SpaceChain OS whitepaper

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Contents

SPACECHAIN OS WHITEPAPER

COMMON LANGUAGE

Every organization requires a language for intercommunication. This language must be unified, applicable to every scenario and serviceable for all communication requirements. This is when the wisdom of men begun to accumulate, and effectiveness of interactions met exponential rise.

Since the birth of common language, men were able to gather, learn and trade with each other.

Common language acts as a strong adhesive that attaches all members together, providing a platform for interactions and communications of accumulated technologies from individuals. Codes are being shared, special equipment is utilized as a resource pool for the in and out flow of information.

WHY DO WE NEED OPERATING SYSTEM?

OPERATING SYSTEM REQUIREMENT FOR AEROSPACECRAFTS

There are a great variety of equipment in the field of aerospace, loaded with various operating systems, like books written in different languages. However, unlike translation between languages, transplants between operating systems are far more complicated.

Hence, one operating system is needed to meet common requirements of as many scenarios as possible, like English the lingua franca.

First of the first, SpaceChain OS fully satisfies the technical requirements from most equipment. For instance, the flight control of a space rocket requires inertial guidance which involves integral operation that are extremely strict in promptness that only a matching real-time operating system with high efficiency can meet such requirements. For return and landing of a rocket, the angle and power of motor requires precise and complicated control operation which only a large operating system ensures such stability. For the great number of satellite-born, rocket-borne and space station equipment, all require a common-use operating system to process data from sensors, display man-machine interface, conduct interactions and data storage.

REAL-TIME OPERATING SYSETM FOR SATELLLITE, RECOEKTS AND OTHER SPACECRAFTS

Strict instantaneity is essentially important for an operating system.

The real-time system operates under scenarios that requires instant control, generally includes: satellite attitude control, satellite housekeeping computer, radar, equipment monitoring display, equipment control, ignition system, motor control system and life maintaining system, etc.

Currently, real-time operating system or small-size embedded system for spacecrafts are INTEGRITY、VxWorks、SpaceOS、Reworks、FreeRTOS、RTEMS、SylixOS，μC/OS II, etc.

GENERAL OPERATING SYSTEM FOR LOAD EQUIPMENT

To meet requirements of the onboard equipment of spacecrafts, a general operating system does not necessarily require strict instantaneity, but it must reach a perfect balance between demands of reliability, stability and usability with fair cost.

The most popular general operating systems are Linuc, SylixOS and Windows, etc.

A general operating system must meet requirements in most scenarios: It should have high compatibility. Only its operation is compatible for as much equipment as possible, that can it be applied to most platform to reduce maintenance barriers and utilization difficulty of codes caused by overmuch systems. It should have strong expansibility and upgrade capability. During replacement or upgrade of hardware, its application should maintain stable to the most extent.

Relative low cost, in case the developers are stopped at the gate.

High transparency, to solve trust issues on codes for different organizations.

OPERATING SYSTEM FOR THE THRID PARTY MIDDLEWARE AND SOFTWARE

The development of upper software and middleware are generally based on a set of API, hence requires corresponding programming interface and compatibility of API on SpaceChain OS.

To reduce developing and learning cost.

To ensure the normal operation of original programs on the new platform with as less modification as possible; to raise sustainability and lower the transplanting cost.

TO MEET THE EDUCATIONAL REQUIREMENT

In the expected consensus system of SpaceChain, new engineers are of essential importance. SpaceChain has a great vision and magnificent plan to nurture more excellent talents in engineering with enthusiasm.

Such operating system should be able to meet requirements specifically applicable to education industrial features, that are: low cost, open and high sustainability.

SECURITY

Information security and operation security are two important aspects that must be kept on.

Information security: To keep the security of communication data link and prevent computing resources of satellite from hijacks; an open satellite faces more attacks than

conventional satellites hence the data requires more security protection.

Operation security: the spacecrafts are usually high in development cost, in this case its reliability and operation security must be ensured to the utmost extent. Segmented aspects of operation security lie in operation reliability and stability and recovery system upon a failure or abnormality.

The operating system should be competent to satisfy such requirements.

OPEN SOURCE

A language for communication must be open-resource and transparent for different enthusiasts and companies to use and contribute codes or be applicable to devices.

BIRTH OF SPACECHAIN OS

SOURCE OF SPACECHAIN OS

The inner core of SpaceChain OS is originated from SylixOS which an open source instant operating system is based of GPL protocol and is currently widely used in various equipment such as aerospace crafts, drones, submarines and power industries, with perfectly reliable codes. It is highly compatible and easy for future expansion to be freely used on as many devices possible.

