开放原子开源基金会
OPENATOM FOUNDATION

OpenHarmony

技术筑生态 智联赢未来

第二届开放原子开源基金会OpenHarmony技术大会

2023.11.04 I 中国·北京

主办单位：OpenHarmony项目群技术指导委员会（TSC）
合作单位：华为、润开鸿、九联开鸿、软通动力、深开鸿
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基于嵌入式龙芯的OpenHarmony适配移植及工控领域实践

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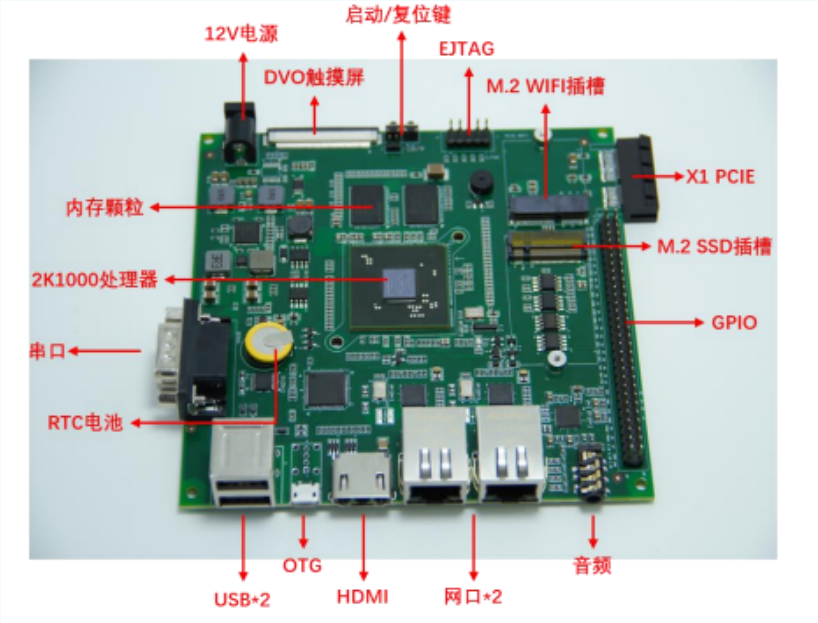
乘风1000开发板实物图及接口



功能	描述
CPU	龙芯 2K1000 处理器
内存	板载 2G DDR3，主频 400Mhz
Bios	8Mb SPI FLASH
GPIO	2.54 间距 27 个可配置 GPIO 插针排
网络	2 个千兆自协商网口（2 个标准接口）
PCIE	1 路 X1 夹板接口 PCIE
EJTAG	1 个 EJTAG 调试接口，可用于程序下载、单步调试
接口	3 路 USB2.0 标准接口（TYPE A USB*2, Micro USB*1） 2 路 CAN 接口，4 路串口(TTL*3, RS232*1)
显示和音频接口	1 路 TYPE A HDMI 接口 DVO 接口适配飞凌嵌入式触摸屏 1 路 3.5mm 标准音频输入/输出接口
存储	M2 接口 支持 SSD 硬盘
电源	12V 3A 圆柱电源
尺寸	120mm*120mm

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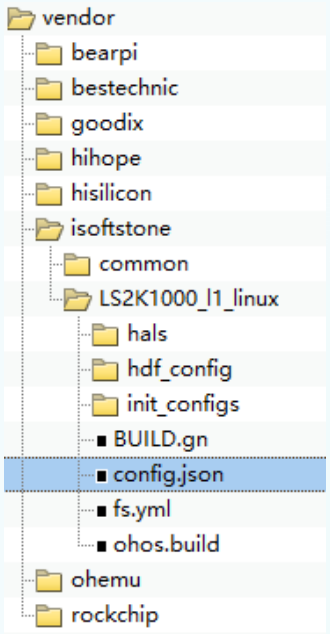
OpenHarmony系统编译构建

龙芯开发板适配工作基于OpenHarmony 3.1 Release版本开发，在码云OpenHarmony开源社区可以下载相关源码。
https://gitee.com/openharmony/manifest/tree/OpenHarmony-3.1-Release



新增产品类型：产品硬件使用龙芯LS2K1000，软件系统为OpenHarmony小型系统，产品名暂定为LS2K1000_l1

编译：hb set命令选择编译产品

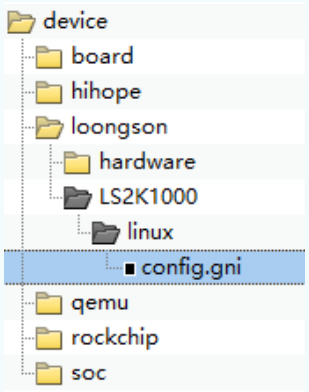
hb build命令进行编译

```
{
    "product_name": "LS2K1000_l1",
    "type": "small",
    "ohos_version": "OpenHarmony 3.1",
    "device_company": "loongson",
    "device_build_path": "device/loongson/LS2K1000",
    "board": "LS2K1000",
    "kernel_type": "linux",
    "kernel_version": "5.10",
    "target_cpu": "loongarch",
```

