Technical Report
for Industrial Robots and Robot Systems –

Communication

0 Introduction

The purpose of this technical report is to recommend an industry roadmap in robot communication standards that will benefit robot end users by providing a standard methods for accomplishing file transfer utilities, backups, plant-wide software distribution, upload and download verification, change monitoring, a definition for the transport and network layers, and physical wiring requirements.

The recommendations in this report build on the well-established commercial, off the shelf protocols of TCP/IP, and FTP in what is called Wave I. It is anticipated that subsequent Wave II and Wave III recommendations may ultimately provide end users of robots with the following:

- Network domain name service (DNS) to resolve IP addresses from host names
- Address resolution protocol (ARP) to prevent network errors from incorrect manual address entry
- Dynamic host configuration protocol (DHCP) to enable automatic configuration of IP addresses
- Simple network management protocol (SNMP) for reporting events and alarms
- Bootstrap protocol (BOOTP) for disaster recovery
- Other well-established protocols that can simplify the integration of robot controllers with factory data systems

Implementation of these commercial, off the shelf technologies within the robot controller infrastructure will take advantage of the ever reducing component costs in the electronic industry, and provide a bridge to the future with hardware that can be better supported and integrated with other plant systems.

The possible benefits from the use of recommendations in Wave I-Wave III technologies could lead to reduced integration costs, reduced maintenance effort/costs, and increased uptime. For example, the foundation laid by the Wave I – III guidelines could pave the way for the use of technologies like Extensible Markup Language (XML) style sheets, evolving wireless technology, and fast Ethernet to present all robotic devices in a similar fashion on mobile man-machine interfaces. Plant personnel and robot vendors could reduce downtime and resolve problems expeditiously by performing remote diagnostics of equipment over the network.

1 Scope

The use of an enterprise interface for robot controllers allows software applications and robot controllers to transfer files and exchange data. The software applications will be external to the robot system. This wave I version defines minimum guidelines for file transfer related capability.

2 Normative references

3 Definitions

[Clause 2 and 3 content yet to be determined]

4 File transfer requirements

Important uses for the file transfer capability of the enterprise interface include program and data transfers, disaster recovery, change monitoring and software distribution.

This guideline is intended to encourage the use of standard information technology (IT) approaches for file transfer between enterprise devices and robot controllers. This will simplify the integration of robot systems into the factory and minimize the overall system cost and support.

4. 1 Program and data transfers

A primary use of the enterprise interface is for transferring robot application programs and data into and out of the robot controller.

4.2 Disaster recovery

The enterprise file transfer interface can be used for disaster recovery of program and data files assuming that backups have been performed.

4.3 Change monitoring

The robot controller's file transfer enterprise interface can be used to make the currently executing program and data files available for upload and comparisons by an external upload, download, and compare (UDC) application. An example of a UDC application would be one that performs program uploads from and downloads to a manufacturing device. It identifies changes to programs by comparing the current robot program logic running in volatile memory with a master copy retained by the UDC application performing the comparison.

4.4 Software distribution

The enterprise file transfer interface also provides a mechanism for transferring files to a robot controller to be used for application software updates. The actual update process may be controller specific.

5 Network Protocol Implementation

The network protocol implementation shall include the following:

a) The complete communication protocol stack and default robot Ethernet communications configuration parameters shall be resident in the robot controller.

b) The protocol stack shall be automatically activated upon robot controller power up.

c) The robot controller shall require no external devices in order to load any software or perform any other service to maintain communications under normal (non-disaster) operating circumstances.

d) Common, open protocols (e.g., TCP/IP) shall be used to implement the protocol stack for the network interface.

e) The protocol stack shall follow the seven-layer Open Systems Interconnection (OSI) reference model as indicated in Table 1.

f) IP addresses shall be configurable on the robot controller

Table 1

Open Systems Interconnection (OSI) Reference Model Layers	Protocols
Application	File Transfer Protocol (FTP)
Presentation	*no implementation*
Session	*no implementation*
Transport	Transmission Control Protocol (TCP)
Network	Internet Protocol (IP)
Data Link	ANSI/IEEE Standard 802.3
Physical	Ethernet 10/100 with RJ-45 connector .

5.1 Application Protocols

The robot controller shall support the protocols recommended in Table 1.

5.2 Data Transport Protocols

The robot controller shall transport data using the following protocols:

a) Both the presentation and session layers shall be excluded from the network protocol stack; neither one shall be implemented as a null layer.

b) The transport layer, which is used for transporting data from one end system to another end system, shall be implemented using TCP. Refer to RFC 793 for the official specification of the TCP.

c) The network layer, which is used for switching and routing network packets, shall be implemented using the IP. Refer to RFC 791 for the official specification of the IP.

d) The data link layer, which is used for point-to-point frame relaying, shall be implemented using the ANSI/IEEE Standard 802.3.

NOTE - A null layer implementation provides interfaces to the upper and lower neighboring layers without performing any functionality of that layer. In effect, it only passes data from one interface to another.

6 Network Services

6.1 Performance with Respect to Robot

Network services shall not adversely impact the performance of the robot at any time.

6.2 File Transfer Service

The robot controller shall provide a network interface capable of handling file transfers to and from software application(s) over a plant-wide network. The robot controller's network interface shall facilitate bi-directional file transfers with respect to the robot controller:

- an upload to the application and
- a download from the application.

6.3 File Transfer Service Implementation

For the application of file exchange, the application layer shall be implemented using file transfer protocol (FTP). Refer to RFC 959 for the official specification of the FTP.

a) FTP shall be the protocol used for both directions of file exchange.

b) The robot controller shall act as both an FTP server and client for file transfer exchange.

6.4 Robot Data File Categories

At times it will be necessary to upload/download only robot data files related to a specific functional area of the robot controller. For this purpose, robot data files related to a functional area are categorized into (typical) groups as described in Table 2.

Table 2

Robot Data File Group	Description
Operating System	Files related to the robot operating system's configuration.
Supplier Application Files	Application files, pertinent to the manufacturing process, which are provided by the supplier and are common to a number of robots.
User Application Files	Application files, pertinent to the manufacturing process, which are customized by the user and are common to a number of robots.
Robot Path Files	Files related to specific robot functions such as robot path and variable data customizable by the robot plant floor operator.
Robot Specific Data Files	Robot specific files containing calibration and configuration data, I/O mapping.
Error Log	Robot system error log files.

The following list designates robot data file categories:

a) The robot supplier shall provide technical information which:
   - categorizes each of their specific files into the appropriate robot data file group; and
   - describes the specific conditions required to upload/download robot data file groups

b) The robot controller shall enable the user to upload/download individual files within:
   - the operating system group;
   - the supplier application file group;
   - the user application file group; and
   - the robot path file group
   - the robot specific data file group.

The robot controller should enable the user to upload all files within the error log group

Annex A

(informative)

Bibliography

Internet Engineering Task Force (IETF) Request for Comment (RFC) 791, Internet Protocol (IP)

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IETF RFC 2131, Dynamic Host Configuration Protocol (DHCP)

IETF RFC 2132, DHCP Options and BOOTP Vendor Extensions

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