ORiN: Standard Network Interface for Robot/Factory Automation

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Background -in Factory-

- Various consumer needs  
  - From mass to customized production
- Serious competition (speed & cost)  
  - No loss, No stock, Short TAT
- IT into Factory (Networking & PC)  
  - Vertical integration (SCM/ERP)

Continuous monitoring and improvement
Quick start-up / No Loss Operation
the standardization of the network interface

<table>
<thead>
<tr>
<th>category of IF</th>
<th>examples</th>
<th>user needs</th>
<th>technical problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>mechanical</td>
<td>motor/encoder IF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>system software</td>
<td>servo IF, motion IF, etc</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>robot language</td>
<td>programming language</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>user</td>
<td>operation IF, teaching box IF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>peripheral</td>
<td>network IF (PC IF)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Classification of communications related to machine controllers

<table>
<thead>
<tr>
<th>communication level</th>
<th>usage</th>
<th>related technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>b/w computers</td>
<td>PCs and machine controllers, controller monitoring, task management</td>
<td>Ethernet (F-L-net)</td>
</tr>
<tr>
<td>b/w controllers</td>
<td>data exchange b/w machine controllers, real-time I/O data acquisition</td>
<td>F-L-net, ControlNet, ME-NET</td>
</tr>
<tr>
<td>b/w devices</td>
<td>data exchange b/w machine controllers and peripheral devices, SWs and displays control</td>
<td>DeviceNet, Interbus-S, Profibus-DP</td>
</tr>
<tr>
<td>b/w motor drives</td>
<td>to control motor drives</td>
<td>SERCOS</td>
</tr>
</tbody>
</table>

- Open interface (API) for PCs
- to provide standard robot-data-access method to shop-floor controllers
- to ensure that shop-floor systems have high cost-performance and easy maintainability.

### FA Network and Layers

- **Network Levels**
  - Headquarters
  - Factory
  - Production Line
  - Process Units
  - Factory Management
  - Shop Floor Management
  - Quality
  - Logistics
  - Facility Management
  - Maintenance
  - Assembly
  - Inspection

- **Physical Layers**
  - WAN (Wide Area Network)
  - LAN (Local Area Network)
  - FDDI (Fiber Distributed Data Interface)
  - Ethernet
  - FL-NET
  - ME-NET
  - MiniMAP
  - Devicenet

- **System Configuration**
  - Headquarter MIS
  - File Server
  - Ethernet

- **Network Interfaces**
  - Open MES
  - ORiN
  - Robots
  - Sensors
  - SWs/IoTs
  - PCs
  - Machine Tools
  - PLCs

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Objective of ORiN

to provide standard methods for accessing FA/robot system information when developing a multi-vendor FA system

• a unified access method
• a common application platform [PC and OS]
• a common API
• a unified user interface

Open Resource Interface for the Network

/ Open Robot Interface for the Network

applications

ORiN

Provider

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ORiN : Features

- Distributed Object
- Device Profiling using
- Web Service

Production line application using ORiN
Virtual robot interface: ORiN

- **RAO**
  - RAO engine: middleware with RAO Interface, which provides common functions to RAO providers as well as client applications
  - RAO provider: software module with portions dependent on respective manufacturers

- **RRD**
  - RRD schema: the data schema that defines names and data types to robot resources of various robot makers according to the XSD (XML data schema) specified by the XML schema
  - RRD data file: actual data is described based on the RRD schema and its schema structure

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Key Technologies for Open Robot Model

- **Robot Access Object (RAO)**
  a middleware that provides standard program interface and services to robot controller based on the distributed object model

- **Robot Resource Definition Format (RRD)**
  a data schema that provides standard format for data from/to robot controller based on the eXtensible Markup Language (XML)

- **Robot Access Protocol (RAP)**
  standard protocol in the Internet using http and XML to allow data-exchange over firewalls
# RAO Engine Class

<table>
<thead>
<tr>
<th>Class name</th>
<th>Resource</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RaoEngine</td>
<td>-</td>
<td>The upper-most ranked class of RAO, which is the only class that can directly create instance externally. [Root class, from which respective classes are generated]</td>
</tr>
<tr>
<td>RaoWorkspace</td>
<td>-</td>
<td>Class that manages robot controllers and users. Note: User class is not supported at present.  [Work class]</td>
</tr>
<tr>
<td>RaoController</td>
<td>Controller</td>
<td>Class that manages the entire resources of robot controller [Controller class]</td>
</tr>
<tr>
<td>RaoVariable</td>
<td>Variable</td>
<td>This handles all variables that are handled by the robot. [Variable class]</td>
</tr>
<tr>
<td>RaoRobot</td>
<td>Robot</td>
<td>Class that handles the information dependent upon the robot arm including arm length and link configuration  [Robot class]</td>
</tr>
<tr>
<td>RaoFile</td>
<td>File</td>
<td>This includes the user program file that operates file-related information within the robot controller.  [File class]</td>
</tr>
<tr>
<td>RaoTask</td>
<td>Task</td>
<td>This handles the status and information relating to the execution type user program within the robot controller.  [Task class]</td>
</tr>
<tr>
<td>RaoStatus</td>
<td>-</td>
<td>Class for debugging, which handles the information relating to the RAO class.  [Status class of RAO (for RAO engine supervision)]</td>
</tr>
</tbody>
</table>