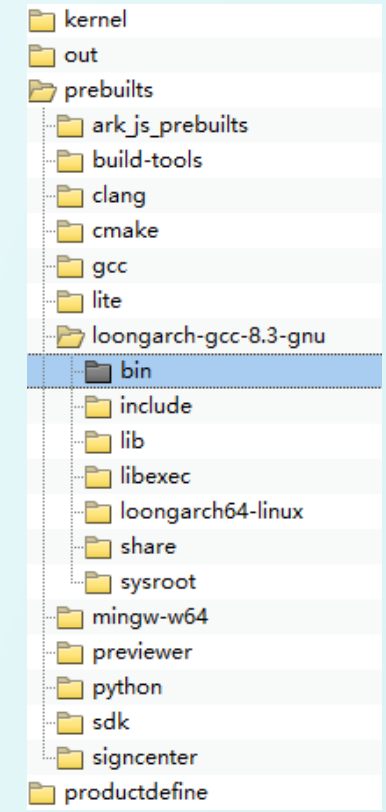
```
root@f7f08442072f:/home/weidingx/share/openharmony/31LTS_gitlab/OpenHarmony-3.1-LTS# hb set
OHOS Which product do you need?  (Use arrow keys)

bestechnic
   iotlink_demo
   display_demo
   xts_demo
   mini_distributed_music_player

goodix
   gr5515_sk_xts_demo
   gr5515_sk_iotlink_demo

isoftstone
 ❯ LS2K1000_l1

ohemu
   qemu_xtensa_mini_system_demo
   qemu_csky_mini_system_demo
   qemu_cm55_mini_system_demo
   qemu_riscv_mini_system_demo
   qemu_small_system_demo
   qemu-arm-linux-min
   qemu_mini_system_demo
   qemu_ca7_mini_system_demo

bearpi
   bearpi_hm_nano

hisilicon
   ipcamera_hispark_taurus
   ipcamera_hispark_aries
   watchos
   wifiiot_hispark_pegasus
   ipcamera_hispark_taurus_linux

built-in
   ohos-arm64
   rk3568
   DAYU
   ohos-sdk
   Hi3516DV300
```

龙芯交叉编译工具配置

通过device目录下config.gni文件指定编译工具、基础C库对应路径




```
# Kernel type, e.g. "linux", "liteos_a", "liteos_m".
kernel_type = "linux"

# Kernel version.
kernel_version = "5.10"

# Board CPU type, e.g. "cortex-a7", "riscv32".
board_cpu = ""

# Board arch, e.g.  "armv7-a", "rv32imac".
board_arch = "loongarch64"

# Toolchain name used for system compiling.
# E.g. gcc-arm-none-eabi, arm-linux-harmonyeabi-gcc, ohos-clang.
# Note: The default toolchain is "ohos-clang".
board_toolchain = "loongarch-gcc"

# The toolchain path instatlled
board_toolchain_path =
     rebase_path("//prebuilts/loongarch-gcc-8.3-gnu/bin")

# Compiler prefix.
board_toolchain_prefix = "loongarch64-linux-"

# Compiler type, "gcc" or "clang".
board_toolchain_type = "gcc"


# Board related headfiles search path.
board_include_dirs = []
board_include_dirs += [ rebase_path("//prebuilts/loongarch-gcc-8.3-gnu/include") ]

# Board adapter dir for OHOS components.
board_adapter_dir = ""

# Sysroot path.
board_configed_sysroot = "//prebuilts/loongarch-gcc-8.3-gnu/sysroot"

# Board storage type, it used for file system generation.
storage_type = ""

# Board related common compile flags.
board_cflags = [
  "-fpic",
  "-D_GNU_SOURCE"
]
```



龙芯OpenHarmony系统编译

```
root@f7f08442072f:/home/weidingx/share/openharmony/31LTS_gitlab/OpenHarmony-3.1-LTS# hb set
OHOS Which product do you need?  LS2K1000_l1
root@f7f08442072f:/home/weidingx/share/openharmony/31LTS_gitlab/OpenHarmony-3.1-LTS# hb build -f
[OHOS INFO] Set cache size limit to 50.0 GB
[OHOS INFO] root_out_dir=//out/LS2K1000/LS2K1000_l1
[OHOS INFO] root_build_dir=//out/LS2K1000/LS2K1000_l1
[OHOS INFO] root_gen_dir=//out/LS2K1000/LS2K1000_l1/gen
[OHOS INFO] current_toolchain=//build/lite/toolchain:loongarch-gcc
[OHOS INFO] host_toolchain=//build/toolchain/linux:clang_x64
[OHOS INFO]
[OHOS INFO] args: Namespace(build_platform_name='phone', build_xts=False, example_subsystem_file=None, gn_root_out_dir='/home/weidingx/share/openharmony/31LTS_gitlab/OpS/out/LS2K1000/LS2K1000_l1', ignore_api_check=['xts', 'common', 'developertest'], os_level='small', platforms_config_file='/home/weidingx/share/openharmony/31LTS_gitlab-LTS/out/preloader/LS2K1000_l1/platforms.build', scalable_build=False, source_root_dir='/home/weidingx/share/openharmony/31LTS_gitlab/OpenHarmony-3.1-LTS/', subsystem_ce/weidingx/share/openharmony/31LTS_gitlab/OpenHarmony-3.1-LTS/out/preloader/LS2K1000_l1/subsystem_config.json', target_cpu='loongarch', target_os='ohos')
[OHOS INFO]
[OHOS INFO] build configs generation is complete.
[OHOS INFO] ohos_build_compiler: gcc
[OHOS INFO] ohos_kernel_type: linux
[OHOS INFO] build kernel commandis  ./kernel_module_build.sh /home/weidingx/share/openharmony/31LTS_gitlab/OpenHarmony-3.1-LTS/out/LS2K1000/LS2K1000_l1 small loongarche/LS2K1000_l1_linux LS2K1000 kernel_linux_5.10
[OHOS INFO] configs = ["//build/lite/config:gcc_opt", "//build/lite/config:board_config", "//build/lite/config:cpu_arch", "//build/lite/config:common", "//build/lite/cok_path", "//build/lite/config:debug", "//build/lite/config:security", "//build/lite/config:exceptions", "//build/lite/config:language_c", "//build/lite/config:language_ite/config:kernel_macros", "//build/lite/config:shared_library_config"]
[OHOS INFO] hks_config_small.h
[OHOS INFO] Done. Made 553 targets from 336 files in 14326ms
[OHOS INFO] [1/3365] COPY ../../../base/global/i18n_lite/frameworks/i18n/i18n.dat data/i18n.dat
[OHOS INFO] [2/3365] STAMP obj/base/security/huks/test/huks_3.0_test.stamp
[OHOS INFO] [3/3365] COPY ../../../base/startup/init_lite/ueventd/etc/ueventd_l1.config etc/ueventd.config
[OHOS INFO] [4/3365] STAMP obj/base/startup/syspara_lite/frameworks/unittest/parameter/unittest.stamp
```

