强“芯”铸魂

基于龙芯开发板
OpenHarmony系统移植
开发指南

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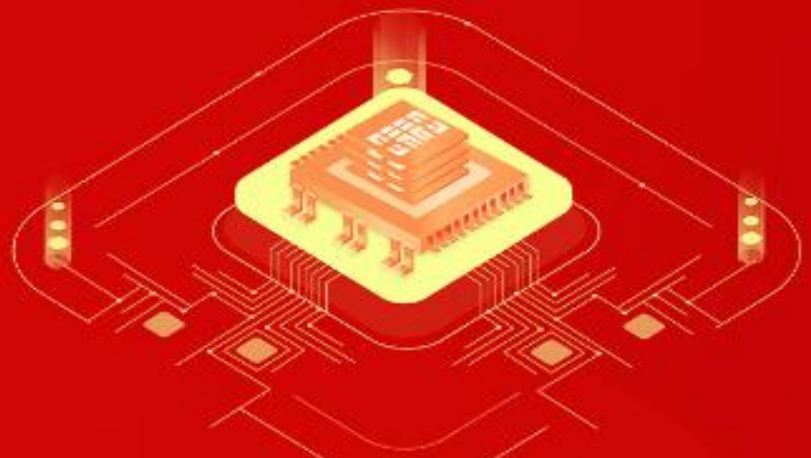

毕业于解放军信息工程学院计算机系，资深网络安全专家；主要技术方向有工控系统网络安全研究、SOC结构设计、结合处理器微结构的软件性能优化、网络设备IO性能优化、网络攻防技术研究等，是安全管理平台国家标准编写组成员和漏洞扫描国家标准编写组成员。10年前就开始推动自主可控芯片在网络安全领域的落地工作，主持过国内首台自主可控防火墙的研发和产品推广工作。

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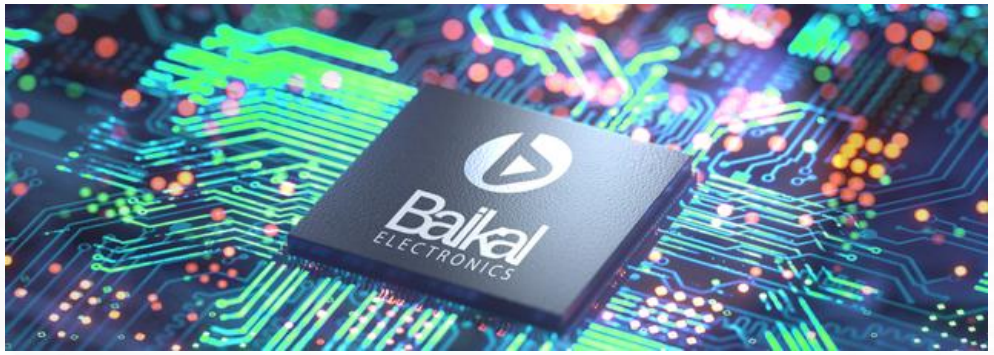


- 2022年3月，ARM暂停向俄罗斯客户和合作伙伴交付产品和提供支持
- 5月4日，英国在最新公布的制裁名单中加入了俄罗斯处理器制造商MCST（生产 Elbrus 处理器）和Baikal Electronics（生产 Baikal 处理器）
- 俄罗斯信息产业ARM发展道路被堵死
- ARM指令集已经成为西方重要制裁工具

- **学名：ISA（Instruction Set Architecture）**

  —— 直译：指令集架构

  —— 各种叫法：架构、指令集、指令架构、指令集系统、指令系统……

- **指令集是对指令功能和运行时环境等内容的定义，涉及软硬件交互的方方面面**

  —— 指令功能

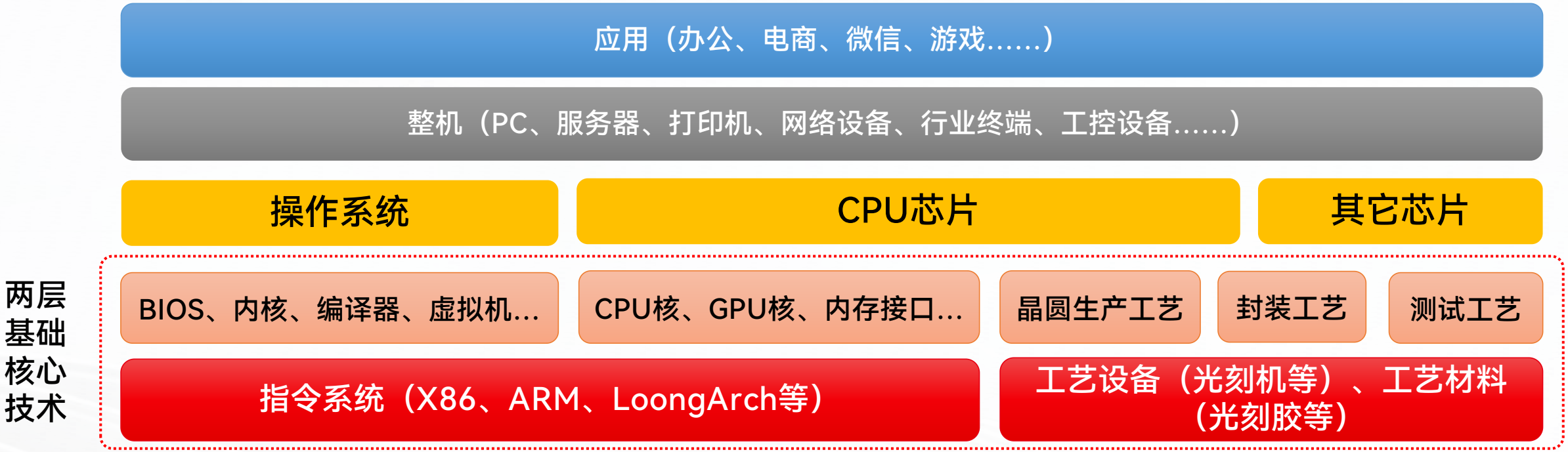
  - 指令定义：算术运算、移位运算、位操作、转移指令、访存指令etc
  - 使用方法：数据类型、寻址方式

