Rockchip RealTime Linux Performance Test Report

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Preface

With the increasing demand for real-time performance of products, the real-time performance of standard Linux can no longer meet the needs of many products. It is necessary to optimize standard Linux to improve real-time performance, such as: PREEMPT_RT patches, Xenomai real-time system.

Overview

This document provides real-time performance test data of Rockchip chips under different RT Linux implementations.

Product Version

Chip Name	Kernel Version
RK3568	kernel-4.19
RK3562	kernel-5.10
RK3588	kernel-5.10
RK3576	kernel-6.1

Target Audience

This document (this guide) is mainly applicable to the following engineers:

Technical Support Engineers

Software Development Engineers

Hardware Development Engineers

Revision Record

Version Number	Author	Modification Date	Modification Description
V1.0.0	Chen Liang	2023-08-14	Initial version
V1.0.1	ZhiZhan Chen	2023-10-07	Modified RK3568 related description
V1.0.2	Caesar Wang	2024-06-20	Added RK3576 support Modified some section contents

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1. Introduction to Real-Time Linux

The standard Linux system aims to construct a complete and stable open-source operating system, striving to reduce the average system response time and enhance throughput. It focuses on the overall functional requirements of the operating system to achieve better average performance. Therefore, standard Linux does not offer hard real-time capabilities.

To address the issue of Linux's lack of hard real-time features, several hard real-time solutions based on Linux have emerged, which can be categorized into two types:

- Direct modification of the Linux kernel source code: Making subtle changes to the Linux kernel code without extensive alterations, and transforming Linux into a fully preemptive real-time system by directly modifying the kernel source code in compliance with the GPL license. The disadvantage is that by modifying the Linux kernel, it is difficult to ensure that the execution of real-time processes will not be disturbed by unpredictable activities of non-real-time processes. The representative of this method is RT-patch (Real Preemption Patch).
- Dual-kernel approach: Adding a real-time kernel that coexists with the Linux kernel in the kernel space, and scheduling the standard Linux kernel as a regular process on the real-time kernel. The advantage is that it can achieve hard real-time performance and conveniently implement a new scheduling strategy. Common dual-kernel methods include RT-Linux, RTAI (Real-Time Application Interface), and Xenomai, which offer good real-time performance.

2. Real-time Performance Testing

2.1 RK3568

Configuration	Description
CPU	4xA55, 1314 MHz (PVTPLL@0.9V@len=0x43)
CACHE	L1-32K, L2-0K, L3-512K
DDR	DDR4, 1560M
OS	Android-13, kernel-4.19
BL31	rk3568_bl31_rt_v1.01.elf (optimize RT latency)

2.1.1 No-Load Test

2.1.1.1 PREEMPT_RT Patch

```
rk3568_t:/ # /data/cyclictest -c 0 -m -n -t 4 -p 99
# /dev/cpu_dma_latency set to 0us
policy: fifo: loadavg: 1.70 1.98 2.00 1/1142 3765

T: 0 ( 3920) P:99 I:1000 C:1569551 Min:      8 Act:   11 Avg:   13 Max:      75
T: 1 ( 3921) P:99 I:1500 C:1046353 Min:      9 Act:   13 Avg:   13 Max:      69
T: 2 ( 3922) P:99 I:2000 C: 784755 Min:      9 Act:   11 Avg:   14 Max:      81
T: 3 ( 3923) P:99 I:2500 C: 627795 Min:      9 Act:   12 Avg:   13 Max:      98
(Testing for 1 hour)
```