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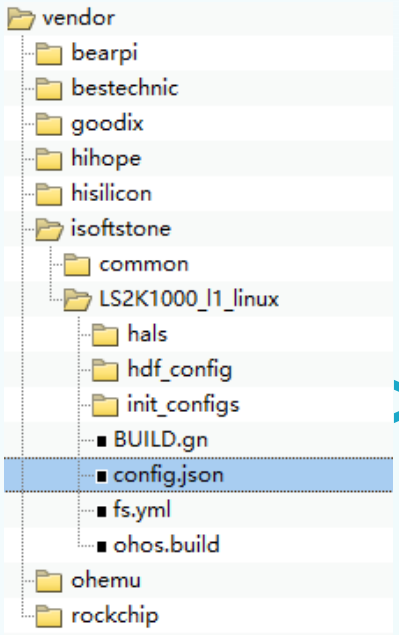
OpenHarmony子系统搭建

OpenHarmony系统支持的子系统由vendor目录下产品侧config.json文件控制

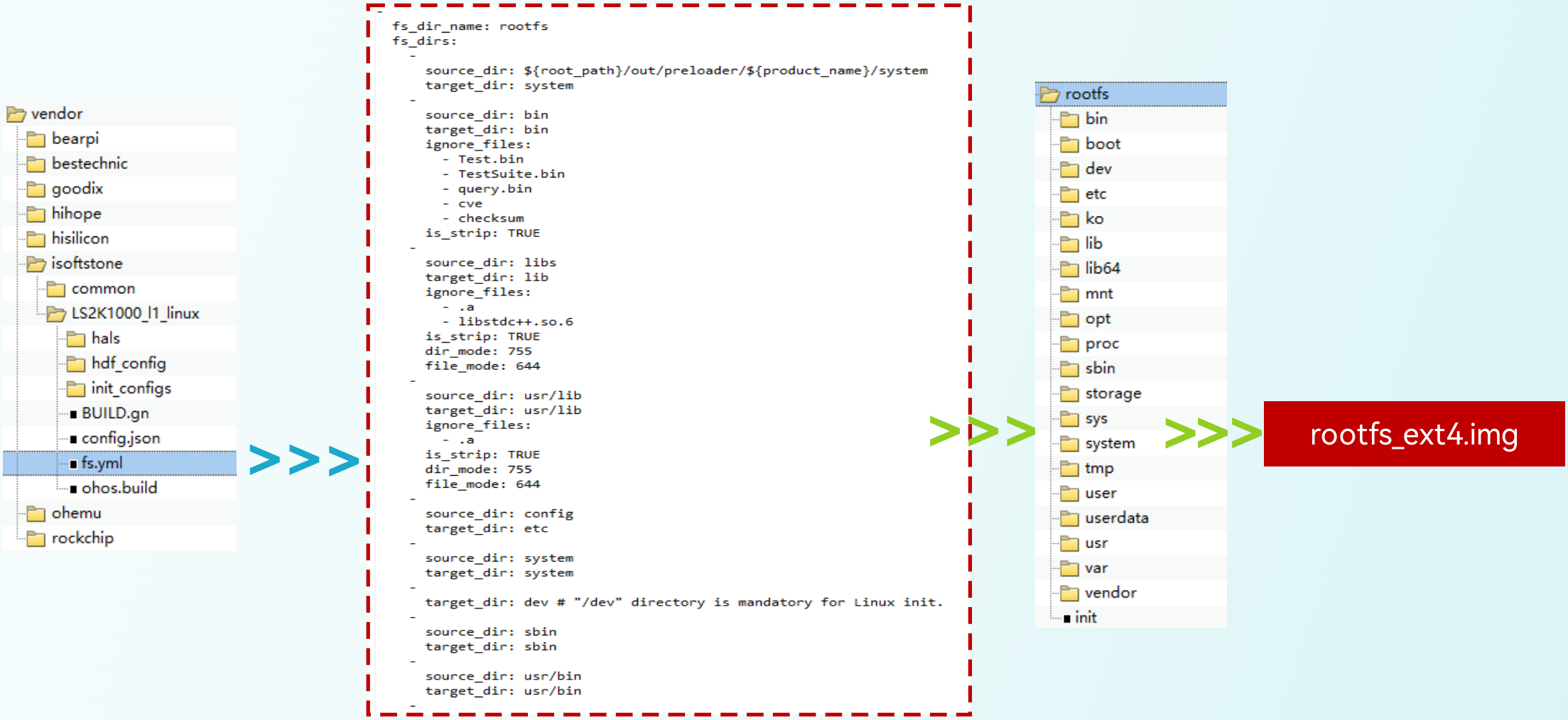


>>>

```
"subsystems": [
  {
    "subsystem": "ace",
    "components": [
      { "component": "ace_engine_lite", "features":[ "" ] }
    ]
  },
  {
    "subsystem": "distributedschedule",
    "components": [
      { "component": "samgr_lite", "features":[] },
      { "component": "safwk_lite", "features":[] },
      { "component": "dmsfwk_lite", "features":[] }
    ]
  },
  {
    "subsystem": "security",
    "components": [
      { "component": "permission", "features":[] },
      { "component": "deviceauth_lite", "features":[] },
      { "component": "huks", "features":
        [
          "huks_config_file = \"hks_config_small.h\""
        ]
      }
    ]
  },
  {
    "subsystem": "startup",
    "components": [
      { "component": "bootstrap_lite", "features":[] },
      { "component": "syspara_lite", "features":[] },
      { "component": "init_lite", "features":[] },
      { "component": "appspawn_lite", "features":[] }
    ]
  },
  {
    "subsystem": "communication",
    "components": [
      { "component": "dsoftbus", "features":[] },
      { "component": "rpc", "features":[] }
    ]
  },
  {
    "subsystem": "utils",
    "components": [
      { "component": "kv_store", "features":[] },
      { "component": "os_dump", "features":[] }
```