  —— 运行时环境

  - 存储管理：段式、页式、段页式
  - 运行级别：内核态/用户态、Ring0/Ring3、调试/主机/客户
  - 异常与中断处理

- **指令集是软硬件之间的“合同”**

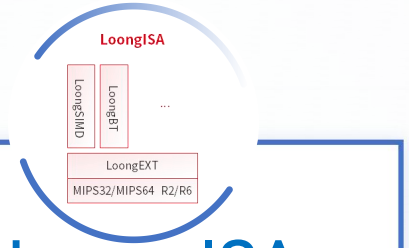
——硬件（CPU设计）要遵循、软件（OS等）也要遵循



- **信息产业中，只依赖人力资源和自然资源的“根技术”**

- **X86**
  - —— 桌面和服务器的主流指令系统
  - —— Intel 主导
  - —— 不授权
  - —— AMD 的授权来源于历史原因

- **ARM**
  - —— 嵌入式和移动设备的主流指令系统
  - —— ARM主导
  - —— 可公开授权
    - 以IP 核授权为主
    - 体系结构授权极少
    - 不允许自行扩展



LoongISA

基于MIPS架构

进行自主扩展

- **我国不可能基于国外指令集建设自主信息产业生态**
  - —— 做跟班可以，想超过不行：丫鬟拿一辈子钥匙还是丫鬟
  - —— 中国人可以用英文写文章，但不可能用英文发展民族文化

龙架构及其优势

自主性

全自主设计，不需任何授权

先进性

吸纳各种指令集的技术优势
指令集效率大幅提高

兼容性

充分考虑生态兼容需求，
实现跨指令集二进制兼容

- 基础指令337条
- 虚拟机扩展10条
- 二进制翻译扩展170+
- 128位向量扩展700+
- 256位向量扩展700+

- **保持典型RISC指令集特性**

  —— load/store结构、指令定长、32组通用定/浮点寄存器

- **去除过时设计**

  ——取消指令延迟槽

  ——去除专用乘法寄存器

- **规整、顺应现代软件需要、高性能**

  ——规整：4级运行模式、平整的寻址空间

  ——现代化：更多位操作指令、原子指令、多线程和虚拟化支持

  ——众多精深的设计改进提升性能

  - 灵活高效的立即数域、ABI优化、支持PC重定位

龙架构先进性：更高的性能

程序执行时间 = 执行的动态指令数 * 平均每条指令的执行周期数 * 每周期的时间

（指令集设计&编译器）　（指令流水线效率）　（主频）

（指令集/结构设计能力的体现）　（微结构设计能力的体现）　（工艺能力的体现）

- 动态指令数是指令集表达能力的一个体现

架构	MIPS	LoongArch	LA/MIPS
动态指令数	1163亿	960亿	83%

Coremark 1.0, 300000 iterations

- 采用龙架构性能比MIPS提升15%左右，至少一代的IPC提升

——相同微架构、相同主频

——动态指令数减少10%~20%

兼容性：龙架构二进制翻译

- 高效的二进制翻译，对LA价值更大

——目标：“十九八七”

