

# **PC BASED REAL TIME DATA EXCHANGE ON 10GbE OPTICAL NETWORK USING RTOS\***

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# PC BASED REAL TIME DATA EXCHANGE ON 10GbE OPTICAL NETWORK USING RTOS

## Agenda:

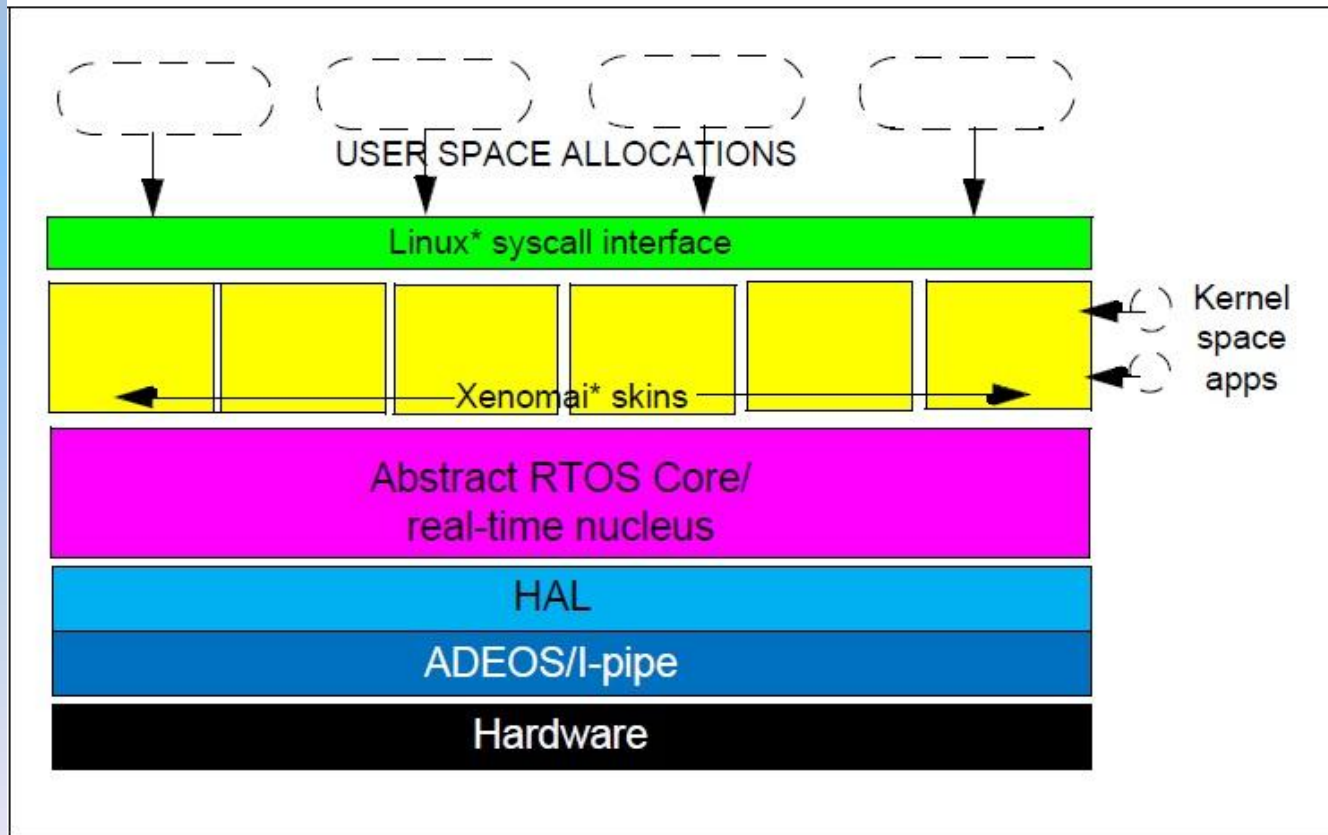
1. Introduction
2. Xenomai and Linux setup
3. 10GbE Ethernet controller – Hardware setup
4. Network performance benchmark tools
5. Results
6. Conclusion