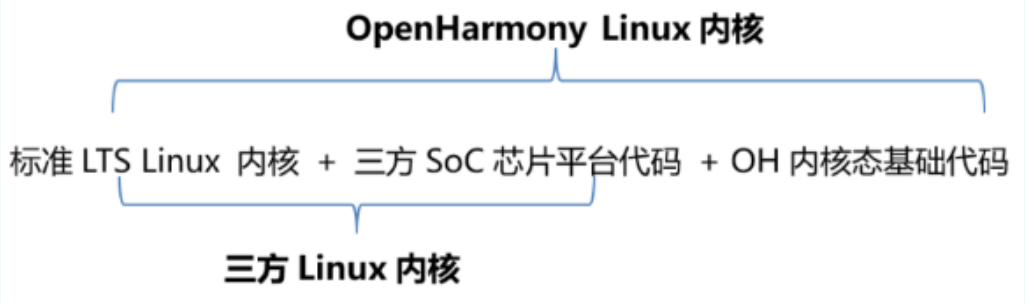
subsystem	componet	feature
startup	bootstrap_lite、syspara_lite、init_lite、appspawn_lite	
distributedschedule	samgr_lite、safwk_lite、dmsfwk_lite	
hiviewdfx	hilog_featured_lite	
utils	kv_store、os_dump	
security	Permission、deviceauth_lite、huks	
graphic	graphic_utils、graphic_hals、ui、Wms、Surface	
aafwk	aafwk_lite	
appexecfwk	appexecfwk_lite	
ace	ace_engine_lite	
applications	loongson_sample_app	
kernel	linux	

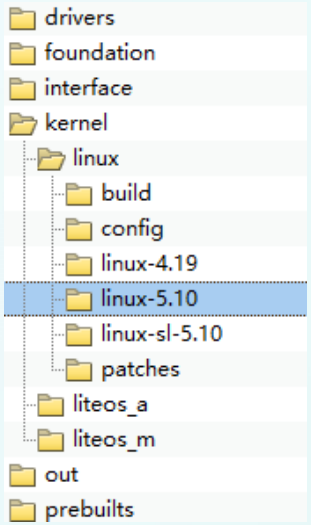
ROOTFS文件系统制作



OpenHarmony系统内核适配

OpenHarmony系统有三类内核：Linux、Liteos_A和Liteos_M，
本次LS2K1000芯片移植使用LINUX内核
其适配如图所述





>>> 产品内核defconfig

>>> 三方SoC芯片内核补丁

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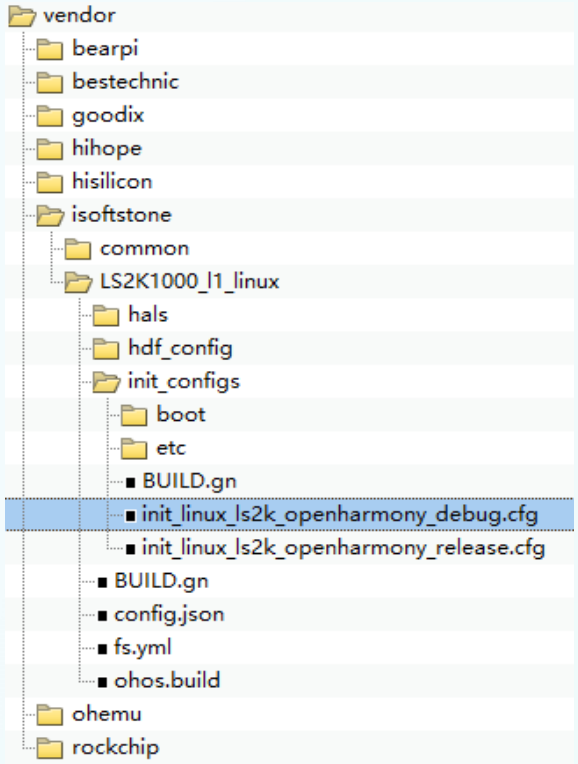
INIT启动引导组件

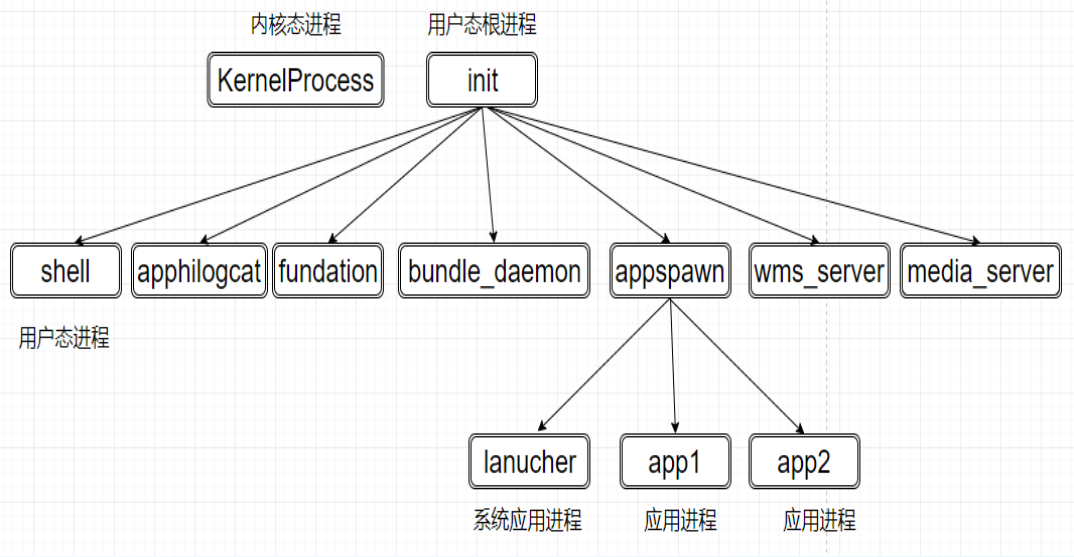
init启动引导组件对应的进程为init进程，是内核完成初始化后启动的第一个用户态进程。init进程启动之后，读取init.cfg配置文 件，根据解析结果，执行相应命令并依次启动各关键系统服务进程，在启动系统服务进程的同时设置其对应权限。