——MIPS/Linux 、 Android/Arm 、 X86/Linux 、 X86/windows 系统

- 只靠软件很难弥补不同指令集之间的差异

——X86/Arm eflags

——浮点栈访问模式

——地址翻译的低效

- 指令集级的“硬”支持——LA指令融合技术

——eflags翻译加速：增加专门指令生成标志位

——浮点栈访问：增加专门指令去模拟

——地址翻译加速

龙架构核心价值：创新的自由

- **打破现有指令集的桎梏**

——X86：不授权；ARM：严格控制授权；RISC V：IOT小架构/扩展困难

——摆脱最底层的束缚：打得一拳开 免得百拳来

- **跟上计算机体系结构的发展步伐**

——体系结构发展的黄金年代

——指令集扩展和创新的需求不断涌现

- **基于龙架构的创新突破**

——彻底解决兼容性问题

——增加更多底层的先进特性

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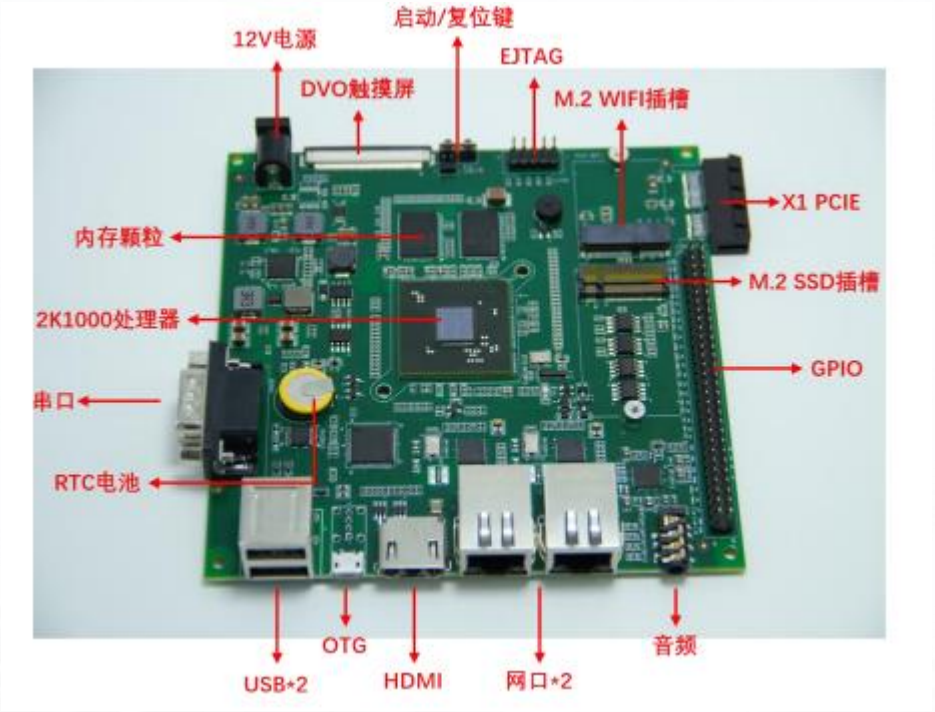
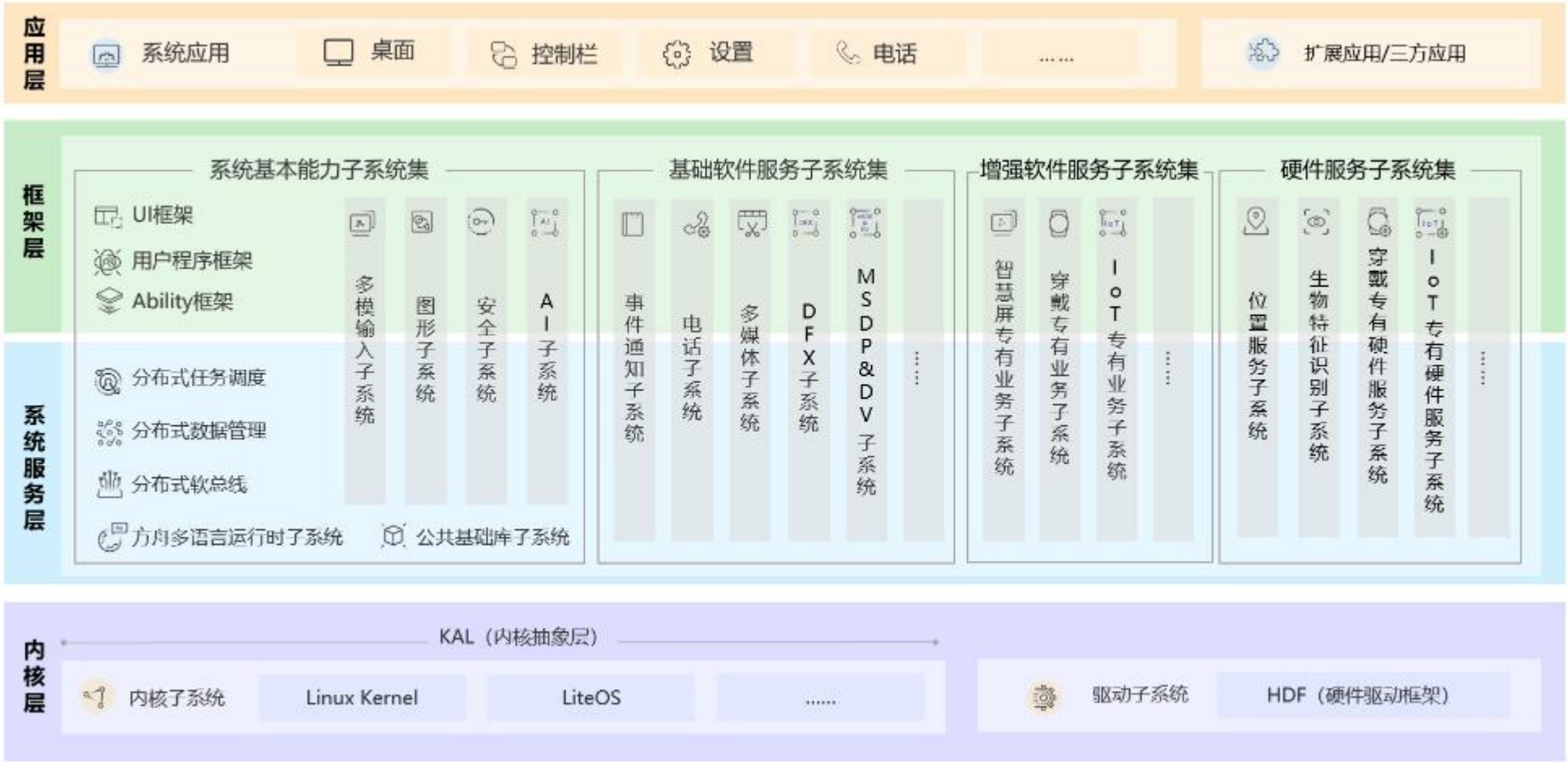


