# Implementation of Real-time Network Extension on Embedded Linux

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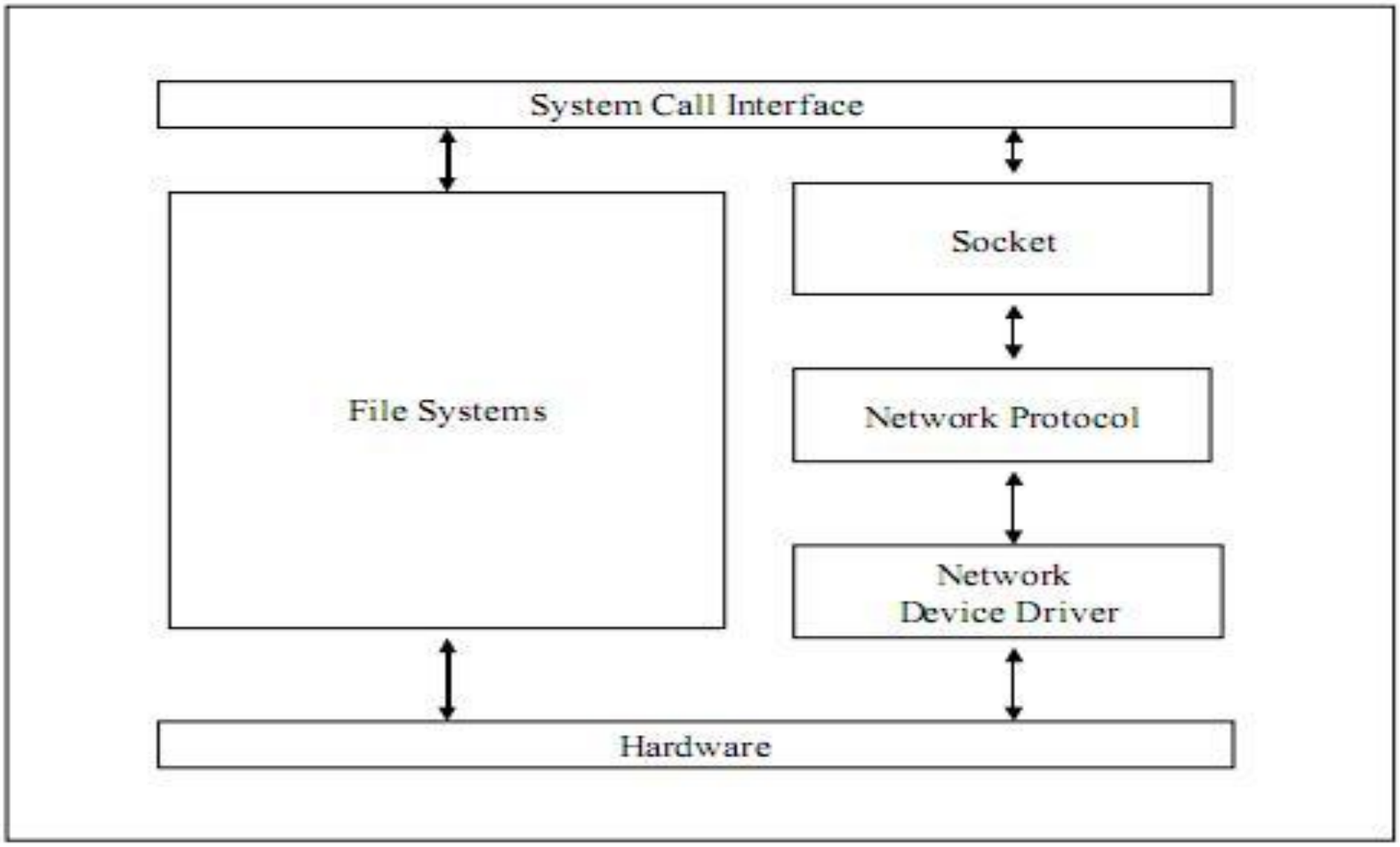
# Topics Covered