> > >

```
"jobs" : [{
        "name" : "pre-init",
        "cmds" : [
            "mkdir /storage/data/log",
            "chmod 0755 /storage/data/log",
            "chown 4 4 /storage/data/log",
            "chmod 0666 /dev/binder",
            "mkdir /storage/data/system",
            "mkdir /storage/data/system/param",
            "chmod 0755 /storage/data/system/param",
            "chown 4 4 /dev/hilog",
            "chown 4 4 /dev/hwlog_exception",
            "chmod 0777 /userdata",
        ]
    }, {
        "name" : "init",
        "cmds" : [
            "start shell",
            "start apphilogcat",
            "start foundation",
            "start bundle_daemon",
            "start appspawn",
            "start media_server",
            "start wms_server",
            "start deviceauth_service",
        ]
    }, {
        "name" : "post-init",
        "cmds" : []
    }
],
"services" : [{
        "name" : "shell",
        "path" : ["/sbin/getty", "-n", "-l", "/bin/sh", "-L", "115200", "ttyS0", "vt100"],
        "uid" : 0,
        "gid" : 0,
        "once" : 0,
        "importance" : 0,
        "caps" : [4294967295]
    }, {
        "name" : "foundation",
        "path" : ["/bin/foundation"],
        "uid" : 7,
        "gid" : 7,
        "once" : 0,
        "importance" : 1,
        "caps" : [23]
```

OpenHarmony系统启动后进程



进程名	进程类型	备注
Kernel Process	内核态进程	
init	用户态根进程	
shell	用户态进程	shell服务
apphilogcat		DFX子系统的logcat服务
fundation		fundation目录下基础组件功能
bundle_daemon		包管理组件
appspawn		应用孵化器服务,为业务hap提供运行环境
media_server		多媒体组件
wms_server		窗口显示组件
com.huawei.lanucher		系统应用程序，用于管理桌面应用程序，是appspawn创建

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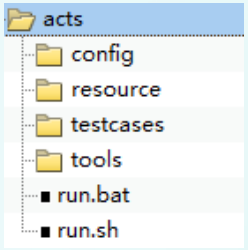
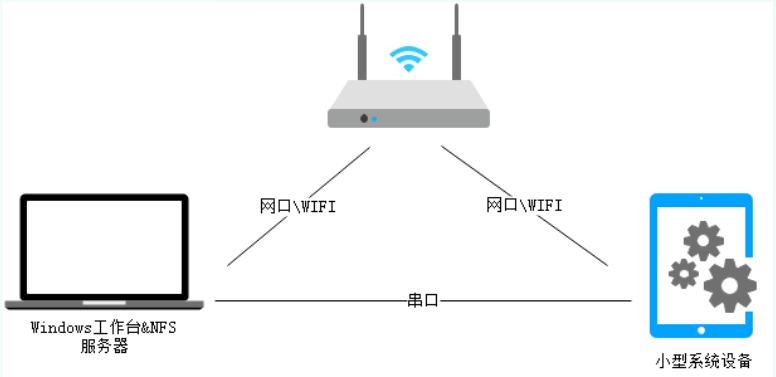
OpenHarmony XTS认证流程

XTS（X Test Suite）子系统是OpenHarmony兼容性测评套件的集合
XTS子系统加入到编译组件中

```
{
  "subsystem": "xts",
  "components": [
    { "component": "developer_test", "features":[] },
    { "component": "xts_acts", "features":[] },
    { "component": "xts_tools", "features":[] }
  ]
},
```



测试组网



执行兼容性测试套件
启动测试界面　acts\run.bat。
执行用例　run acts
测试报告
acts\reports\summary_report.html

XTS认证测试结果

Test Summary

Platform:	Ipcamera	Test Type:	ACTS
Device Name:	local_COM3	Host Info:	Windows-10-10.0.19041-SP0
Test Start/ End Time:	2022-09-26 14:52:03/ 2022-09-26 15:02:48	Execution Time:	10min 45sec
version:	OpenHarmony-ACTS-1.0.1		

8	8	425	425	0	0	0	0
Modules	Run Modules	Total Tests	Passed	Failed	Blocked	Ignored	Unavailable

Test detail

Module	Testsuite	Total Tests	Passed	Failed	Blocked	Ignored	Time	Operate
ActsAbilityMgrTest	AbilityMgrTest	31	31	0	0	0	123.792	
ActsBootstrapTest	SamgrApiTest	7	7	0	0	0	0.003	
ActsBundleMgrTest	BundleMgrTest	40	40	0	0	0	17.189	
ActsHuksLiteFunctionTest	HksAesTest	4	4	0	0	0	3.456	
ActsHuksLiteFunctionTest	HksAgreementTest	2	2	0	0	0	0.173	