功能	描述
CPU	龙芯 2K1000 处理器
内存	板载 2G DDR3，主频 400Mhz
Bios	8Mb SPI FLASH
GPIO	2.54 间距 27 个可配置 GPIO 插针排
网络	2 个千兆自协商网口（2 个标准接口）
PCIE	1 路 X1 夹板接口 PCIE
EJTAG	1 个 EJTAG 调试接口，可用于程序下载、单步调试
接口	3 路 USB2.0 标准接口（TYPE A USB*2, Micro USB*1） 2 路 CAN 接口，4 路串口(TTL*3, RS232*1)
显示和音频接口	1 路 TYPE A HDMI 接口 DVO 接口适配飞凌嵌入式触摸屏 1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



组件源码路径名命规则为：{领域}/{子系统}/{组件}
芯片解决方案的源码路径规则为：device/{芯片解决方案厂商}/{开发板}
产品解决方案的源码路径规则为：vendor/{产品解决方案厂商}/{产品名称}。

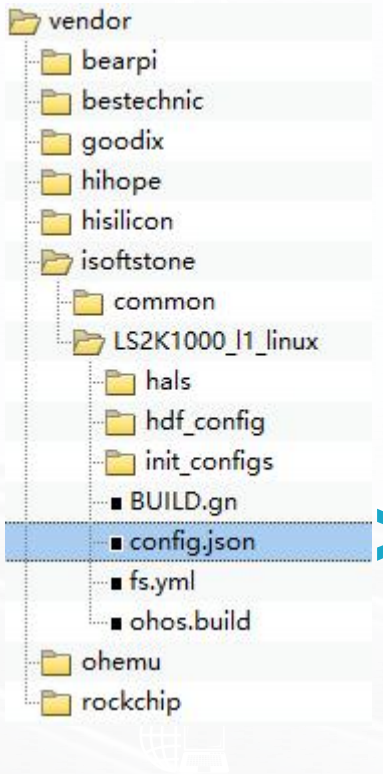
龙芯开发板适配工作基于OpenHarmony 3.1 Release版本开发，在码云OpenHarmony开源社区可以下载相关源码。

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

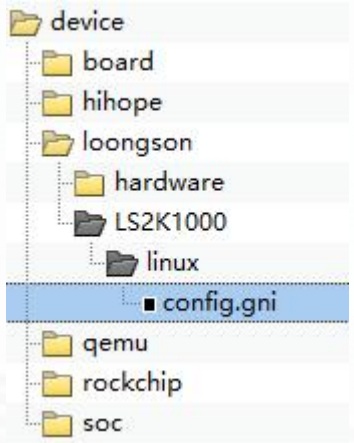
hb build命令进行编译



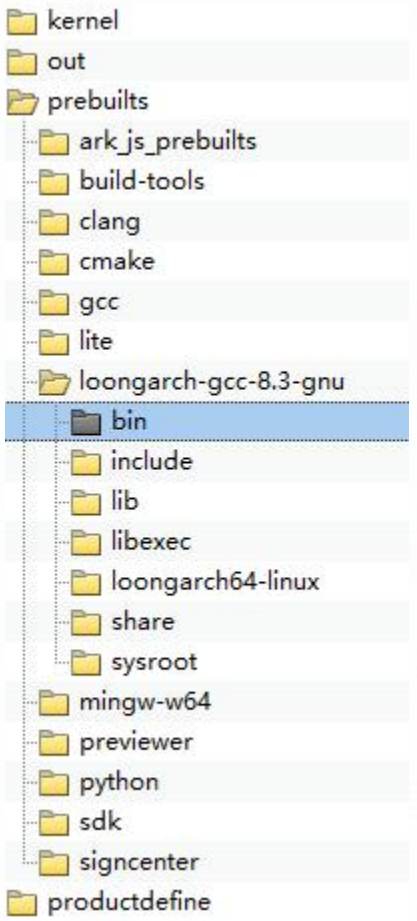

```
{
    "product_name": "LS2K1000_l1",
    "type": "small",
    "ohos_version": "OpenHarmony 3.1",
    "device_company": "loongson",
    "device_build_path": "device/loongson/LS2K1000",
    "board": "LS2K1000",
    "kernel_type": "linux",
    "kernel_version": "5.10",
    "target_cpu": "loongarch",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