# PC BASED REAL TIME DATA EXCHANGE ON 10GbE OPTICAL NETWORK USING RTOS \*

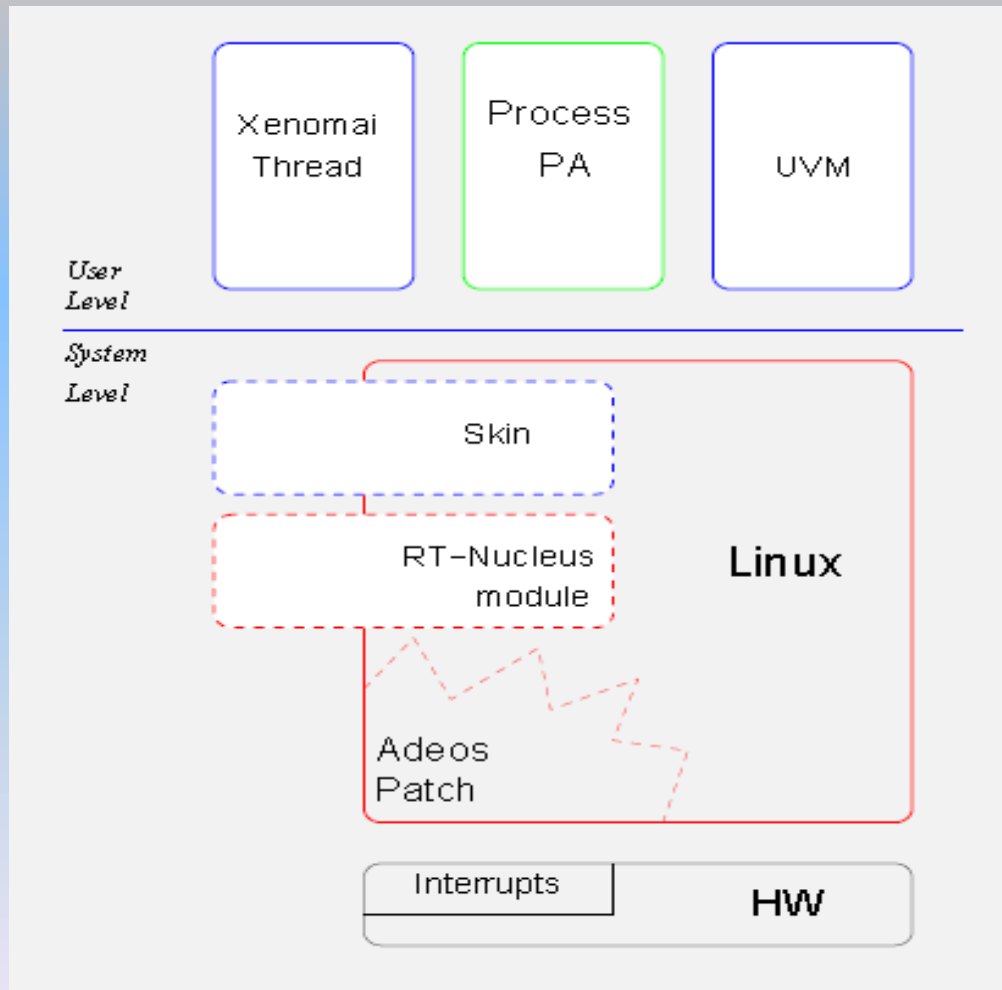
- PC based Real-Time Operating System (RTOS) offers alternative for industrial controls
- Most PCs, operate on a non-real time OS with non-deterministic response to real time events and data
- It is possible to build hard-real time response for user applications on PC - Xenomai framework with RT\_Linux provides a better solution
- Intel's 10GbE PCIe Ethernet controller (82599 chipset) cards, such as X540-T2(RJ45) and X520-SR2 (Optical), with Linux drivers are tested with Xenomai kernel for benchmark

# Xenomai Architecture – Software setup

## Xenomai\* Architecture



# Xenomai, Adeos and Linux



Software versions used

Xenomai ver 2.6.1 with  
Adeos patch 3.2.21 –  
x86-1.patch

Applied the patch on  
Vanilla Kernel – 3.2.21  
(Ubuntu OS 12.04)

Resultant kernel is  
with Xenomai  
framework – confirmed  
with Xeno-Test.

# 10GbE Ethernet – Hardware setup

- Test node for Cat6A: PC Core i5-CPU with PCIe 2.0 x8 host interface;  
Ethernet controller card: Intel X540-T2 10GbE dual adapter with 2xRJ45 for Cat6A cable.
- Test node for Optical: PC Core i5- CPU with PCIe 2.0 x8 host interface;  
Ethernet controller card: Intel X-520-SR2; Intel 82599 based 10GbE dual port optical network adapter; Optical cable is LC/LC multimode fibre.

# Intel X540-T2 10GbE Dual Adapter – Cat6A



This Ethernet Converged Adapter X540-T2 is the latest 10GbE adapter with compatibility to 1GbE. Supports hardware IEEE1588, virtualization and Linux.