XTS认证查询产品及系统信息

vendor > loongson > LS2K1000_l1_linux > hals > utils > sys_param > C hal_sys_param.c > ...

```
15
16  #include "hal_sys_param.h"      ding, 2个月前 • add loongson compile framework ...
17
18  static const char OHOS_DEVICE_TYPE[] = {"Loongson Board"};
19  static const char OHOS_DISPLAY_VERSION[] = {"OpenHarmony 3.1 Release"};
20  static const char OHOS_MANUFACTURE[] = {"isoftstone"};
21  static const char OHOS_BRAND[] = {"Loongson"};
22  static const char OHOS_MARKET_NAME[] = {"Loongarch 2K1000L1"};
23  static const char OHOS_PRODUCT_SERIES[] = {"V1"};
24  static const char OHOS_PRODUCT_MODEL[] = {"Loongarch 2K1000"};
25  static const char OHOS_SOFTWARE_MODEL[] = {"Loongson Board System v1.0"};
26  static const char OHOS_HARDWARE_MODEL[] = {"Loongson Board 2K1000"};
27  static const char OHOS_HARDWARE_PROFILE[] = {"aout:true,display:true"};
28  static const char OHOS_BOOTLOADER_VERSION[] = {"PMON 5.0.2-Release"};
29  static const char OHOS_ABI_LIST[] = {"Loongarch64"};
30  static const char OHOS_SERIAL[] = {"OH20220816"};  // provided by OEM.
31  static const int OHOS_FIRST_API_VERSION = 1;
32
33  static const char EMPTY_STR[] = {""};
34
35  const char* HalGetDeviceType(void)
36  {
37      return OHOS_DEVICE_TYPE;
38  }
39
40  const char* HalGetManufacture(void)
41  {
42      return OHOS_MANUFACTURE;
43  }
44
45  const char* HalGetBrand(void)
46  {
47      return OHOS_BRAND;
48  }
```

代码中的产品信息和系统查询输出

```
# query.bin
******To Obtain Product Params Start******
The Product Type is [Loongson Board]
The manuFacture is [isoftstone]
The brand is [Loongson]
The marketName is [Loongarch 2K1000L1]
The productSeries is [V1]
The softwareModel is [Loongson Board System v1.0]
The HardwareModel is [Loongson Board 2K1000]
The HardwareProfile is [aout:true,display:true]
The serial is [OH20220816]
The osName is [OpenHarmony-1.0.1.0]
The OS Version is [OpenHarmony 3.1 Release]
The bootloaderVersion is [PMON 5.0.2-Release]
The Security Patch is [2022-08-01]
The AbiList is [Loongarch64]
The sdkApiLevel is [8]
The firstApiLevel is [1]
The productSeries is [OpenHarmony 2.3 beta]
The VersionID is [Loongson Board/isoftstone/Loongson/V1/OpenHarmony-1.0.1.0/Loongarch 2K1000/Loongson Board System v1.0/8/OpenHarmony 2.3 beta/debug]
The buildType is [debug]
The buildUser is [jenkins]
The buildHost is [linux]
The buildTime is [2022-10-10 02:19:23]
The BuildRootHash is []
******To Obtain Product Params End  ******
#
```

龙芯OpenHarmony兼容性认证结果

证书编号：NO. OAOH20221000017

开放原子开源基金会
OPENATOM FOUNDATION

OpenHarmony
生态产品兼容性证书

鸿湖万联（江苏）科技发展有限公司

乘风1000开发板

通过 OpenHarmony 3.1 Release 版本兼容性测评
特此授予 OpenHarmony 生态产品兼容性证书

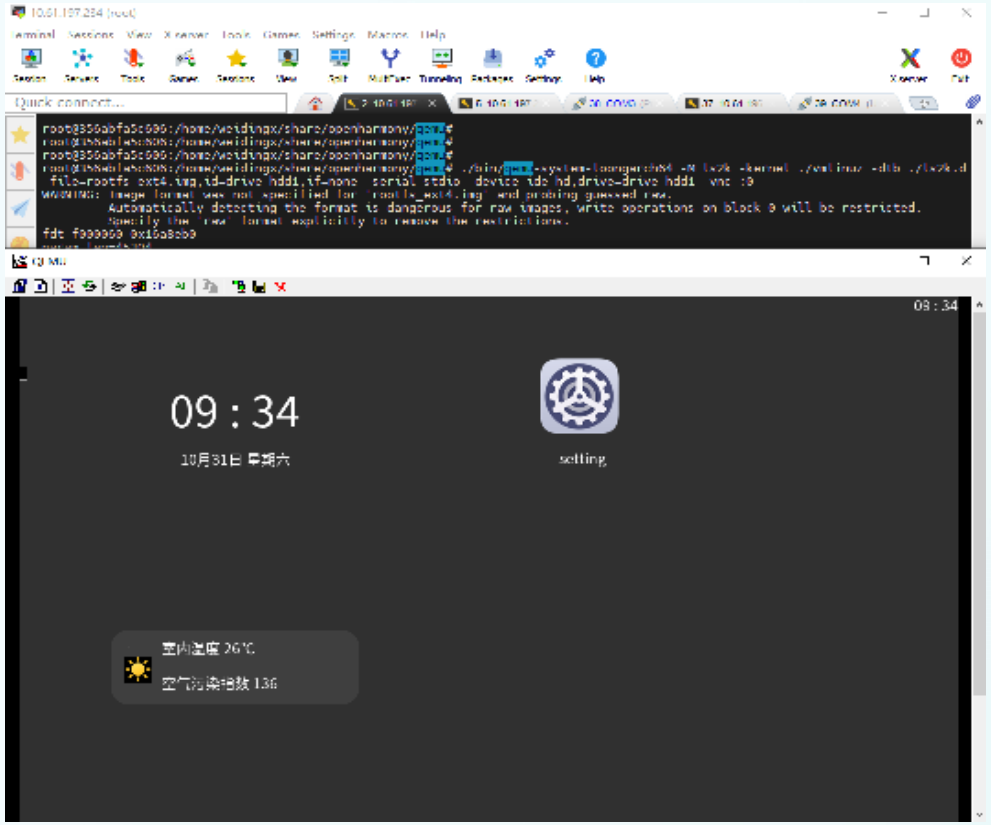
OpenAtom OpenHarmony 项目群工作委员会
2022 年 10 月 19 日

声明：本证书仅系对申请方所提交的测试报告满足兼容性要求的认可。OpenHarmony 项目群工作委员会不对申请人产品实际兼容、产品质量或性能等提供任何保证和担保。测评结果最终以OpenHarmony项目群官方网站公示情况为准。