```
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
```

- 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"
]
```



```
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
[OHOS INFO] ----------------------------------------
[OHOS INFO] c targets overlap rate statistics
[OHOS INFO] subsystem           files NO.       percentage      builds NO.      percentage      overlap rate
[OHOS INFO] aafwk                    60         2.2%             60         2.2%    1.00
[OHOS INFO] ace                     669         24.4%           669         24.4%   1.00
[OHOS INFO] appexecfwk               38         1.4%             38         1.4%    1.00
[OHOS INFO] communication           244         8.9%            244         8.9%    1.00
[OHOS INFO] distributedschedule      43         1.6%             43         1.6%    1.00
[OHOS INFO] global                   15         0.5%             15         0.5%    1.00
[OHOS INFO] graphic                 325         11.8%           325         11.8%   1.00
[OHOS INFO] hdf                      81         3.0%             81         3.0%    1.00
[OHOS INFO] hiviewdfx                 7         0.3%              7         0.3%    1.00
[OHOS INFO] powermgr                 20         0.7%             20         0.7%    1.00
[OHOS INFO] securec                  78         2.8%             78         2.8%    1.00
[OHOS INFO] security                183         6.7%            183         6.7%    1.00
[OHOS INFO] startup                  77         2.8%             77         2.8%    1.00
[OHOS INFO] third_party             949         34.6%           949         34.6%   1.00
[OHOS INFO] utils                    10         0.4%             10         0.4%    1.00
[OHOS INFO]
[OHOS INFO] c overall build overlap rate: 1.00
[OHOS INFO]
[OHOS INFO]
```

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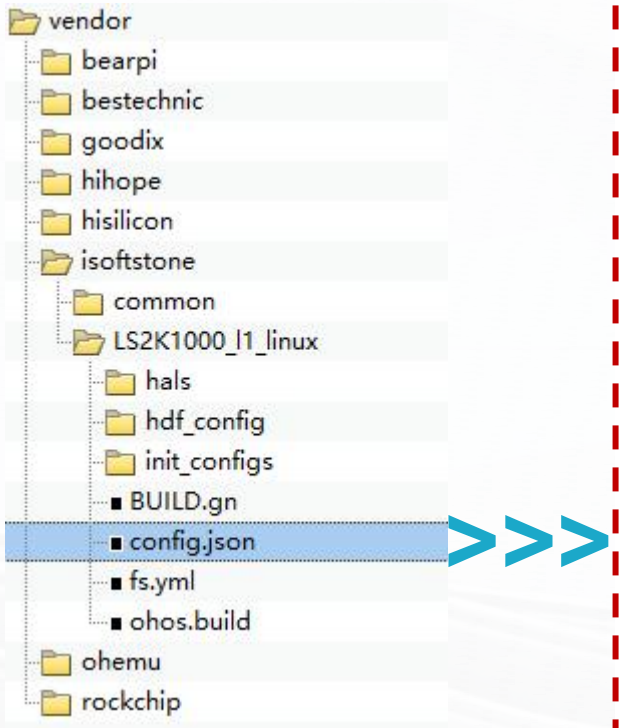
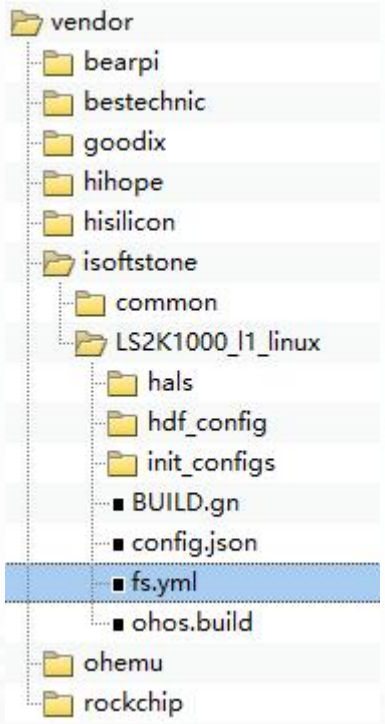
OpenHarmony系统支持的子系统由vendor目录下产品侧config.json文件控制