2.1.1.2 Xenomai Cobalt Mode

```
rk3568_t:/ # /data/cyclictest -c 0 -m -n -t 4 -p 99
# /dev/cpu_dma_latency set to 0 microseconds
policy: fifo: loadavg: 0.29 0.18 0.12 1/1107 4216

T: 0 ( 4021) P:99 I:1000 C:12501264 Min:      1 Act:    8 Avg:    7 Max:      68
T: 1 ( 4022) P:99 I:1500 C:8334176 Min:      2 Act:    8 Avg:    7 Max:      70
T: 2 ( 4023) P:99 I:2000 C:6250631 Min:      2 Act:    9 Avg:    8 Max:      66
T: 3 ( 4024) P:99 I:2500 C:5000505 Min:      2 Act:    6 Avg:    7 Max:      58
(Testing for 3 hours)
```

2.1.2 Pressure Test 1

`stress-ng -c 4 --io 2 --vm 1 --vm-bytes 4M --timeout 1000000s`

2.1.2.1 PREEMPT_RT Patch

```
rk3568_t:/ # /data/cyclictest -c 0 -m -n -t 4 -p 99
# /dev/cpu_dma_latency set to 0us
policy: fifo: loadavg: 9.36 9.67 9.84 8/1152 3678

T: 0 ( 3482) P:99 I:1000 C:5892687 Min: 9 Act: 20 Avg: 25 Max: 123
T: 1 ( 3483) P:99 I:1500 C:3928444 Min: 9 Act: 20 Avg: 25 Max: 116
T: 2 ( 3484) P:99 I:2000 C:2946323 Min: 9 Act: 13 Avg: 26 Max: 120
T: 3 ( 3485) P:99 I:2500 C:2357050 Min: 10 Act: 20 Avg: 26 Max: 126
(Testing for 2 hours)
```

2.1.2.2 Xenomai Cobalt Mode

```
rk3568_t:/ # /data/cyclictest -c 0 -m -n -t 4 -p 99
# /dev/cpu_dma_latency set to 0us
policy: fifo: loadavg: 7.65 7.80 7.75 8/1118 3998

T: 0 ( 3492) P:99 I:1000 C:21069118 Min:      2 Act:    4 Avg:   13 Max:       85
T: 1 ( 3493) P:99 I:1500 C:14046070 Min:      2 Act:   13 Avg:   15 Max:       76
T: 2 ( 3494) P:99 I:2000 C:10534550 Min:      2 Act:    6 Avg:   16 Max:       70
T: 3 ( 3495) P:99 I:2500 C:8427637 Min:       2 Act:   15 Avg:   15 Max:       96
(Testing for 5 hours)
```

2.1.3 Pressure Test 2

`stress-ng -c 4 --io 2 --vm 1 --vm-bytes 4M --timeout 1000000s` + Fishing Expert

2.1.3.1 PREEMPT_RT Patch

```
rk3568_t:/ # /data/cyclictest -c 0 -m -n -t 4 -p 99
# /dev/cpu_dma_latency set to 0us
policy: fifo: loadavg: 11.92 12.59 12.59 9/1196 3372

T: 0 ( 1796) P:99 I:1000 C:52099573 Min:      9 Act:   34 Avg:   30 Max:      176
T: 1 ( 1797) P:99 I:1500 C:34733036 Min:      9 Act:   41 Avg:   32 Max:      165
T: 2 ( 1798) P:99 I:2000 C:26049766 Min:     10 Act:   55 Avg:   32 Max:      171
T: 3 ( 1799) P:99 I:2500 C:20839804 Min:     10 Act:   26 Avg:   31 Max:      156
(Testing for 12 hours)
```

2.1.3.2 Xenomai Cobalt Mode

```
rk3568_t:/ # /data/cyclictest -c 0 -m -n -t 4 -p 99
# /dev/cpu_dma_latency set to 0us
policy: fifo: loadavg: 10.21 10.06 9.99 10/1193 3177

T: 0 ( 2062) P:99 I:1000 C:41956558 Min:      2 Act:   34 Avg:   20 Max:      112
T: 1 ( 2063) P:99 I:1500 C:27971036 Min:      2 Act:   29 Avg:   20 Max:      128
T: 2 ( 2064) P:99 I:2000 C:20978270 Min:      2 Act:   30 Avg:   18 Max:       82
T: 3 ( 2065) P:99 I:2500 C:16782616 Min:      2 Act:   28 Avg:   18 Max:      105
# (Test duration: 12 hours)
```

