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

Chairman, Vice Chairman, Board Member

Executive committee

- Conference executive committee
- Exhibition steering committee
- Developer executive committee

- Education WG
- Component specification WG
- China WG
- Korea WG
- English WG

Set up WG flexibly

General meeting

Board of directors

Secretariat

Auditor

Secretary general

- organization regular member: 98
- Individual regular member: 10
- associate member(individual): 62
- special member: 30
  (organization: 22, individual: 8)

Total number of members: 199
  (by May 1, 2012)
Development of TOPPERS RTOS (partial)

First generation kernel

- ITRON Specification
- TOPPERS/JSP
- TOPPERS/FI4

Research

- TOPPERS/FDMP
- TOPPERS/HRP

New generation kernel

Research & Development

- TOPPERS/ASP
- TOPPERS/FMP
- TOPPERS/HRP2

International automotive standard specification

- OSEK/VDX
- TOPPERS/ATK1

AUTOSAR OS

- TOPPERS/ATK2 (tentative/under dev.)
The first generation kernel

TOPPERS/JSP kernel
- Conform to the standard profile of μITRON4.0 specification

TOPPERS/FI4 kernel
- Conform to the full profile of μITRON4.0 specification

TOPPERS/FDMP kernel
- Function Distributed MultiProcessor RTOS kernel

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

TOPPERS/ATK1 (Automotive kernel ver.1)
- Conform to the international standard of embedded automotive application: OSEK/VDX OS specification
Next generation kernel

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

TOPPERS/FMP kernel
- Extension of ASP kernel to multiprocessor

TOPPERS/ATK2 (tentative/under dev.)
- 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

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)
- GT-541 (Brother)
- IPSiO GX e3300 (Ricoh)
- UA-101 (Roland)
- 945SH (SHARP)
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

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:
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 category2 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 shutdown OS has been modified in the implementation
  - Parts of SC3
    - Forced termination of OS application and ISR category2, as well as memory protection of ISR category2 are excluded
- Design documents about the implementation
- Development of test suits with partial automation
- Conduct of test
The efficiency for conducting test has been improved greatly by test automation.
Guaranteed quality via automatic extensive test

Test target: system service

<table>
<thead>
<tr>
<th>Type of system services</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC1 system service</td>
<td>34</td>
</tr>
<tr>
<td>SC3 system service</td>
<td>52</td>
</tr>
</tbody>
</table>

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

List of test cases

<table>
<thead>
<tr>
<th>Type of test</th>
<th>Normal case (Num.)</th>
<th>Abnormal case (Num.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC1 system service test</td>
<td>8,305</td>
<td>601</td>
</tr>
<tr>
<td>SC3 system service test</td>
<td>49,569</td>
<td>1,248</td>
</tr>
<tr>
<td>Ref: MODISTARC verification*</td>
<td>50</td>
<td>16</td>
</tr>
</tbody>
</table>

(* ) 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
   ▶ 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
  ▶ Learn the basic method for constructing an embedded software on RTOS through training seminars

Seminar materials for senior
  ▶ 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/kr/index.html (Korean)

Contact Information: TOPPERS secretariat email secretariat@toppers.jp