Evaluation of Performance Differences of Xenomai Real-Time Operating System on Virtual and Physical Platforms

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PART 1
Introduction

Background of the Study
Objectives

Background

Real-time operating systems play a crucial role in industrial control and embedded systems, ensuring timely response and stability of tasks.

Xenomai, as a powerful real-time operating system, holds significant importance and promising prospects in industrial control systems.

The advantages and challenges of the widespread application of virtualization technology in industrial control systems.

Objectives

Performance evaluation of the Xenomai real-time operating system in virtualized environments and the impact of virtualization technology on real-time operating systems.

Investigating performance optimization and improvement measures to provide guidance for future applications and research.

Exploring the demands and expectations for the application of the Xenomai real-time operating system in virtualized environments.

PART 2

Experimental Setup

Introduction to the experimental environment
Experimental methods
Latency detection

Experimental Environment

1 Environment

VMware ESXI 6.7/ESXI 8.0

Dell 5820 Tower(DDR4 16GB*4、RTX A2000)

Industrial Personal Computer

Xenomai-3.2+Linux 5.10

Network boot

2 Test

CPU & GPU Test

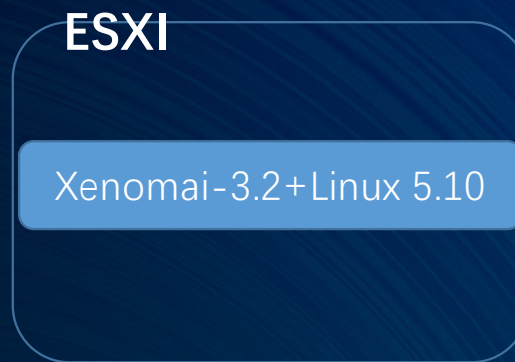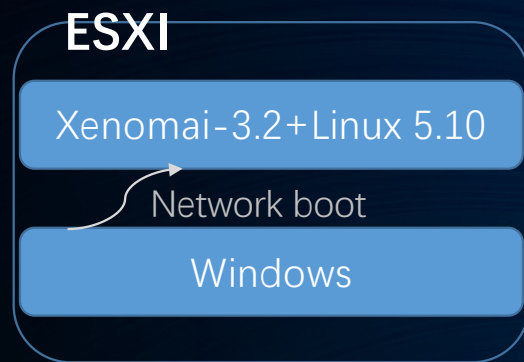Latency Test

Experimental methods

Stress Test – 3DMark

GPU Score /CPU Score	Individual		concurrent	
	GPU1	GPU2	GPU1	GPU2
Avg	615.3/1651.3	5763.6/6893	627.6/1656.6	5779.3/6333.3

GPU Score /CPU Score	ESXI	Physical
	9840/5817	9983/5814

Direct pass-through of graphics cards on ESXi,

as well as CPU and GPU performance on virtual platforms, are both feasible.

Latency Detection

Performance Test Tools and Standards

Severity

限位开关监测
<1ms

磁共振控制
100-800us

PID控制器
1-5ms

音频处理   VOIP
1-20ms   500ms

游戏画面渲染
2-25ms

模拟系统
分钟-小时
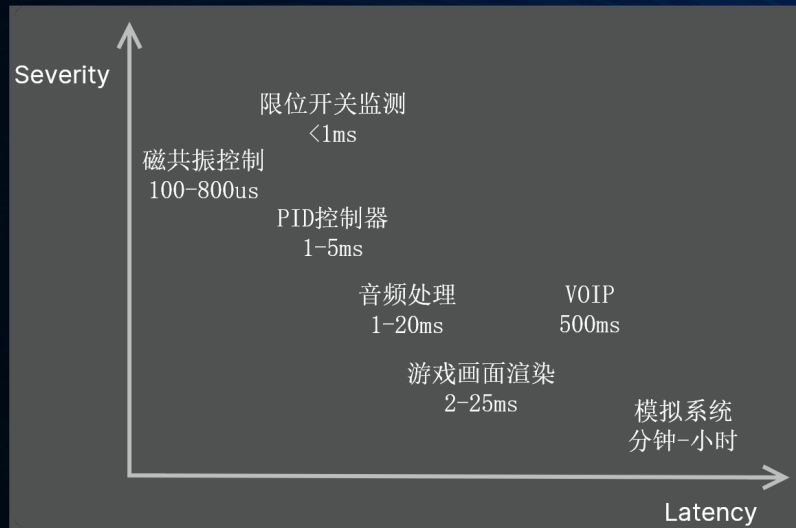
Latency

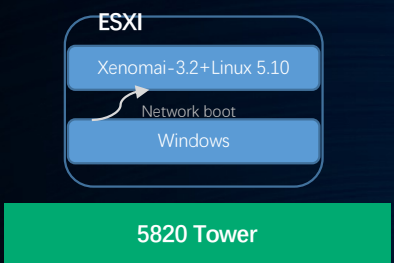## Own Testing Software

Running the Software

<800μs

PART 3

Performance Evaluation

Comparison of Real-time Performance
Analysis of Latency
Results of Optimization Efforts