SUPPORT VAIROUS PLATFORMS

SpaceChain OS supports 6 major hardware platforms including ARM, DSP, SPARC, X86, MIPS and RISC-V, which basically cover all existing processor structures. PowerPC and SPARC, MIPS are mainly adopted in the aerospace field and processor ARM and RISC-V with potential are now getting noticed in the low-orbit sector.

SUPPORT GRAPHICS AND MULTIMEDIA

SpaceChain OS supports complete graphic frames such as QT, Micro windows and mu C/GUI that properly meet the interaction and display requirements for browsing, graphic display and touch control.

SpaceChain OS has strong multimedia functions including QT MultiMedia, FFMPEG, VoIP, xAudio, xCamera and realizes complete coding and decoding for audio and video, Internet-based transmission, 7.1 channel audio mixing, video acquisition and format conversion, etc.

API AND EXPANSIBILITY

SpaceChain OS application programming interface conforms to various standards such as IEEE, ISO and IEC, supports 4 sets of API that are POSIX 1003.1b, VxWorks V6.8 (90%), GJB7714-2012 and Sylix API

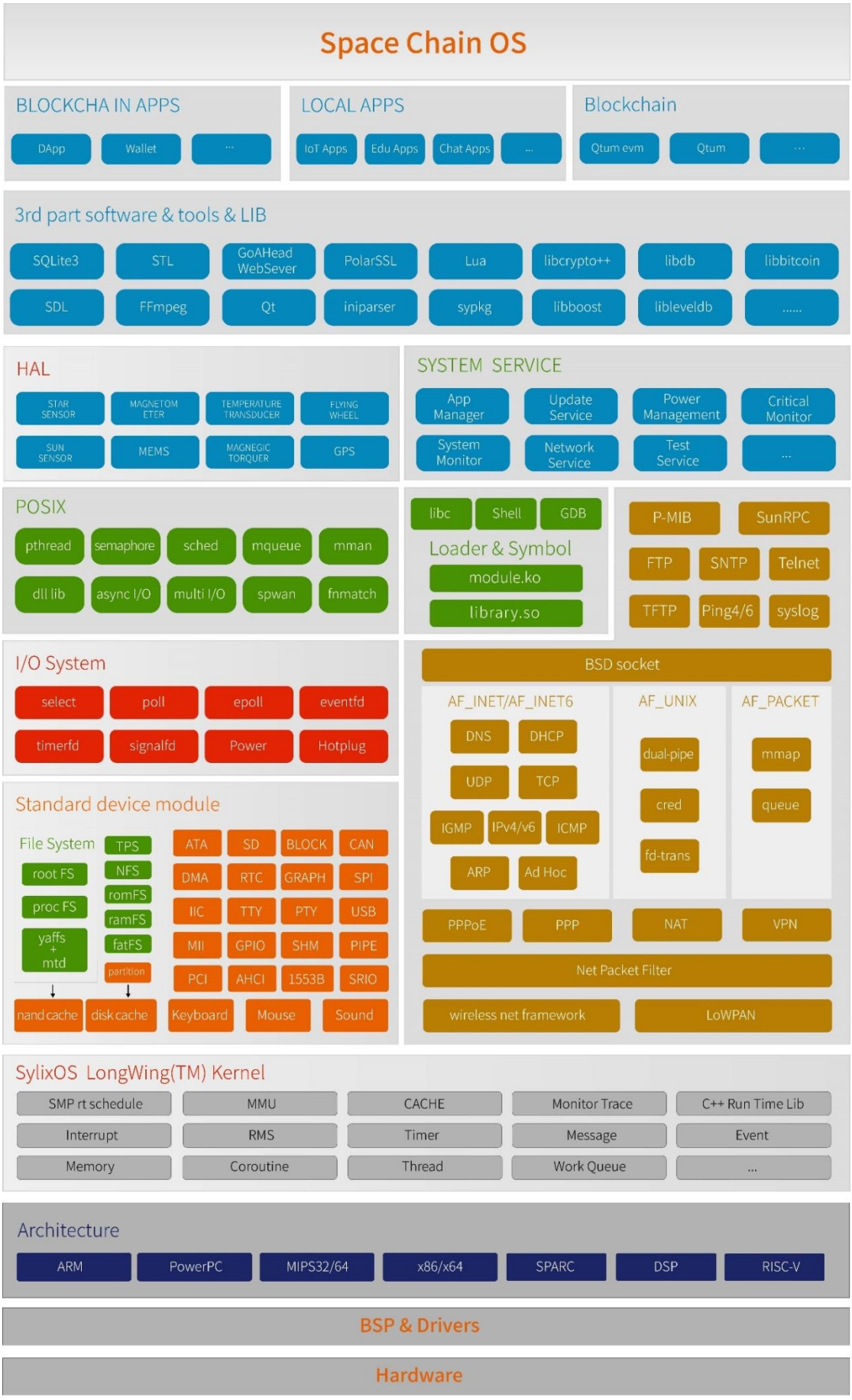
With its strong expansibility, SpaceChain OS not only perfectly meets the strict demands in aerospace application environment, but also conveniently applies its safe and stable features in other sectors and scenarios like ground equipment, handset terminals, radar and test control stations. Such scenarios may not require instantaneity or extreme reliability. Cross-platform applications can greatly save development and learning cost.