龙芯调试工具及手段

龙芯架构的调试手段及工具比较成熟，常用的QEMU仿真、GDB、KDB及KGDB等均已具备，这些调试手段的引入，减少了对硬件开发板的依赖，提高开发调试效率；定位了多个内存重复释放，内存被踩的疑难问题，成为OpenHarmony开发调试的利器。

QEMU



KDB

```
# echo "ttyS0,115200" > /sys/module/kgdboc/parameters/kgdboc
[14857.598626] KGDB: Registered I/O driver kgdboc
#
# echo g > /proc/sysrq-trigger
[14868.602465] sysrq: DEBUG

Entering kdb (current=0x90000000914e53c0, pid 134) on processor 0 due to Keyboard Entry
[0]kdb> help
Command          Usage                    Description
-----------------------------------------------------------
md               <vaddr>                  Display Memory Contents, also mdWcN, e.g. md8c1
mdr              <vaddr> <bytes>          Display Raw Memory
mdp              <paddr> <bytes>          Display Physical Memory
mds              <vaddr>                  Display Memory Symbolically
mm               <vaddr> <contents>       Modify Memory Contents
go               [<vaddr>]                Continue Execution
rd                                        Display Registers
rm               <reg> <contents>         Modify Registers
ef               <vaddr>                  Display exception frame
bt               [<vaddr>]                Stack traceback
btp              <pid>                    Display stack for process <pid>
bta              [D|R|S|T|C|Z|E|U|I|M|A]
                                          Backtrace all processes matching state flag
btc                                       Backtrace current process on each cpu
btt              <vaddr>                  Backtrace process given its struct task address
env                                       Show environment variables
set                                       Set environment variables
help                                      Display Help Message
more>
[0]kdb> kgdb
Entering please attach debugger or use $D#44+ or $3#33
```

GDB

```
linux@linux-ZhaoYang-E4-IIL:~/Downloads$
linux@linux-ZhaoYang-E4-IIL:~/Downloads$ ./loongarch64-linux-gnu-static-gdb vmlinux
GNU gdb (GDB) 8.1.50.20190122-git
Copyright (C) 2018 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://gnu.org/licenses/gpl.html>
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law.
Type "show copying" and "show warranty" for details.
This GDB was configured as "--host=x86_64-buildroot-linux-gnu --target=loongarch64-linux-gnu".
Type "show configuration" for configuration details.
For bug reporting instructions, please see:
<http://www.gnu.org/software/gdb/bugs/>.
Find the GDB manual and other documentation resources online at:
    <http://www.gnu.org/software/gdb/documentation/>.

For help, type "help".
Type "apropos word" to search for commands related to "word"...
Reading symbols from vmlinux...done.
(gdb) set serial baud 115200
(gdb) target remote /dev/ttyUSB0
Remote debugging using /dev/ttyUSB0
0x90000000002100f8 in arch_kgdb_breakpoint () at arch/loongarch/kernel/kgdb.c:253
253     arch/loongarch/kernel/kgdb.c: No such file or directory.
(gdb) info thread
  Id   Target Id         Frame
```

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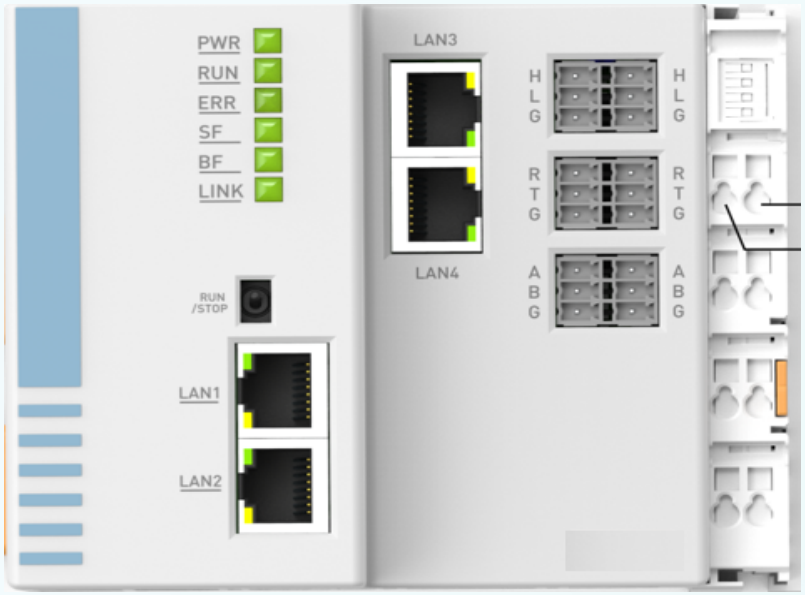
龙芯矿鸿认证产品



硬件概述:

CPU: 龙芯2K1500 双核1G

文件存储能力: 8G

输入电压范围: 直流19-29V

功耗: ≤15W

以太网接口: 4路

CAN接口: 2路

RS485接口: 2路

RS232接口: 2路

鸿湖万联基于矿鸿系统的业务能力

煤矿行业设备

上达设备及应用

矿鸿商业发行版

下联芯片板卡

煤矿设备芯片

采集类	生产类	运输类	人员类	巡检类
				
摄像头 传感器	采煤机 液压支架	皮带运输机 矿车	矿工及装备	智能巡检机器人

矿鸿增强特性

矿鸿软总线　矿鸿多信道通信备份　煤矿设备传输协议(MDTP)

