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INFORMATION TECHNOLOGY – RESPONSIVE LINK (RL)

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This International Standard has been approved by vote of the member bodies, and the voting results may be obtained from the address given on the second title page.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

INTRODUCTION

The Responsive Link standard defines a real-time communication protocol between computers networked in a machine or in a site with point-to-point interfaces. Complex machines, such as robots, automobiles and network routers, have a growing demand for distributed processing. In addition, modernization of facilities such as factories, offices, schools and homes is creating a ubiquitous computing environment. Unlike conventional PC applications for documentation and internet applications that exchange texts without hard time constraints, these types of cooperative computing require real-time and reliable responses to physical events occurring in the real world. Although most conventional real-time systems employ a single processor that invokes tasks corresponding to outside events, the need for distributed processing architecture is inevitable for the larger-scale systems mentioned above, because operational targets are physically separated and scalable processing power becomes necessary as the number of components increases. For distributed nodes to cooperate in real-time, an interconnecting network shall realize real-time communication. The Responsive Link provides such real-time communication between computers by providing dual full-duplex communication channels, fixed-size prioritized packets, packet overtaking based on priority, and automatic error correction.

Real-time

An operation of a dynamic system is called a real-time operation if the combined reaction- and operation-time of the task is shorter than the allowed maximum delay, with respect to circumstances outside the operation. A system is said to be a hard real-time system if the correctness of an operation depends not only on logical correctness, but also on the time at which it is performed. An operation performed after the deadline is, by definition, incorrect, and has no value. In a soft real-time system the value of an operation declines steadily after the deadline expires. Whether a system is hard real-time or soft real-time and how much time is allowed before a deadline are application dependent.

Although it is known that static estimation of the time required for generating a response is important for a computer to output a response before a deadline, such static estimation is often very difficult or impossible. Instead, most real-time systems rely on priority-based scheduling.

Real-time scheduling

As real-time scheduling algorithms, the earliest deadline first (EDF) scheduler, the rate monotonic (RM) scheduler and their variations have been established, as explained in Annex B. These algorithms commonly schedule tasks based on priorities determined by margins to deadlines. Thus, an important function is preemption, i.e. the scheduler deprives the execution privilege of the lower-priority task and allows the higher-priority task to run.

In order to realize real-time communication, a function similar to task preemption shall also be employed in communication. There are several methods for this communication preemption: provision of two separate channels for high- and low-priority packets, setting different communication paths according to priority and assigning a shorter path for high-priority communication, and allowing higher-priority packets to overtake lower-priority packets. Responsive Link has all of these capabilities.

Important features

Responsive Link has the following distinctive features that allow realization of real-time communication.

- Separation of data transmission and event transmission (see Annex A).
- Prioritized routing: When multiple packets with different priority levels are sent to the same destination, different routes can be set in order to realize exclusive communication lines or detours (see Annex E).
- Priority-based packet overtaking: The packet with the highest priority overtakes the other packets at each node (see Annex B and Annex D).

- Packet acceleration/deceleration using priority replacement: Packet priority can be replaced with a new priority at each node in order to accelerate/decelerate packets under distributed control and realize real-time communication.
- Fixed packet size: 64-byte data and 16-byte event.
- Point-to-point serial link (see Annex A).
- Independent routing of the data link and the event link (see Annex E).
- Hardware forward error correction to prevent retransmission.
- Other useful features are as follows:
  - variable link speeds (533, 267, 133, 66,7, 33,3, 16,7 and 8,3 Mbit/s),
  - automatic reconfiguration (plug & play),
  - topology free,
  - low latency (240 ns required to pass through one routing node at 66,7 Mbit/s).

Typical applications and operations

As a typical application of the Responsive Link, Figure 1 shows a distributed control configuration of a humanoid robot. The electronic control part of the humanoid robot consists of several control nodes with local sensing and actuating devices. The distributed controllers are connected to each other by Responsive Link. In this figure, rectangles represent node controllers, and dotted lines show the Responsive Link cable, which is a point-to-point serial link.

For a humanoid robot to walk stably, a servo loop of 1 ms or shorter is needed. In this configuration, the farthest two nodes can exchange a 16-byte packet within 5 µs. Since the time is guaranteed not to fluctuate, the distributed control of a humanoid is considered to be sufficiently possible.

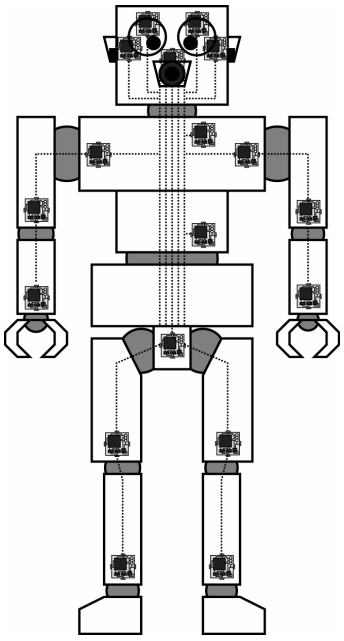

Figure 1 – A humanoid robot

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1 Scope

This International Standard specifies the communications protocol and interface of Responsive Link, the real-time communication for parallel/distributed control. This standard corresponds approximately to the functions specified in layer 1 to layer 4 of the OSI reference model.

The purpose of this standard is to facilitate the development and use of Responsive Link in real-time systems by providing a common data protocol. This standard provides a real-time communication protocol for interconnections among distributed real-time systems, including embedded systems, control systems, amusement systems, robot systems and intelligent buildings.

2 Normative reference

The following referenced document is indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 7498-1, *Open systems interconnection – Basic reference model: The basic model*