Currently, SpaceChain OS supports third-party middlewares including but not limited to: OpenSSL, Python, unixODBC, GoAhead, FastDB, SQLite, Lua, QGIS, uGFX, OpenMP4.0 and OpenBLAS, together with corresponding encryption, scripting language and various site bus and standards.

For specific information please refer to OS user's guide and function descriptions.

SpaceChain OS are strong in upgrade capability. It supports various upgrading methods such as dynamic loading, separate development of APP and operating system, one-key upload, deploying application, supporting application and OS self-online update to meet requirements for an open satellite platform. By separating APP and OS, it provides support for the separation and sharing of aerospace craft operation resources. Applications from engineers and enthusiast could safely operates via sandbox with independent address resource.

The SpaceChain OS structural diagram is shown as follows.


Space Chain OS
BLOCKCHA IN APPS
DApp
Wallet
...
LOCAL APPS
IoT Apps
Edu Apps
Chat Apps
...
Blockchain
Qtum evm
Qtum
...
3rd part software & tools & LIB
SQLite3
STL
GoAHead WebSever
PolarSSL
Lua
libcrypto++
libdb
libbitcoin
SDL
FFmpeg
Qt
iniparser
sypkg
libboost
libleveldb
.....
HAL
STAR SENSOR
MAGNETOMETER
TEMPERATURE TRANSDUCER
FLYING WHEEL
SUN SENSOR
MEMS
MAGNEGIC TORQUER
GPS
SYSTEM SERVICE
App Manager
Update Service
Power Management
Critical Monitor
System Monitor
Network Service
Test Service
...
POSIX
pthread
semaphore
sched
mqueue
mman
dll lib
async I/O
multi I/O
spwan
fnmatch
libc
Shell
GDB
Loader & Symbol
module.ko
library.so
P-MIB
SunRPC
FTP
SNTP
Telnet
TFTP
Ping4/6
syslog
I/O System
select
poll
epoll
eventfd
timerfd
signalfd
Power
Hotplug
BSD socket
AF_INET/AF_INET6
AF_UNIX
AF_PACKET
DNS
DHCP
UDP
TCP
IGMP
IPv4/v6
ICMP
ARP
Ad Hoc
dual-pipe
cred
fd-trans
mmap
queue
Standard device module
File System
TPS
NFS
romFS
ramFS
fatFS
partition
root FS
proc FS
yaffs + mtd
nand cache
disk cache
ATA
SD
BLOCK
CAN
DMA
RTC
GRAPH
SPI
IIC
TTY
PTY
USB
MII
GPIO
SHM
PIPE
PCI
AHCI
1553B
SRIO
Keyboard
Mouse
Sound
PPPoE
PPP
NAT
VPN
Net Packet Filter
wireless net framework
LoWPAN
SylixOS LongWing(TM) Kernel
SMP rt schedule
MMU
CACHE
Monitor Trace
C++ Run Time Lib
Interrupt
RMS
Timer
Message
Event
Memory
Coroutine
Thread
Work Queue
...
Architecture
ARM
PowerPC
MIPS32/64
x86/x64
SPARC
DSP
RISC-V
BSP & Drivers
Hardware

OPEN SOURCE

The major key for SpaceChain OS to realize massive knowledge sharing, reuse of source code and APP, ensure the reusability and continuity is the open source and transparency of OS.

SpaceChain OS is a set of open source operating system including Sylix OS kernel, third-party middleware, satellite application, QTUM and various other middleware and application programs that its source codes are all open to public and free to download visiting SylixOS.SpaceChain.com.