矿鸿分布式数据管理　矿鸿高可靠高安全特性　矿鸿分布式编程框架

OpenHarmony™

统一系统

一套系统覆盖各类设备

统一标准

设备接口、数据协议标准化

万物互联

人机互联，机机互联，万物感知

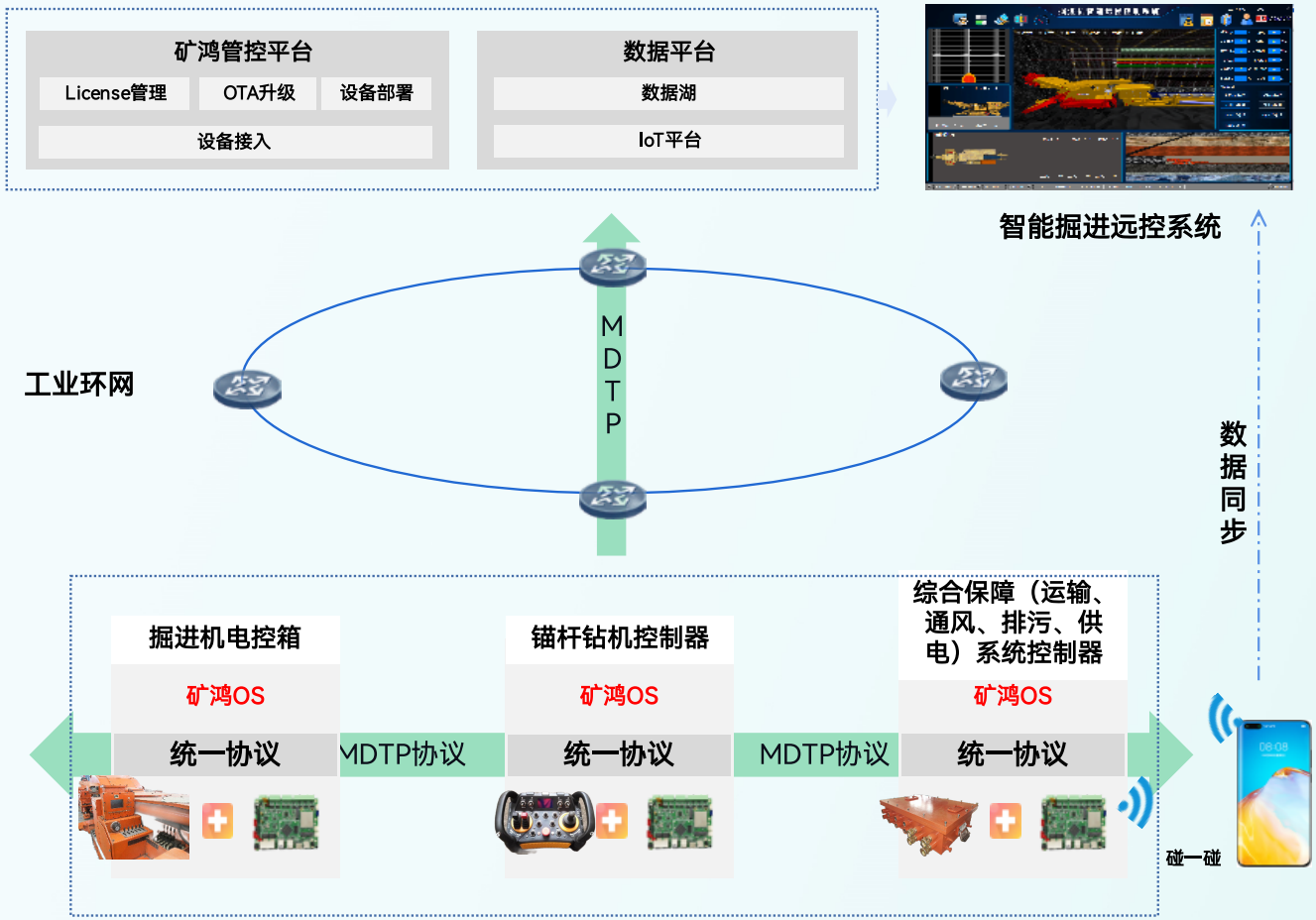
安全可信

安全标准认证、核心代码自研

意法半导体	恩智浦	瑞芯微	龙芯	全志	飞腾
STM32	imax 6ull	RK3399/RK3568/RK3588	2k1000/2k1500	A40I/T507	E2000

鸿湖万联基于矿鸿系统的业务地图

基于矿鸿底座的智能综掘解决方案



应用亮点

5G+矿鸿掘进面设备改造

对掘进机电控箱、锚杆钻机控制器、掘进面（运输、通风、排放、供电等）控制器进行5G+矿鸿改造，实现各类控制器统一操作系统、各类设备协议统一，实现数据统一接入，并通过矿鸿管控平台进行管理。

手机“碰一碰”特性

1、通过矿鸿防爆手机使用碰一碰功能识别设备ID，通过MDTP协议和设备交互，获取设备信息查询及控制。

智能掘进远控集控

通过矿鸿系统+5G网络，实现掘进面各类掘锚设备控制器以及皮带运输控制器、通风控制器、排污控制器进行数据预警监控以及远程可视化控制。

助力Qt应用鸿蒙化，汇集一流的技术团队，帮助多个用户完成应用迁移

在鸿蒙生态中，团队作为Qt SIG的负责人，成功推出了专为鸿蒙系统优化的Qt开源版本，为开发者提供了高效、稳定的开发工具。此外，我们已为多个知名应用如某工业监控软件、某电子阅读器等鸿蒙生态应用完成从Windows、Linux至鸿蒙的迁移，得到了广大用户的认可和好评。背后的团队成员均拥有超过10年的软件经验，横跨HMI、国防、工业自动化等多个领域，丰富的经验使我们能深入理解客户需求，提供更专业、更定制的解决方案。

图形框架平台

跨平台鸿蒙应用一站式解决方案，帮助开发者快速开发高质量应用，确保高效性能和无缝集成

鸿蒙应用开发向导

DevEco集成开发环境一体化开发工具，结合模板与IDE插件，简化开发流程，帮助开发者高效打造优质应用

自动化测试工具

提供全面的自动化界面测试能力，包括脚本录制、回放和元素识别等，提高测试效率和软件质量

Thank you.