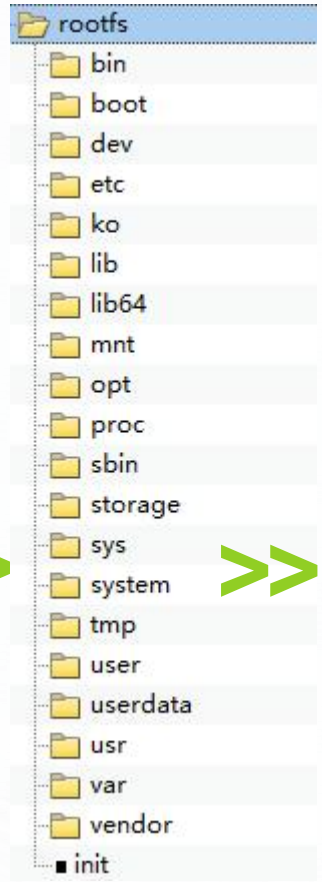

```
"subsystems": [
  {
    "subsystem": "ace",
    "components": [
      { "component": "ace_engine_lite", "features":[ "" ] }
    ]
  },
  {
    "subsystem": "distributedschedule",
    "components": [
      { "component": "samgr_lite", "features":[] },
      { "component": "safwk_lite", "features":[] },
      { "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":[] },
```

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

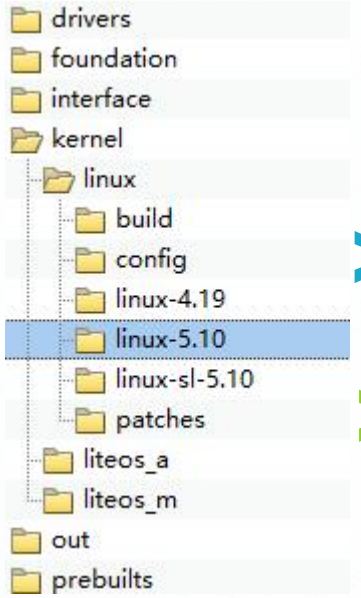



```
fs_dir_name: rootfs
fs_dirs:
  -
    source_dir: ${root_path}/out/preloader/${product_name}/system
    target_dir: system
  -
    source_dir: bin
    target_dir: bin
    ignore_files:
      - Test.bin
      - TestSuite.bin
      - query.bin
      - cve
      - checksum
    is_strip: TRUE
  -
    source_dir: libs
    target_dir: lib
    ignore_files:
      - .a
      - libstdc++.so.6
    is_strip: TRUE
    dir_mode: 755
    file_mode: 644
  -
    source_dir: usr/lib
    target_dir: usr/lib
    ignore_files:
      - .a
    is_strip: TRUE
    dir_mode: 755
    file_mode: 644
  -
    source_dir: config
    target_dir: etc
  -
    source_dir: system
    target_dir: system
  -
    target_dir: dev # "/dev" directory is mandatory for Linux init.
  -
    source_dir: sbin
    target_dir: sbin
  -
    source_dir: usr/bin
    target_dir: usr/bin
  -
```



