Real-Time Ethernet on Top of RTAI

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Overview

• Motivation

• Concepts and Features

• Recent Improvements

• Applications at the RTS

• Summary and Outlook
Motivation

Ethernet technology:

- Inexpensive components
  - Connectors and cables
  - Network adapters
  - Hubs or switches
  - Embedded PCs

- High data rates
  - 10/100/... MBit/s

- Single-cable solution
  - Real-time data and standard TCP/IP over the same link

➡ Software Solution
Open Source License

• Define really open protocols
• Remain vendor independent (long-term availability)
• Create flexible platform for science and industry
• Use of existing OSS
  – Original version (David Schleef, 2000)
  – Drivers (Linux kernel)
  – UDP/IP stack (Linux, only in the beginning, now reference)
  – RTAI as real-time OS
• Build up user and developer community
  – 3rd-party feedback
  – Patches
  – Extensions (drivers, ICMP, etc.)
A Brief Look Inside...

- Linux-like NIC driver layer
- Optional media access control (RTmac)
- VNIC tunnels non real-time traffic
- Extensible stack (Layer 3 and 4)
  - Independent buffer pools (sockets, NICs, VNIC, etc.)
  - IP fragmentation supported with restrictions
- BSD socket API (UDP and Packets)
Real-Time Media Access Control

• Requires dedicated network

• RTmac controls transmission access to NIC

• Multiple access control mechanisms feasible

• Basic TDMA
  – Master transmits periodic synchronization packet (SOF)
  – Clients transmit only within a dedicated slot (offset relative to SOF)
  – Global time stamp service
Real-Time Configuration Protocol

- Generic protocol consisting of 3 stages
- Independent of MAC mechanism (RTmac discipline)
- Stage 1
  - Client invitation
  - Distribution of RTmac configuration
- Stage 2
  - Hardware address exchange
  - Distribution of arbitrary configuration data
- Stage 3
  - Final synchronisation after system initialisation
Network Diagnosis

- RTcap: Real-time capturing support
- Ethereal plug-in (RTmac/TDMA, RTcfg)
RTnet Requirements

- Linux 2.4.19 or better (2.6 is work-in-progress)
- RTAI 24.1.11 or better (including 3.x)
- Available for x86 and PowerPC
- Standard NIC with supported chipset
  - Intel 8255x EtherExpress Pro100
  - DEC 21x4x Tulip
  - RealTek RTL8139
  - AMD PCnet32/PCnetPCI
  - VIA Rhine
  - NatSemi DP8381x
  - MPC8xx (SCC and FEC Ethernet)
  - MPC8260 (FCC Ethernet)
  - SMSC LAN91C111
Recent Improvements

• Release 0.7.0
  – API based on Real-Time Driver Model (RTDM)
  – Rewritten routing system
  – Real-time IP forwarding (allows structured RT networks)
  – Revised and new management tools
    (rtifconfig, rtroute, rtping)

• Real-Time Publish-Subscribe on Top of RTnet
  – OCERA component ORTE runs on RTnet
  – ORTE: GPL implementation of RTI's RTPS protocol
  – Requirements: ORTE CVS check-out, RTAI 3.x, RTnet 0.7.0
  – See www.ocera.org
Experimental Robots at the RTS
MoRob, SPB, LiRE

• MoRob – Modular Educational Robotic Toolbox
  – International project to develop a robotics framework for education and research
  – Covers hardware and software

• SPB – Scalable Processing Box
  – Embedded x86 boards in a box
  – Mass storage: Flash disk
  – CAN, RS-232, RS-485, 1-2 LAN

• LiRE – Linux Real-Time Environment
  – Precompiled embedded Linux/RTAI distribution
  – Runs on SPB and any RTAI-capable x86 box
  – Includes RTnet packages => simple access to RT Ethernet!

www.morob.org
Yet Another RT-Middleware...

TCP Router

TCP/IP

TCP/IP

TCP/IP

TCP Client

TCP Client

TCP Client

Application (e.g. GUI)

FIFOs

User Mode

Kernel Mode

RTnet

RTnet Router

RTnet Router

System A

System B

System C

Mailbox

Mailbox

Mailbox
Distributed Real-Time Computing

- Scenario: Interconnected 3D Laser Scanners
- ca. 100 kByte/s per scanner
- Synchronised time stamps
- Scanners with built-in RTnet
- Remote administration
Summary and Outlook

• RTnet: Software-based hard real-time Ethernet
• Community project maintained by the RTS
• Provides foundation for both direct communication and various real-time middlewares
• Highly flexible, adaptable to project needs (network topology, unicast/broadcast, configuration, etc.)

• TDMA Version 2
  – More flexible slot assignment
  – Hot-plugging
  – Fall-back master
• Support for ARM platforms (depends a bit on RTAI...)
rtnet.sourceforge.net

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