2.2 RK3562

Configuration	Description
CPU	4xA53, 2016MHz
CACHE	L1-32K, L2-512K
DDR	LP4X, 1320M
OS	BUILDROOT, kernel-5.10

2.2.1 No-Load Test

2.2.1.1 PREEMPT_RT Patch

```
root@rk3562-buildroot:/# cyclictest -c 0 -m -n -t 4 -p 99
# /dev/cpu_dma_latency set to 0us
policy: fifo: loadavg: 1.00 1.26 1.31 1/202 1344

T: 0 ( 1152) P:99 I:1000 C:51905271 Min:      4 Act:    6 Avg:    6 Max:       46
T: 1 ( 1153) P:99 I:1500 C:34603508 Min:      4 Act:    6 Avg:    6 Max:       55
T: 2 ( 1154) P:99 I:2000 C:25952627 Min:      4 Act:    6 Avg:    6 Max:       28
T: 3 ( 1155) P:99 I:2500 C:20762098 Min:      4 Act:    6 Avg:    6 Max:       55
(Testing for 14 hours)
```

2.2.1.2 Xenomai Cobalt Mode

```
root@rk3562-buildroot:/# cyclictest -c 0 -m -n -t 4 -p 99
# /dev/cpu_dma_latency set to 0us
policy: fifo: loadavg: 0.02 0.02 0.00 1/152 2459

T: 0 ( 2377) P:99 I:1000 C:14773911 Min:      2 Act:    4 Avg:    4 Max:       31
T: 1 ( 2378) P:99 I:1500 C:9849274 Min:      2 Act:    4 Avg:    4 Max:       28
T: 2 ( 2379) P:99 I:2000 C:7386955 Min:      2 Act:    4 Avg:    4 Max:       18
T: 3 ( 2380) P:99 I:2500 C:5909564 Min:      2 Act:    4 Avg:    4 Max:       32
(Testing for 4 hours)
```

2.2.2 Pressure Testing

```
stress -c 4 --io 2 --vm 1 --vm-bytes 256M --timeout 1000000s
```

2.2.2.1 PREEMPT_RT Patch

```
root@rk3562-buildroot:/# cyclictest -c 0 -m -n -t 4 -p 99
# /dev/cpu_dma_latency set to 0us
policy: fifo: loadavg: 9.42 8.33 8.61 9/220 1477

T: 0 ( 1472) P:99 I:1000 C:7971377 Min:      4 Act:    8 Avg:   10 Max:       69
T: 1 ( 1473) P:99 I:1500 C:5314247 Min:      5 Act:   16 Avg:   12 Max:       72
T: 2 ( 1474) P:99 I:2000 C:3985679 Min:      5 Act:   10 Avg:   10 Max:       63
T: 3 ( 1475) P:99 I:2500 C:3188543 Min:      5 Act:   12 Avg:   12 Max:       76
(2-hour test)
```

2.2.2.2 Xenomai Cobalt Mode

```
root@rk3562-buildroot:/# cyclictest -c 0 -m -n -t 4 -p 99
# /dev/cpu_dma_latency set to 0us
policy: fifo: loadavg: 7.93 7.92 7.92 9/165 2370

T: 0 ( 2266) P:99 I:1000 C:6493284 Min:      2 Act:   11 Avg:    9 Max:      69
T: 1 ( 2267) P:99 I:1500 C:4328849 Min:      2 Act:   12 Avg:   10 Max:      72
T: 2 ( 2268) P:99 I:2000 C:3246637 Min:      2 Act:   11 Avg:    9 Max:      40
T: 3 ( 2269) P:99 I:2500 C:2597305 Min:      2 Act:   13 Avg:    9 Max:      73
(Testing for 2 hours)
```