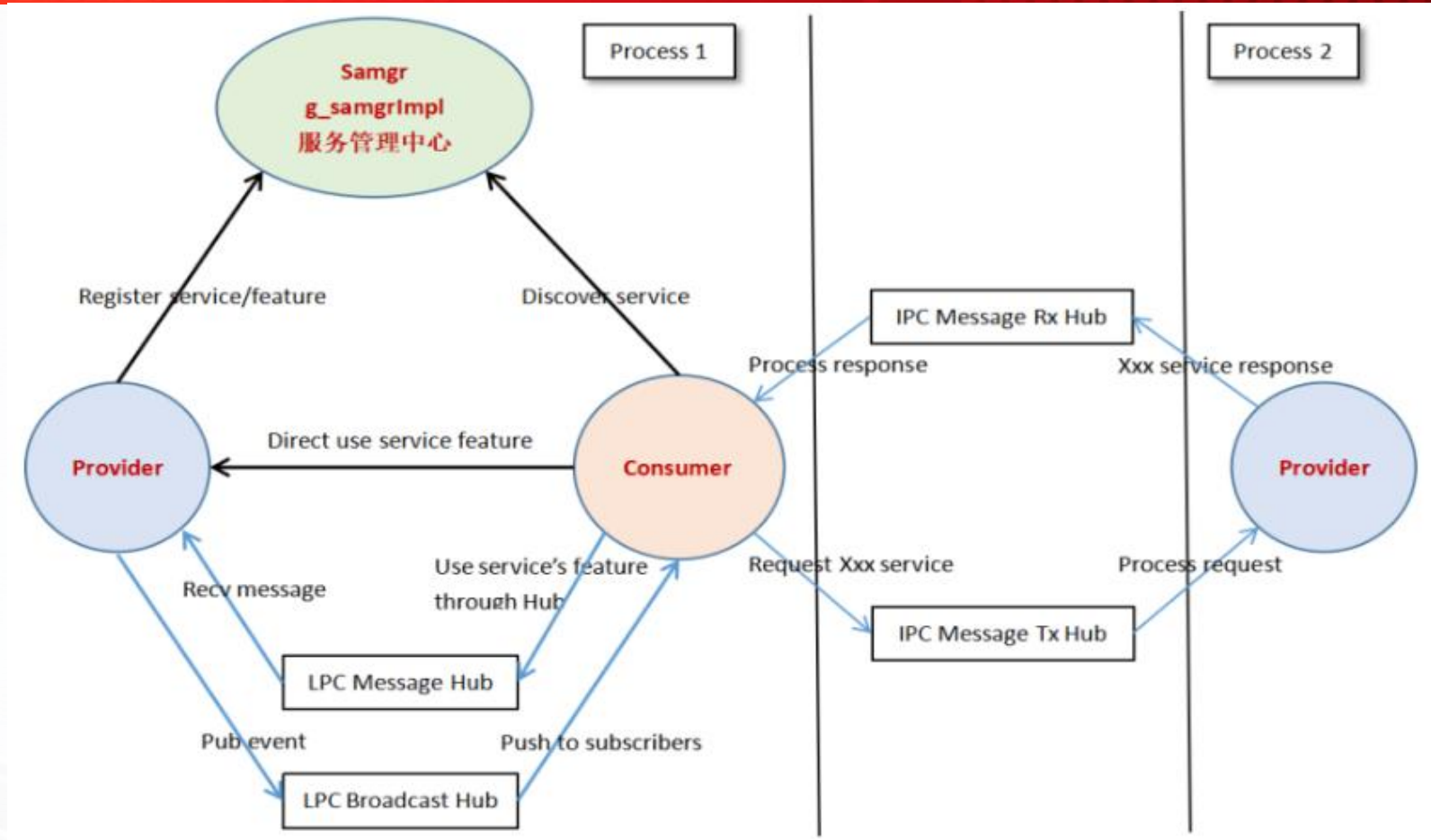
rootfs_ext4.img

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



Provider：服务的提供者，为系统提供能力（对外接口）。
Consumer：服务的消费者，调用服务提供的功能（对外接口）。
Samgr：作为中介者，管理Provider提供的能力，同时帮助Consumer发现Provider的能力。

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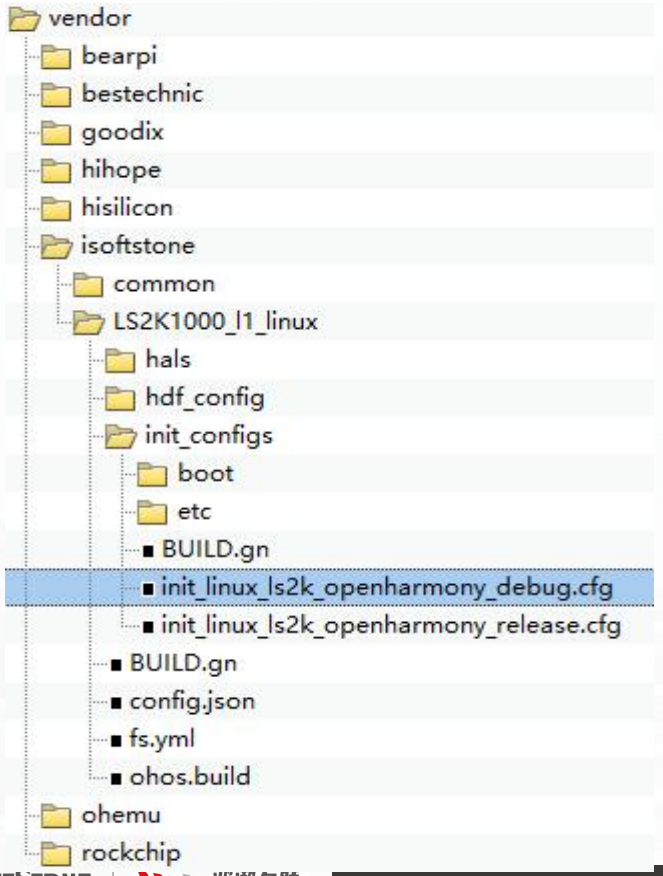
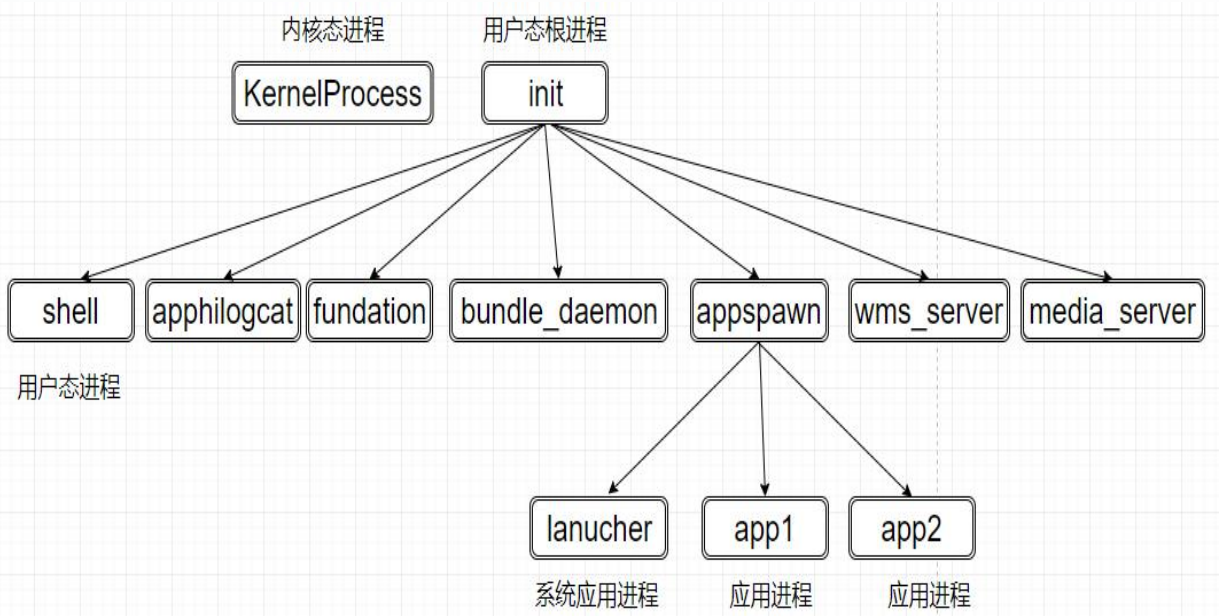
INIT启动引导组件