- Linux Communication stack
- Embedded Linux
- PowerPC440
- Xenomai
- Rtnet

# Linux Communication stack

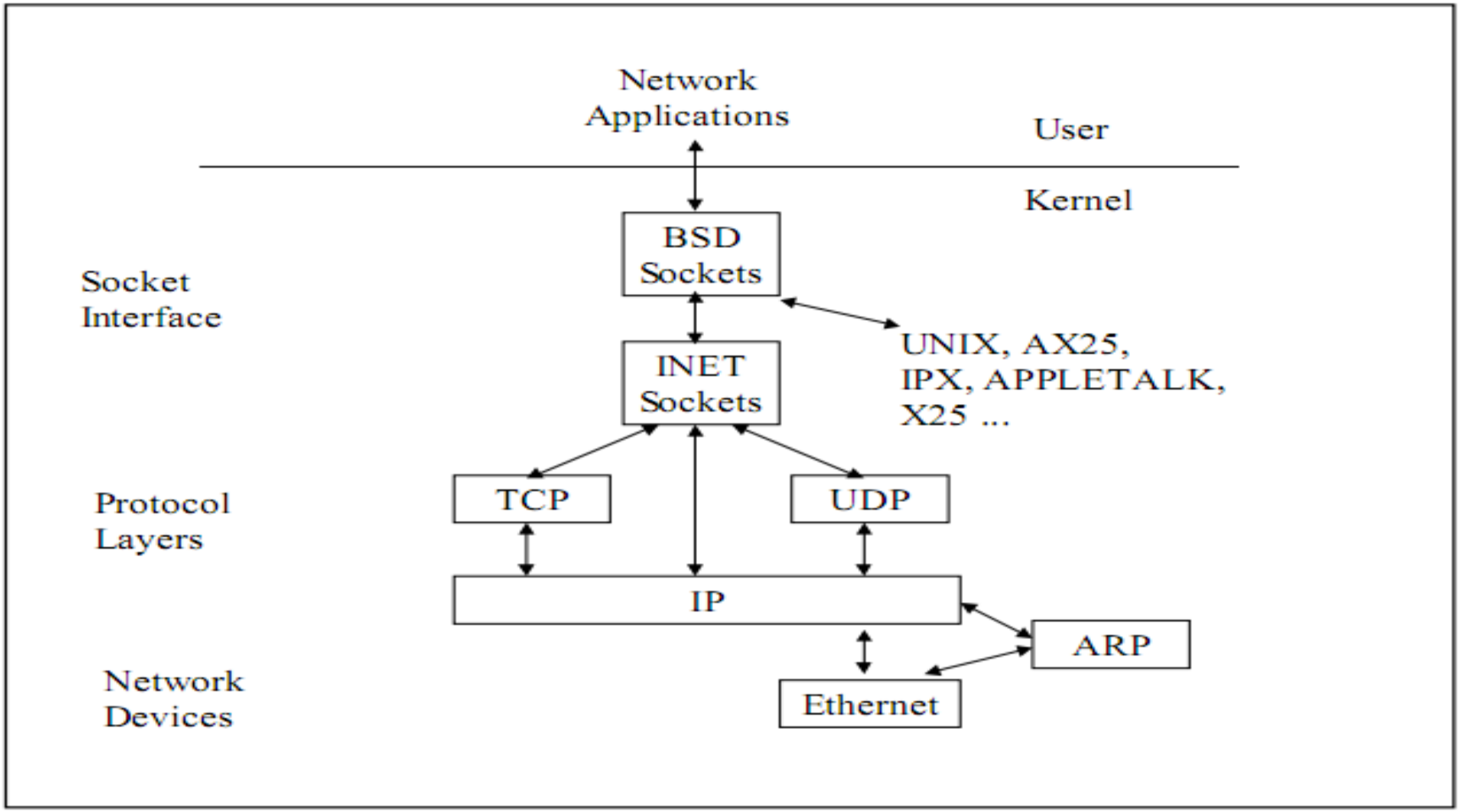
- Hardware
- Network Subsystem
  - Network device driver
  - Network protocol
  - Socket
- File system
- System call interface

# Linux I/O system Architecture




Linux I/O System Architecture.

# Network subsystem




The Layer Architecture of Linux Network Subsystem.