Sharing of knowledge can never be closed. SpaceChain selected open source SpaceChain OS and open source command instruction set RISC-V as the basis for development of education plan. SpaceChain is willing to provide space computing capabilities to the education plan, in which the participants enjoy the verification and application in space environment by uploading their own APPs.

An open source code could strengthen the foundation of mutual trust and cooperation.

From the technical perspective, an open source operating system is the most suitable for embedded development and coordination that it brings the following strengths:

Easy for development and fault location
Improves the system reliability and lowers the technical risks.
Suitable for embedded customization, modification with high technical transparency.

SAFETY

OPERATION

SpaceChain OS provides formal verification model, power failure safety document system, SIL authentication.

Formal verification model SpaceChain OS develops its core codes adopting formal verification model. The system codes (source codes and assembly code) based on high order logic proof Isabelle/HOL expressional language builds system abstract standard, adopts man-machine interactive theorem proving method to prove the evolving relations in two layers, executive standard and abstract standard, C language realization and executive standard.

Power failure safe document system- The embedded equipment faces more operation risks than desktop equipment, for instance the power failure at any time. In this case, SpaceChain OS adopts TpsFs document system that endures the completeness of document system and data structure in all extreme circumstances. This creative function avoided many problems including failure of online upgrade, system failure after rebooting due to power failure, etc.

Functional Safety Authentication - Functional safety requires the equipment under control to reliably enter and maintain its safety state, avoiding possible damage to personnel or environment in case of any component failure or safety-related control system failure either caused by random hardware failure

or system failure. SpaceChain will later reach SIL3 level through update to conform to the standard safety operating system inner core.

Safety sandbox and parallel virtualization -SpaceChain is currently developing parallel virtualization technology to provide a safe sandbox under ARINC653 standard with better performance. Standing beyond the traditional process address space isolation, this micro inner core based on L4 realizes multi-safety subsection sandbox isolation that supports parallelization.

INFORMATION SECURITY

Opennessleadsto transparency but not information disclosure or danger.

There are various kinds of applications in aerospace and satellite systems, like control applications in high demand of instantaneity, or support application with relative low demand in instantaneity.

SpaceChain OS internally built safety module, firewall, network thunder shielding system and provides traffic control, load balancing functions.

SpaceChain OS supports trusted computing through double guarantee in aspect of both hardware and software to ensure mutual trust between equipment and software running on it. Illegal equipment or software will not be able to join the network or trick the trusted equipment or software for unsanctioned operation.

SpaceChain OS utilizes the virtualizing capability of conventional safety sandbox, adopts data isolation, information flow control, resource control and fault isolation to form multiple logical computing subsections with different security levels, allowing every logic subsection to have independent resource and is able to timely process resource allocation, information flow and isolate faults, in order to keep the effective balance between multi-layer safety demand and instantaneity of operating system.

SpaceChain OS provides a sandbox based on blockchain technology to ensure separation and independence of data from different applications. Every developer has his own safe environment to run his application program like IOS phone operating system. The error or failure of an APP does not affect other APP, OS operation or even base hardware safety. Blockchain technology ensures the encryption in the process of data transmission and keep the origin and authentication of the stored data from any illegal tampering.

MISCELLANEOUS

Deep learning- SpaceChain OS supports deep learning. Aiming to the feature of embedded equipment, it supports a mode that separates training and application, reducing computing scale of equipment to lower the cost at the same time maintaining the same outcome. To deep learning applications, SpaceChain OS could realize hardware isolation and network model establishment. Currently this function is in the process of technical verification.

DEVELOPMENT AND APPLICATIONS

BLOCKCHAIN PLATFORM

Qtum quantum chain is one intelligent contract platform realized upon PoS and UTXO that promotes the popularization of decentralized Apps (Dapp) on mobile ends. By adopting PoS, all nodes with complete function are able to realize on embedded equipment.

SpaceChain OS now supports QTUM to realize blockchain sandbox function and releases EVM virtual machine with the specific codes and related documents posted on GitHub.

We are continuously working on supportive mechanism for enterprise Ethereum alliance to expand the range of applications to a greater scale.

By supporting the above platforms, we could incorporate the blockchain mechanism in the small-scale embedded system, which merely cost several ten dollars for one constituent plugboard. At lower cost, deployment of blockchain to mass scale is becoming possible.

DESIGN SOLUTION, CASE AND APPLICABLE SCENARIOS

Currently, SpaceChain OS provides a great number of complete design solutions and cases including Sparc, PowerPC, Cortex-R5 and Zynq, etc., to be specified in the following:

- PowerPC

  At present, the PowerPC processor using in aerospace are the SM750 processor from State Micro and P1022 processor from NXP.