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]
```



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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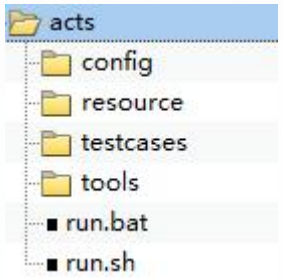
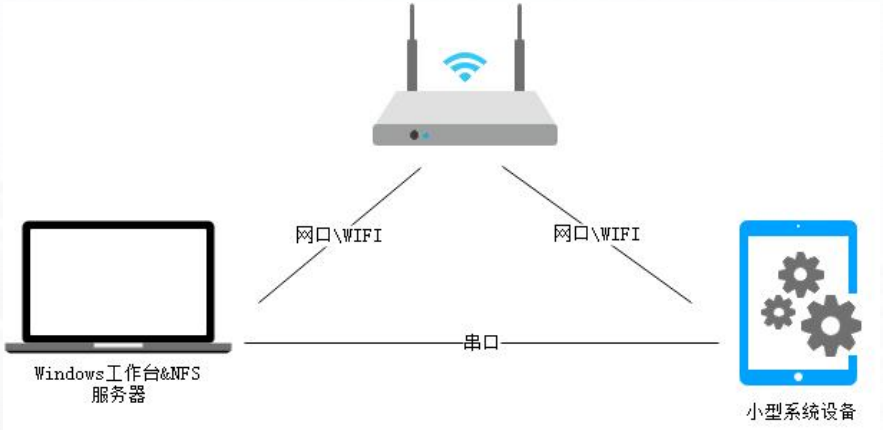
XTS（X Test Suite）子系统是OpenHarmony兼容性测评套件的集合

XTS子系统加入到编译组件中，参与编译：hb build --gn-args build_xts=true

```
{
  "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 ACTS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	

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

```c
#include "hal_sys_param.h"

static const char OHOS_DEVICE_TYPE[] = {"Loongson Board"};
static const char OHOS_DISPLAY_VERSION[] = {"OpenHarmony 3.1 Release"};
static const char OHOS_MANUFACTURE[] = {"isoftstone"};
static const char OHOS_BRAND[] = {"Loongson"};
static const char OHOS_MARKET_NAME[] = {"Loongarch 2K1000L1"};
static const char OHOS_PRODUCT_SERIES[] = {"V1"};
static const char OHOS_PRODUCT_MODEL[] = {"Loongarch 2K1000"};
static const char OHOS_SOFTWARE_MODEL[] = {"Loongson Board System v1.0"};
static const char OHOS_HARDWARE_MODEL[] = {"Loongson Board 2K1000"};
static const char OHOS_HARDWARE_PROFILE[] = {"aout:true,display:true"};
static const char OHOS_BOOTLOADER_VERSION[] = {"PMON 5.0.2-Release"};
static const char OHOS_ABI_LIST[] = {"Loongarch64"};
static const char OHOS_SERIAL[] = {"OH20220816"};  // provided by OEM.
static const int OHOS_FIRST_API_VERSION = 1;

static const char EMPTY_STR[] = {""};

const char* HalGetDeviceType(void)
{
    return OHOS_DEVICE_TYPE;
}

const char* HalGetManufacture(void)
{
    return OHOS_MANUFACTURE;
}

const char* HalGetBrand(void)
{
    return OHOS_BRAND;
}
```

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  ******
#
```

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THANKS

感谢您的观看！