# RAO provider Class

<table>
<thead>
<tr>
<th>Class name</th>
<th>Resource</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RaoProvController</td>
<td>Controller</td>
<td>Controller class dependent upon each robot vendor corresponding to the RaoController [Controller class] It provides the functions relating to controller resources</td>
</tr>
<tr>
<td>RaoProvVariable</td>
<td>Variable</td>
<td>Variable class dependent upon each robot vendor corresponding to the RaoVariable [Variable class] It provides the functions relating to variable resources.</td>
</tr>
<tr>
<td>RaoProvRobot</td>
<td>Robot</td>
<td>Robot class dependent upon each robot vendor corresponding to the RaoRobot [Robot class] It provides the functions relating to robot resources.</td>
</tr>
<tr>
<td>RaoProvFile</td>
<td>File</td>
<td>File class dependent upon each robot vendor corresponding to the RaoFile [File class] It provides the functions relating to file and folder resources.</td>
</tr>
<tr>
<td>RaoProvTask</td>
<td>Task</td>
<td>Task class dependent upon each robot vendor corresponding to the RaoTask [Task class] It provides the functions relating to task resources.</td>
</tr>
</tbody>
</table>
Example: Sequence Chart

Describes controller information.

Describes robot information.

Describes a system variable.

Describes a user variable.

Describes file information.

Describes task information.

<0, *> in the figure means that the allowable description frequency of the classification name on its right side is at least 0, and unlimited at most.

<1, *> in the figure means that the allowable description frequency of the classification name on its right side is at least 1, and unlimited at most.
RRD Optional Data Schema Structure

Note 1) <0, *> in the figure means that the allowable description frequency of the classification name on its right side is at least 0, and unlimited at most.

Note 2) <1, *> in the figure means that the allowable description frequency of the classification name on its right side is at least 1, and unlimited at most.

Implementation
Open Resource Interface for the Network / Open Robot Interface for the Network

ORiN forum
The Japan Robot Association

http://www.orin.jp/
Design and Implementation Policy

**Design policy**
- **Vendor acceptable and useful standard**
  - (1) Loose standardization
    - *allow various types of robot specifications*
  - (2) Expandability
    - *vendor unique option allowed*
  - (3) Modularity
    - *of network protocols applicable to robots in the market*
  - (4) Separation of specifications and implementation
    - *OOP technology*

**Implementation policy**
- **PC technology of the states of art**
  - (1) De-facto standard platforms
  - (2) Distributed object model
    - *Network transparency, Language independence*
  - (3) Extended markup Language (XML)
    - *Standard framework for defining vendor unique specification*

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**RAO Engine and Provider**

- **RAO** provides standard access functions based on distributed objects
- **Provider** absorbs maker specific functions

**Standard Interface for Application Developers**
- Client Applications

**Standard Interface for Robot Manufacturers**
- A Co. Provider

**Robots from various vendors**
- A Co. Controller

**Application**
- Client Applications
- Proxy
- OPC provider
- RRD

**Controller**
- A Co. Provider

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RRD: Robot Resource Definition

Define robot-profiles from vendors using XML.

[Robot profiling data]

RRD provider:
Provider to provide RRD data to applications through RAO

ORiN Applications

Powered By

Remote Maintenance

3D Monitoring

Program Maintenance

Operation Monitoring

The Internet

Mobile Browser / Phone

Office/HQ

LAN

Production Management

Robots

On-site
ORiN: Summary

Device Independent Interface

API

Device Interface

Application Independent Interface

Before

- Close dependency on Devices/Networks/Protocols
- One-off/Order-made
- Low Reliability
- Poor Maintenance

After

- Independency on Devices/Networks/Protocols
- Standard Products
- High Reliability
- Good Maintenance
1999 International Robot Exhibition

- JARA Booth
- More than 40 PCs
- 14 manufacturers (13: robot, 1: PLC)
- Remote connection via ISDN (Tokyo-Kobe)
- Production system management
- Wireless monitoring
- PHS Wireless LAN
- ISDN

2001 International Robot Exhibition

- Various Applications
- 6 major robot makers
- JARA Booth: 5 robots
- Remote maintenance via the Internet
- Ethernet
- Tokyo Big Site

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Merits of RAPI/ORiN

**End Users**
- Multi-vendor system
- Mfg. monitor system
- Remote maintenance

**Software Vendors**
- Market for various application software
- Cost reduction by standard package

**Packages for Industries**

**System Integrators**
- High quality Mfg. System with less-cost
- WEB service solutions

**Manufacturers**
- Reduce development cost for comm. interface and testing
- Interoperability bw. manufacturers

**Expand FA/Robot Application Fields**

- unified access method for robot data exchange
- common application platform and API

Independent from robot/FA-controller architectures
ORiN forum Web-site

http://www.orin.jp/

Open Resource Interface for the Network / Open Robot Interface for the Network
Japan Robot Association

ORiN forum

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