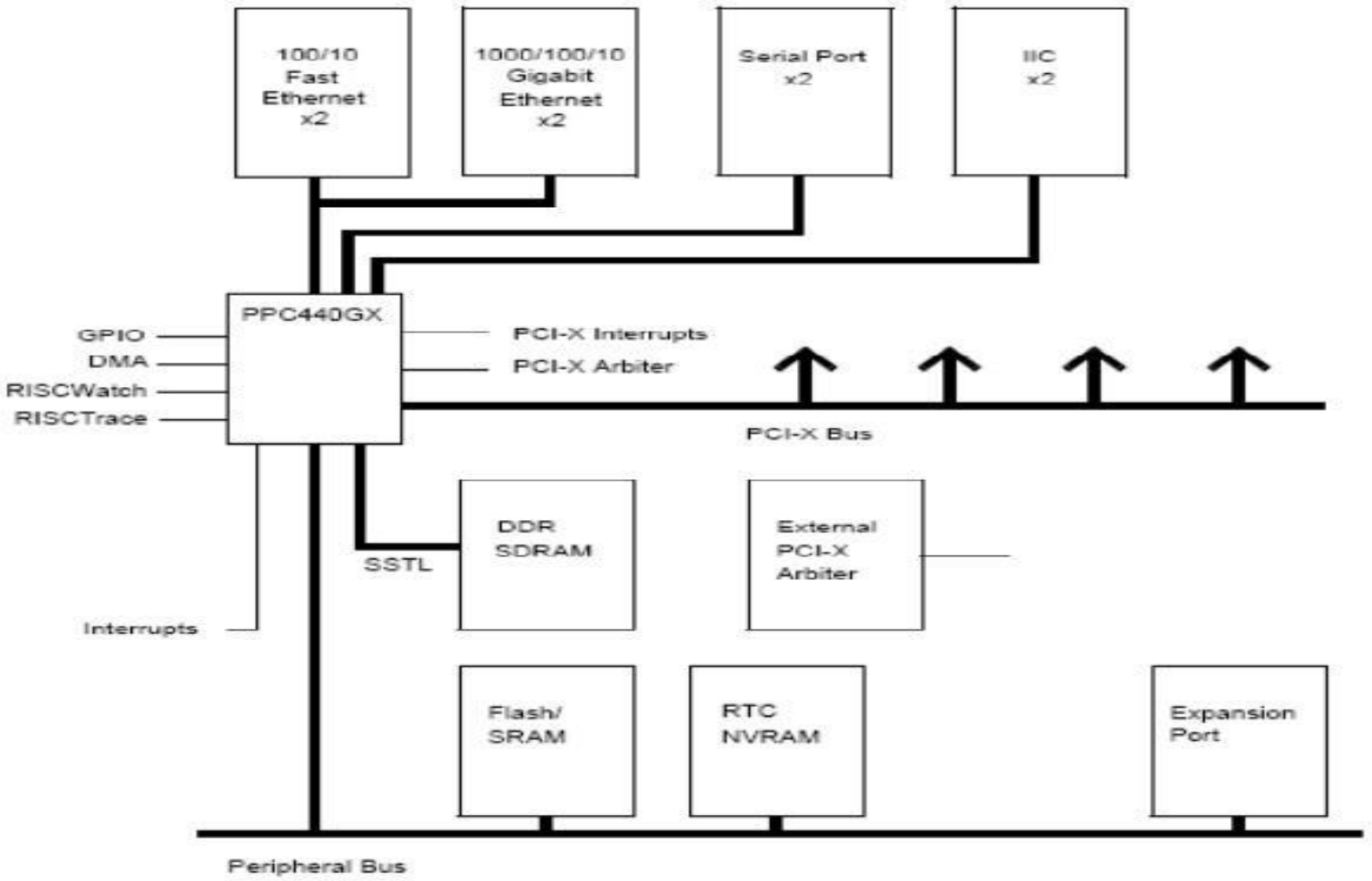
# Embedded Linux ?

# PowerPC440

- Addresses high-end embedded application.
- High performance and low power.
- Wide range of peripheral.

It contains high-performance RISC processor core, DDR SDRAM controller, PCI-X bus interface, Ethernet interface, control for external ROM and peripherals, DMA, serial ports, IIC interface, and general purpose I/O

# Architecture



# Is Linux real-time ?

How to make Linux real time ?

- Using a second kernel to schedule real-time tasks: solutions include Xenomai/ADEOS, RTLinux and RTAI,etc.
- Improving Linux kernel itself with regards to preemption, low latency, etc.

# Setting up Boot loader and Linux Kernel

- U – Boot
- Download the uImage and startup system
- Mounting the root file system.

# Xenomai

A new real-time operation system emulation framework based on Linux.

- Implementing real-time interface
- Debugging real-time software on Linux.
- Migration of application from traditional RTOS APIs to a Linux-based real-time environment.