Latency Performance

Latency Performance on Virtual Platform

ESXI

Xenomai-3.2+Linux 5.10

Network boot

Windows

5820 Tower

```
RTD|    -0.513|    0.608|  2333.112|    434|     0|   -1.331|  2333.112
RTD|    -1.255|    0.729|  1521.867|    474|     0|   -1.331|  2333.112
RTD|    -0.929|    0.539|  2285.148|    504|     0|   -1.331|  2333.112
```
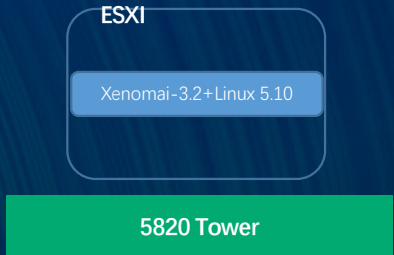
noStress	user-task latency(us)	kernel-task latency(us)
lat min	1.087	-1.356
lat avg	2.002	0.601
lat max	2403.469	2333.112

```
C---|----------|----------|----------|----------|----------|----------
---
RTS|    -1.356|    0.601|  2333.112|    743|     0| 00:00:31/00:00:31
```

noStress	user-task latency(us)	kernel-task latency(us)
lat min	1.091	-0.299
lat avg	2.025	-0.011
lat max	1940.781	2893.072

ESXI

Xenomai-3.2+Linux 5.10

5820 Tower

Latency Performance

Latency Performance on Physical Platform

IPC

Xenomai-3.2+Linux 5.10

Network boot

5820

Windows
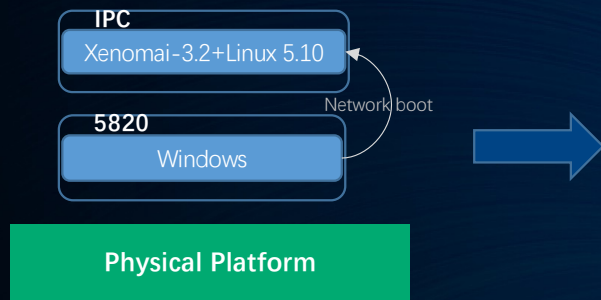
Physical Platform

noStress	user-task latency(us)	kernel-task latency(us)
lat min	-2.539	-2.822
lat avg	-2.136	-2.471
lat max	0.357	-0.110
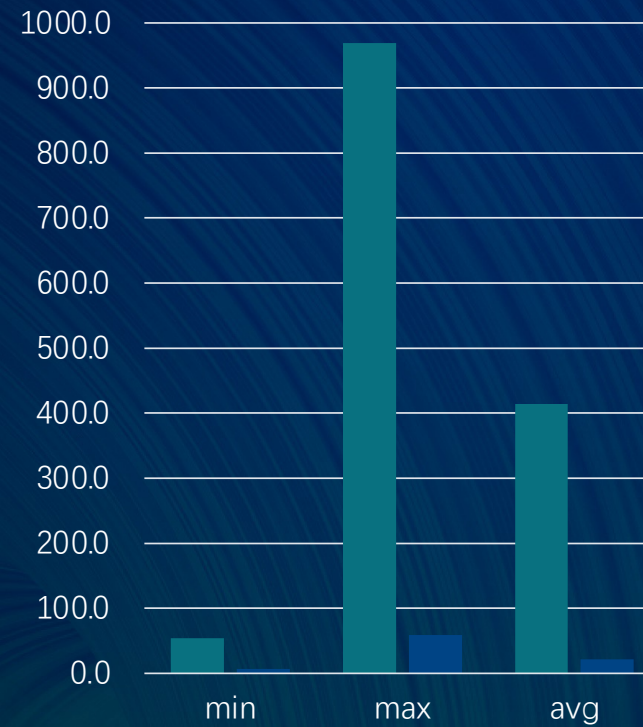
Analysis of Latency

Analysis Procedure

1 Investigation of the impact of virtualization technology on real-time performance

In-depth understanding of the characteristics of ESXi virtualization technology and its limitations and effects on real-time performance.

2 Performance monitoring and analysis

Using performance monitoring tools to monitor and analyze the resource utilization and latency of virtual machines and host machines to determine the performance bottlenecks.