# Intel X520-SR2 10GbE Dual Adapter - Optical



Intel's Ethernet X520-SR2 Adapter for Optical interface is flexible and scalable. Supports hardware IEEE1588, Virtualization and Linux.



# Network Performance Benchmark Tools

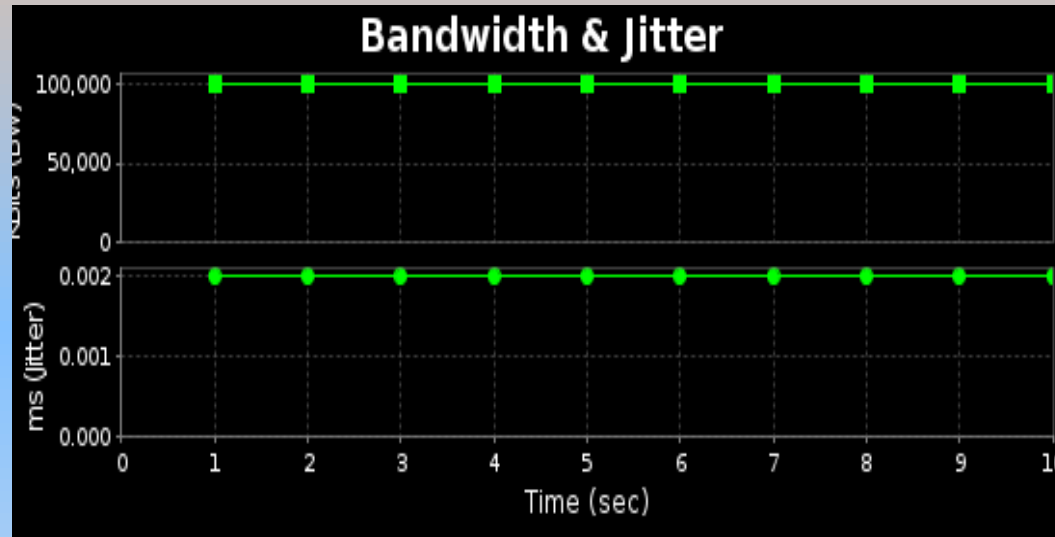
Standard benchmark tools used

- Jperf
- Netperf
- Iperf
- Tshark etc.

Tests for UDP and TCP protocol

Jitter, Transaction rate, bandwidth and RTT

# Performance for UDP protocol - server (lower bandwidth – no data loss)

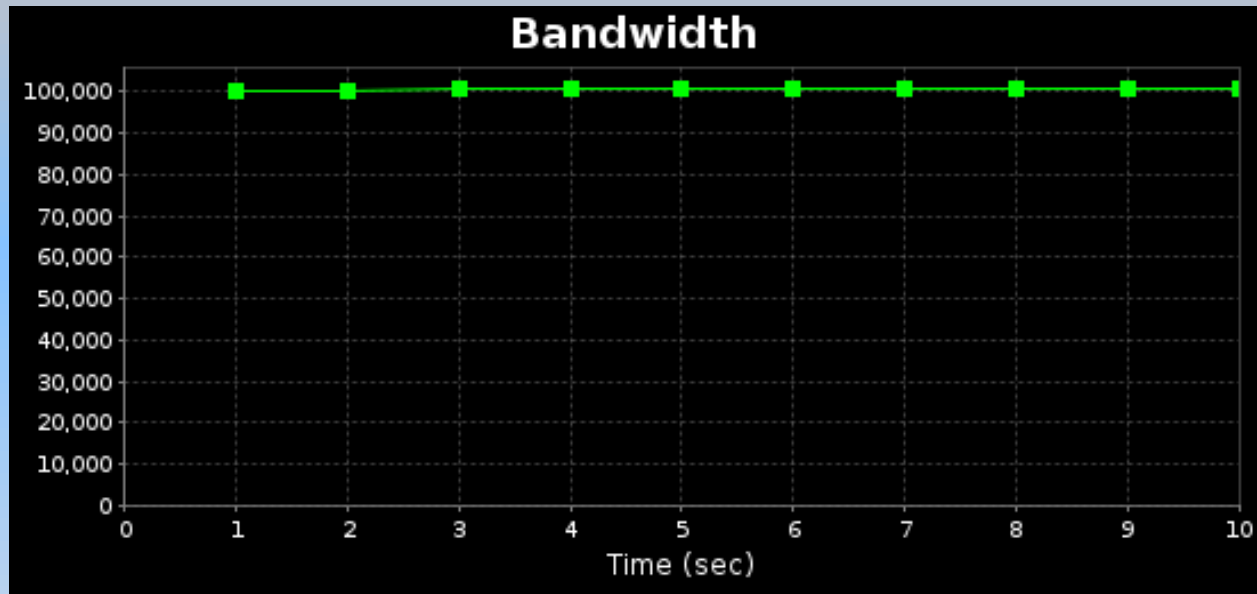


UDP Server with jitter of 2uSec,

Transfer	Bandwidth	Jitter	Lost/Total Datagrams
122649 KBytes	100454 Kbps	0.002 ms	0/85436 (0%)