# Architecture of Xenomai

- Xenomai's task is made real time using Real Time Interface co-kernel.
- Linux kernel has lower priority.
- Possible using Adaptive Domain Environment for Operating Systems ( Adeos )  layer.
- Sharing of hardware interrupts and system originated events like traps and faults.
- Implemented using pipes

# Architecture of Xenomai

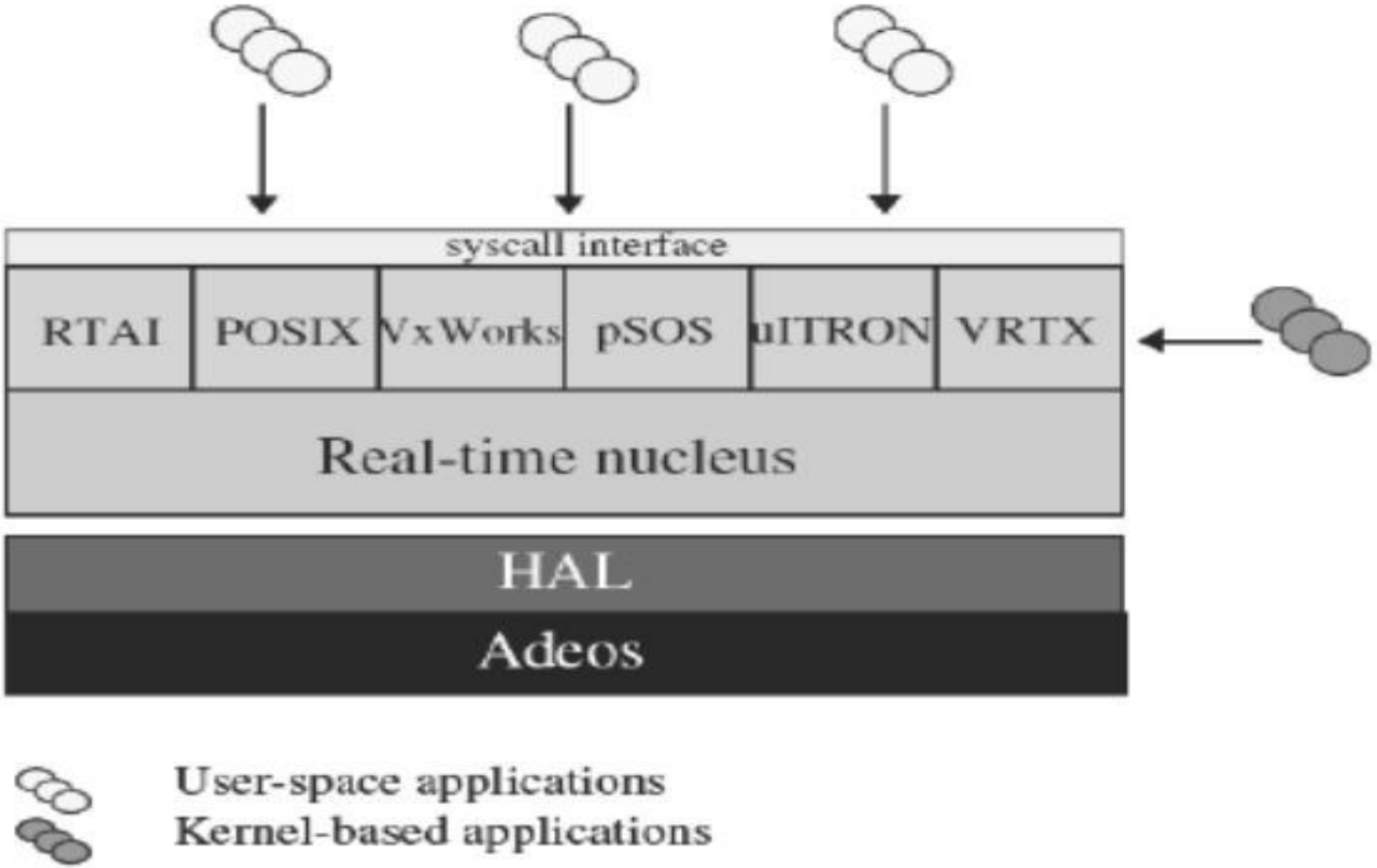



Figure 2. Architecture of Xenomai

# Performance of Xenomai

- Real time thread measuring its scheduled latency over periods of 100uS.
- Posting result on screen every 1 sec using stand Linux services.