2.3 RK3588

Configuration	Description
CPU	4xA76(big), 2.2GHz, 4xA55(little), 1.8GHz
CACHE	A76: L1-64K, L2-512K A55: L1-32K, L2-128K
DDR	LP4X, 2112M
OS	BUILDROOT, kernel-5.10

2.3.1 No-load Test

2.3.1.1 PREEMPT_RT Patch

```
root@rk3588:/# cyclictest -c 0 -m -t 8 -p 99
# /dev/cpu_dma_latency set to 0us

policy: fifo: loadavg: 2.71 3.24 3.29 1/322 3955
T: 0 ( 3406) P:99 I:1000 C:6766462 Min:      3 Act:    4 Avg:    4 Max:      11
T: 1 ( 3407) P:99 I:1500 C:4510976 Min:      4 Act:    4 Avg:    4 Max:      13
T: 2 ( 3408) P:99 I:2000 C:3383228 Min:      4 Act:    4 Avg:    4 Max:      13
T: 3 ( 3409) P:99 I:2500 C:2706579 Min:      4 Act:    4 Avg:    4 Max:      13
T: 4 ( 3410) P:99 I:3000 C:2255481 Min:      1 Act:    1 Avg:    1 Max:       8
T: 5 ( 3411) P:99 I:3500 C:1933267 Min:      1 Act:    1 Avg:    1 Max:       7
T: 6 ( 3412) P:99 I:4000 C:1691609 Min:      1 Act:    1 Avg:    1 Max:       8
T: 7 ( 3413) P:99 I:4500 C:1503652 Min:      1 Act:    1 Avg:    1 Max:       8
(2-hour test)
```

2.3.1.2 Xenomai Cobalt Mode

```
root@rk3588:/# cyclictest -c 0 -m -n -t 8 -p 99
# /dev/cpu_dma_latency set to 0us

policy: fifo: loadavg: 0.63 0.60 0.55 1/206 1336
T: 0 ( 1163) P:99 I:1000 C:43237018 Min:      1 Act:    2 Avg:    2 Max:       6
T: 1 ( 1164) P:99 I:1500 C:28824678 Min:      1 Act:    2 Avg:    2 Max:       6
T: 2 ( 1165) P:99 I:2000 C:21618508 Min:      1 Act:    2 Avg:    2 Max:       6
T: 3 ( 1166) P:99 I:2500 C:17294807 Min:      1 Act:    2 Avg:    2 Max:       6
T: 4 ( 1167) P:99 I:3000 C:14412339 Min:      1 Act:    2 Avg:    2 Max:       6
T: 5 ( 1168) P:99 I:3500 C:12353433 Min:      1 Act:    2 Avg:    2 Max:       6
T: 6 ( 1169) P:99 I:4000 C:10809254 Min:      1 Act:    2 Avg:    2 Max:       6
T: 7 ( 1170) P:99 I:4500 C:9608226 Min:       1 Act:    2 Avg:    2 Max:       6
(Testing for 12 hours)
```

2.3.2 Pressure Testing

`stress-ng -c 8 --io 2 --vm 1 --vm-bytes 1024M --timeout 1000000s`

2.3.2.1 PREEMPT_RT Patch

```
root@rk3588:/# cyclictest -c 0 -m -t 8 -p 99
# /dev/cpu_dma_latency set to 0us

policy: fifo: loadavg: 15.20 15.28 15.29 11/345 10678
T: 0 ( 6379) P:99 I:1000 C:6473077 Min:      3 Act:   13 Avg:    7 Max:      28
T: 1 ( 6380) P:99 I:1500 C:4315388 Min:      4 Act:    7 Avg:    7 Max:      24
T: 2 ( 6381) P:99 I:2000 C:3236536 Min:      3 Act:    4 Avg:    6 Max:      24
T: 3 ( 6382) P:99 I:2500 C:2589231 Min:      4 Act:    8 Avg:    7 Max:      30
T: 4 ( 6383) P:99 I:3000 C:2157683 Min:      1 Act:    1 Avg:    2 Max:      16
T: 5 ( 6384) P:99 I:3500 C:1849443 Min:      1 Act:    2 Avg:    2 Max:      15
T: 6 ( 6385) P:99 I:4000 C:1618261 Min:      1 Act:    2 Avg:    2 Max:      16
T: 7 ( 6386) P:99 I:4500 C:1438455 Min:      1 Act:    2 Avg:    2 Max:      15
(2-hour test)
```