  SM750 is one 32-bit superscalar low-power micro processor that adopts PowerPC RISC architecture and is compatible with MPC 750 chip from Motorola with a main frequency of 266MHz, anti-radiation, super-wide temperature space-level chip.

  P1022 is a dual-ore processor with E500 core from NXP, it has the main frequency of 1 GHz with relative high performance that can be applied to scenarios that require high performance such as data processing or scientific computing. At present, the SM750 processor from State Micro has been completely adapted. Since it is a main processor with relative less targeted peripherals that it can only be extended via bridge chips or FPGA, therefore SpaceChain OS has done a lot of optimization accordingly, such as safety bootloader, selection vote towards key data, remote upgrade, power failure safe write-balanced flash document system, etc.

- Cortex-R5

  ARM’s product collection is renamed to Cortex after its classic processor ARM11 and down categorized to A, R and M divisions to provide service to different target markets. Cortex series belong to the ARMv7 architecture, which was the latest ISA of ARM up to 2010. The ARMv7 architecture clearly defined three distinct divisions of work: series “A” is targeted at high-end operating system and user applications based on virtual memory; series “R” is targeted at real-time system whereas series “M” is targeted at micro-controller. The Cortex-R real time processor provides high performance

computation resolving solutions to embedded system that requires high reliability, usability, fault-tolerance, maintainability and real-time responsive processors.

The Cortex™-R5 is perfectly applicable to aerospace, primarily because it has two distinctive features for security: optional unit correction and dual-bit error detection for caches with ECC bits and/or TCM memory. The processor automatically corrects unit soft errors and can provide ECC protection on all external interfaces. A dual-processor configuration for a redundant fault-tolerant/fault detection system with redundant Cortex-R5 CPUs in lock-step or dual cores that run independently. Each core uses its own bus interface interrupts or operates its own programs.

Cortex-R processors currently used in aerospace include the TMS570LS3137 processor and TMS 570LC43x processor from TI. Presently SpaceChain OS has completed the adaption of above processors and supports the two safety features, ensures that the error-tolerance and error-correction capability for the satellite hardware system in case of impact by high-energy particles. It mainly applies to the main mission computer of low-orbit small satellite.

- Sparc

  SpaceChain OS uses Sparc VC8 and SpaceChain OS, brings in new functions compare to the conventional OS and software, which includes the following:

  Application software OTA solution scheme allows the on-orbit satellite to update its application software through OTA update mode which is highly convenient for future expansion of applications.

  System software completeness solution scheme- The customized Bootloader can perform checking on the OS and software completeness before the satellite operating system or software start, it improves the system reliability.

  Multiple redundant backups- The conventional space backup, whether hot or cold is all multi-hardware solutions with high cost and a waste of space and energy. The newly invented software redundant backup system allows multiple sets of software of operating systems to deploy on the same satellite hardware platform; in case any one of the set is faulty that requires switching of tasks, it can be switched manually or automatically to another set. It greatly improves system reliability and provides fundamental technical support for future functions to be incorporated.

- ARM+FPGA（ZYNQ7000）

Zynq is a proven and mature solution that is widely used in power, rail transport, satellite and drone industries. Its heterogeneous FPGA+ARM solution offers the possibility of miniaturization for many platforms. In power-sensitive scenarios that somehow occasionally requires high-performance computation, Zynq has become an excellent load device.

SpaceChain OS supports all Zynq 7000 peripherals including QSPI, USB3.0, HDMI, SD, ETHERNET, DMA and more.

HOW TO USE SPACECHAIN OS?

Interested parties can visit SpaceChain official website and SpaceChain OS Github to download code, documents and developing tools.

All updates will be announced on the above platforms for the first time. If you have more questions, please feel free to visit the community or via email to info@SpaceChain.com to join discussion and acquire latest information.

SUBSEQUENT PLAN

SpaceChain OS started the architecture design in November 2017 and started the development of the operating system in the same period, performed simultaneous implementation of the join cooperation of testing process and the operating system. In the subsequent development progress, SpaceChain OS will consistently work on its core tech with Sylix OS, independent branches will not be considered for development. We will keep our focus on:

Keep on developing more new middleware and function base and to develop and test general technologies.

To make load experiments for verifying the reliability and stability of new functions.

To add more user document, tools and manuals to simplify the learning progress and lowering access barriers.

To promote application range and areas of SpaceChain OS.

We look forward to your support and expect your participation!