3 Analysis of virtualization technology parameters

Analyzing the impact of ESXi parameter settings on Xenomai real-time performance, such as CPU scheduling policies, memory allocation, etc.

Analysis of Latency

Optimization Scheme

1 **Optimization of virtual machine resource configuration**

Adjusting the allocation of CPU, memory, network, and storage resources for virtual machines to ensure that Xenomai has sufficient resources to support it.

3 **Tuning of host BIOS parameters**

such as high-performance power, disabling hyper-threading, etc.

2 **Tuning of virtualization technology parameters**

Using performance monitoring tools to monitor and analyze the resource utilization and latency of virtual machines and host machines to determine the performance bottlenecks.

Results of Optimization Efforts

noStress	user-task latency(us)	kernel-task latency(us)
lat min	-0.170	-2.295
lat avg	1.862	0.103
lat max	1656.459	1767.215

ESXI

Xenomai-3.2+Linux 5.10

5820 Tower
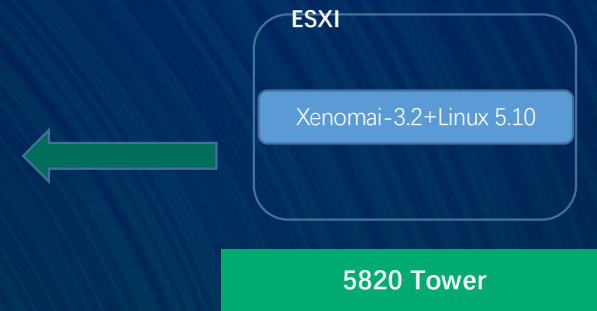
PART 4

Conclusion and Outlook

Conclusion
Outlook

Conclusion

Summary

On the Virtual Platform

unstable latency and significant latency fluctuations

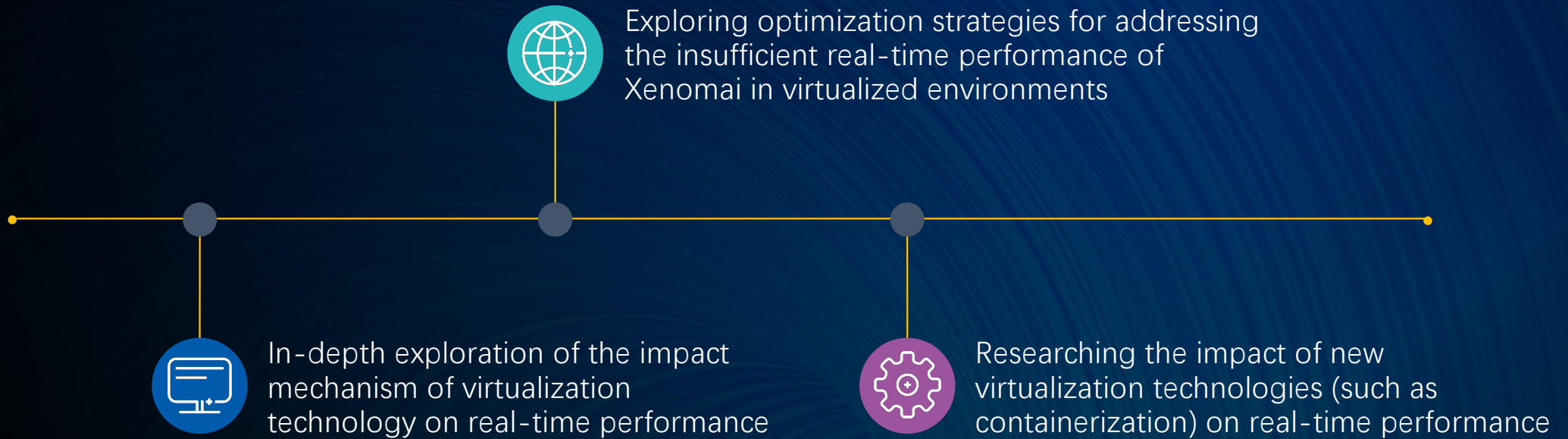**Optimize ESXi Parameter**

no significant improvement in performance

Limitations in this Study

not address other possible factors find effective optimization strategies

Outlook

Future Research Directions

Exploring optimization strategies for addressing the insufficient real-time performance of Xenomai in virtualized environments

In-depth exploration of the impact mechanism of virtualization technology on real-time performance

Researching the impact of new virtualization technologies (such as containerization) on real-time performance

Outlook

In-depth Exploration

Virtualization technology on real-time performance
Optimization Strategies

More offline activities

More communication
More sharing

Community Suggestions and Expectations

Collaboration
Knowledge Sharing
Innovation

Thanks!