2.3.2.2 Xenomai Cobalt Mode

```
root@rk3588:/# cyclictest -c 0 -m -n -t 8 -p 99
# /dev/cpu_dma_latency set to 0us

policy: fifo: loadavg: 12.82 12.81 12.81 11/225 1490
T: 0 ( 1179) P:99 I:1000 C:12797171 Min:      1 Act:    4 Avg:    4 Max:      19
T: 1 ( 1180) P:99 I:1500 C:8531447 Min:       1 Act:    4 Avg:    3 Max:      16
T: 2 ( 1181) P:99 I:2000 C:6398585 Min:       1 Act:    4 Avg:    4 Max:      25
T: 3 ( 1182) P:99 I:2500 C:5118868 Min:       1 Act:    3 Avg:    5 Max:      28
T: 4 ( 1183) P:99 I:3000 C:4265723 Min:       1 Act:    5 Avg:    4 Max:      17
T: 5 ( 1184) P:99 I:3500 C:3656334 Min:       1 Act:    4 Avg:    5 Max:      18
T: 6 ( 1185) P:99 I:4000 C:3199292 Min:       2 Act:    4 Avg:    5 Max:      17
T: 7 ( 1186) P:99 I:4500 C:2843815 Min:       1 Act:    5 Avg:    5 Max:      19
(Testing for 4 hours)
```

2.4 RK3576

Configuration	Description
CPU	4xA72(big): 2.3GHz, 4xA53(little): 2.2GHz
CACHE	A72: L1-I-48K, L1-D-32K, L2-1M A53: L1-I-32K, L1-D-32K, L2-512K
DDR	LP4X, 2112M
OS	BUILDROOT, kernel-6.10

2.4.1 No-Load Test

2.4.1.1 PREEMPT_RT Patch

```
root@rk3576-buildroot:/# cyclictest -c0 -m -t -p99 -D8H
# /dev/cpu_dma_latency set to 0us
policy: fifo: loadavg: 3.50 3.32 3.17 1/309 3491

T: 0 ( 2675) P:99 I:1000 C:28799996 Min:      2 Act:    3 Avg:    3 Max:      34
T: 1 ( 2676) P:99 I:1500 C:19199994 Min:      2 Act:    3 Avg:    3 Max:      25
T: 2 ( 2677) P:99 I:2000 C:14399993 Min:      2 Act:    3 Avg:    3 Max:      27
T: 3 ( 2678) P:99 I:2500 C:11519993 Min:      2 Act:    3 Avg:    3 Max:      28
T: 4 ( 2679) P:99 I:3000 C:9599993 Min:      2 Act:    2 Avg:    2 Max:      17
T: 5 ( 2680) P:99 I:3500 C:8228564 Min:      2 Act:    2 Avg:    2 Max:      19
T: 6 ( 2681) P:99 I:4000 C:7199993 Min:      2 Act:    2 Avg:    2 Max:      16
T: 7 ( 2682) P:99 I:4500 C:6399993 Min:      2 Act:    2 Avg:    2 Max:      16
(Testing for 8 hours)
```