**Table 1: Latency without load**

| MIN | MAX | AVG | OVERRUN |
|---|---|---|---|
| -4.226 | -3.574 | 6.385 | 0 |

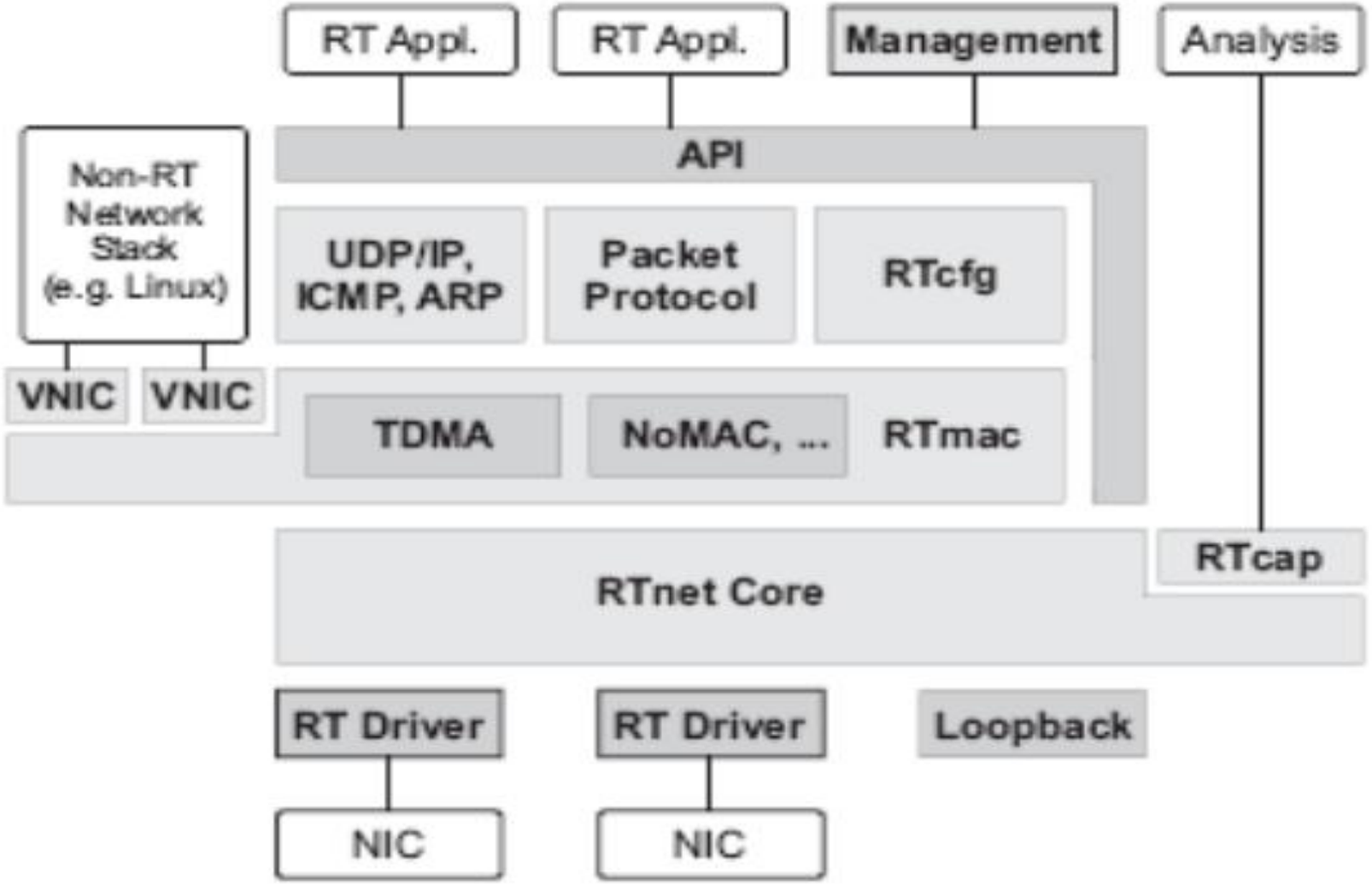
**Table 2: Latency with load**

| MIN | MAX | AVG | OVERRUN |
|---|---|---|---|
| -4.211 | -3.521 | 13.935 | 0 |

# RTnet

- Hard real-time network protocol stack for Xenomai
- Implements UDP/IP, ICMP and ARP in deterministic way
- Provides a POSIX socket API to real time user space processes and kernel modules
- Non deterministic media is managed by the pluggable RTmac layer

# RTnet Stack




RTnet Stack

# Rtnet Testing

- Round Trip Time ( RRT)
- rtping
- Different data size

**Table 3: RTT with RTnet**

| Byte | Min | Avg | Max |
|---|---|---|---|
| 50 | 89 | 96 | 113 |
| 100 | 90 | 105 | 117 |
| 200 | 115 | 125 | 134 |
| 400 | 147 | 161 | 183 |
| 800 | 224 | 235 | 283 |
| 1000 | 263 | 270 | 278 |
| 1460 | 344 | 353 | 364 |

# Conclusion

- Xenomai and RTnet based on Embedded Linux
- Can be used to implement distributed real-time systems, fieldbus coupling devices, low cost real time network analyzer.
- Can optimize network performance.