index.html （Korean）

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