2.4.1.2 Xenomai Cobalt Mode

```
root@rk3576:/# ./usr/demo/cyclictest -c 0 -m -n -t 8 -p 99 -D 2H
# /dev/cpu_dma_latency set to 0us

policy: fifo: loadavg: 0.54 0.54 0.54 1/207 1104
T: 0 ( 1557) P:99 I:1000 C:7199995 Min:      1 Act:    2 Avg:    2 Max:      12
T: 1 ( 1558) P:99 I:1500 C:4799996 Min:      1 Act:    2 Avg:    2 Max:       8
T: 2 ( 1559) P:99 I:2000 C:3599997 Min:      1 Act:    2 Avg:    2 Max:      14
T: 3 ( 1560) P:99 I:2500 C:2879998 Min:      1 Act:    2 Avg:    2 Max:       9
T: 4 ( 1561) P:99 I:3000 C:2399998 Min:      1 Act:    2 Avg:    2 Max:      13
T: 5 ( 1562) P:99 I:3500 C:2057141 Min:      1 Act:    2 Avg:    2 Max:       9
T: 6 ( 1563) P:99 I:4000 C:1799998 Min:      1 Act:    2 Avg:    2 Max:       7
T: 7 ( 1564) P:99 I:4500 C:1599998 Min:      1 Act:    2 Avg:    2 Max:       8
(Testing for 2 hours)
```

2.4.2 Pressure Test

```
stress-ng -c8 --io 8 --cpu-load 100 -vm 4 --vm-bytes 512M --timeout 10000000s
```

2.4.2.1 PREEMPT_RT Patch

```
root@rk3576-buildroot:/# cyclictest -c0 -m -t -p99 -D8H
# /dev/cpu_dma_latency set to 0us
policy: fifo: loadavg: 24.41 23.87 23.55 17/341 2533
T: 0 ( 1425) P:99 I:1000 C:28799993 Min:      3 Act:    6 Avg:    9 Max:       44
T: 1 ( 1426) P:99 I:1500 C:19199994 Min:      3 Act:    7 Avg:    9 Max:       36
T: 2 ( 1427) P:99 I:2000 C:14399992 Min:      3 Act:    7 Avg:    8 Max:       35
T: 3 ( 1428) P:99 I:2500 C:11519992 Min:      3 Act:   11 Avg:   10 Max:       39
T: 4 ( 1429) P:99 I:3000 C:9599985 Min:       2 Act:   10 Avg:    8 Max:       41
T: 5 ( 1430) P:99 I:3500 C:8228558 Min:       2 Act:   12 Avg:    7 Max:       35
T: 6 ( 1431) P:99 I:4000 C:7199986 Min:       2 Act:    8 Avg:    9 Max:       48
T: 7 ( 1432) P:99 I:4500 C:6399988 Min:       2 Act:    6 Avg:    7 Max:       38
(Testing for 8 hours)
```

2.4.2.2 Xenomai Cobalt Mode

```
root@rk3576:/# ./usr/demo/cyclictest -c0 -m -n -t -p99 -D 2H
# /dev/cpu_dma_latency set to 0us
policy: fifo: loadavg: 21.61 21.60 21.64 20/241 1759

T: 0 ( 1653) P:99 I:1000 C:7199993 Min:       2 Act:    7 Avg:    7 Max:       43
T: 1 ( 1654) P:99 I:1500 C:4799991 Min:       2 Act:   11 Avg:    6 Max:       40
T: 2 ( 1655) P:99 I:2000 C:3599991 Min:       2 Act:    5 Avg:    6 Max:       43
T: 3 ( 1656) P:99 I:2500 C:2879986 Min:       2 Act:   16 Avg:    6 Max:       39
T: 4 ( 1657) P:99 I:3000 C:2399988 Min:       2 Act:    7 Avg:    7 Max:       42
T: 5 ( 1658) P:99 I:3500 C:2057132 Min:       2 Act:   12 Avg:    6 Max:       45
T: 6 ( 1659) P:99 I:4000 C:1799991 Min:       2 Act:    7 Avg:    8 Max:       44
T: 7 ( 1660) P:99 I:4500 C:1599991 Min:       2 Act:   16 Avg:    8 Max:       47
(2-hour test)
```