UDP Server output

# Performance for UDP protocol - client



Transfer	Bandwidth
122649 KBytes	100453 Kbits/sec
UDP Client output	

## Performance for UDP protocol (higher bandwidth – higher data loss)

UDP server output with BW = 1Gbps

```
iperf -s -u -P 0 -i 1 -p 5001 -C -f g
```

Interval	Bandwidth	Jitter	Lost/Total Datagrams
0.0-10.0 sec	0.68 Gbits/sec	0.002 ms	4566/582135 (0.78%)
0.0-10.0 sec 1 datagrams received out-of-order			

# Transaction Rate for UDP protocol

Netperf result for UDP protocol

```
NEWI5:~# netserver -L 192.168.10.1 -p 5679  
Starting netserver with host '192.168.10.1' port '5679' and  
family AF_UNSPEC
```

```
NEWI5:~$ netperf -t UDP_RR -L 192.168.10.2 -H  
192.168.10.1 -p 5679
```

Socket Send bytes	Size Recv Bytes	Request Size bytes	Resp. Size bytes	Elapsed Time secs.	Trans. Rate per sec
163840	163840	1	1	10.01	102245.9

# Netperf command and result for CPU utilization

Netperf command for UDP request response with CPU utilization

**NEWI5:~# netserver -L 192.168.10.1 -p 9999**

**NEWI5:~\$ netperf -t UDP\_RR -L 192.168.10.2 -H 192.168.10.1 -p 9999 -c -C**

Socket Send bytes	Size Recv bytes	Reques t Size bytes	Resp. Size bytes	Elapse d Time Secs.	Trans. Rate per sec	CPU local % S	CPU remote % S	S.dem local us/Tr	S.dem remote us/Tr
163840	163840	1	1	10.01	98200. 4	22.72	22.72	9.255	9.255

# Performance for TCP protocol (no data loss)

## Command and result for TCP protocol

**NEWI5:~# netserver -L 192.168.10.1 -p 5679**

Starting netserver with host '192.168.10.1' port '5679' and family AF\_UNSPEC

**NEWI5:~\$ netperf -t TCP\_RR -L 192.168.10.2 -H 192.168.10.1 -p 5679**

MIGRATED TCP REQUEST/RESPONSE TEST from 192.168.10.2 () port 0 AF\_INET to 192.168.10.1 () port 0 AF\_INET : first burst 0

Socket	Size	Request	Resp.	Elapsed	Trans.
Send	Recv	Size	Size	Time	Rate
bytes	Bytes	bytes	bytes	Secs.	per sec
16384	87380	1	1	10.01	82986.52

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RTT, as given by ping command

```
NEWI5:~# ping -I 192.168.10.1 192.168.10.2
```

```
64 bytes 192.168.10.2: icmp_req=4 ttl=64 time=0.006 ms
```

```
6 packets Tx, 6 received, 0% packet loss, time 5000ms
```

```
rtt min/avg/max/mdev = 0.006/0.010/0.022/0.006 ms
```



# Conclusion

- Linux kernel with Xenomai extension can provide Hard real time performance,
- Intel's 10GbE Ethernet controllers are useful for complex applications. The RTT of the order of 6 to 10 uSec is possible.
- TCP protocol offers reasonable performance with higher reliability. UDP protocol may be used for lower bandwidth application, however at higher bandwidth the data loss increases.
- For multiple node networks, TCP protocol is recommended. A real time network with the order of 10uSec round trip time is possible with pre-emptive Linux, using Xenomai framework system.

# **PC BASED REAL TIME DATA EXCHANGE ON 10GbE OPTICAL NETWORK USING RTOS \***

Thank you....

Questions?

# Notes:

- Xenomai 2.6.1 was released on July 10, 2012
- RTnet driver for 10GbE card is not yet available, however, the MSI-X can set the interrupt priority
- Other methods for RT nucleus module are under investigation