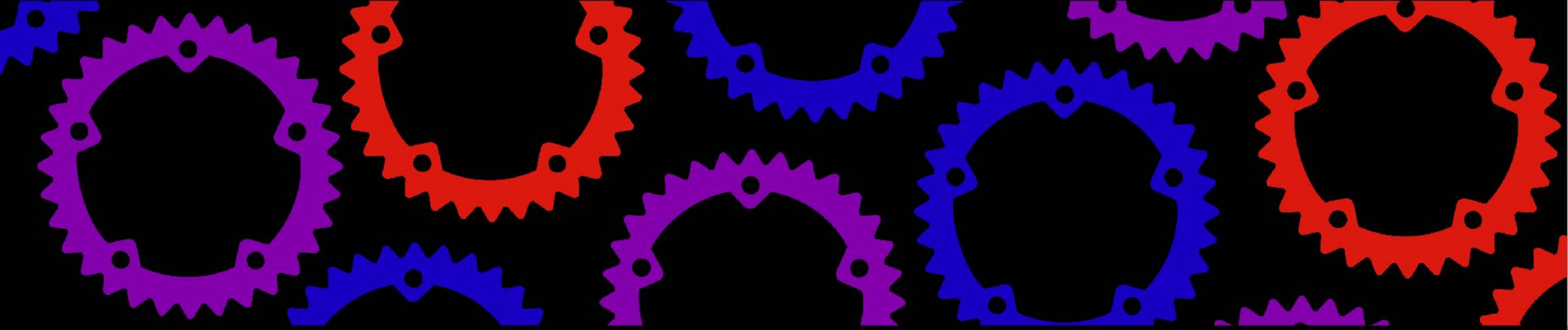


Linux From Scratch in Rust

Mingshen Sun

2019.04.20
RustCon Asia, Beijing

Intro

- **Linux From Scratch (LFS)** is a project that provides you with step-by-step instructions for **building you own custom Linux system**, entirely from source code.

- ***Why/Can/How we do LFS entirely in Rust?***

whoami

- Senior Security Research in **Baidu X-Lab**, Baidu USA
- System security, mobile security, IoT security
- MesaLock Linux, MesaPy, Rust OP-TEE TrustZone SDK, TaintART, Pass for iOS, etc.
- `mssun @ GitHub` | https://mssun.me

Why LFS in Rust?

- **Cause we are in a Rust conference! Yes, it's fun!**

Why LFS in Rust?

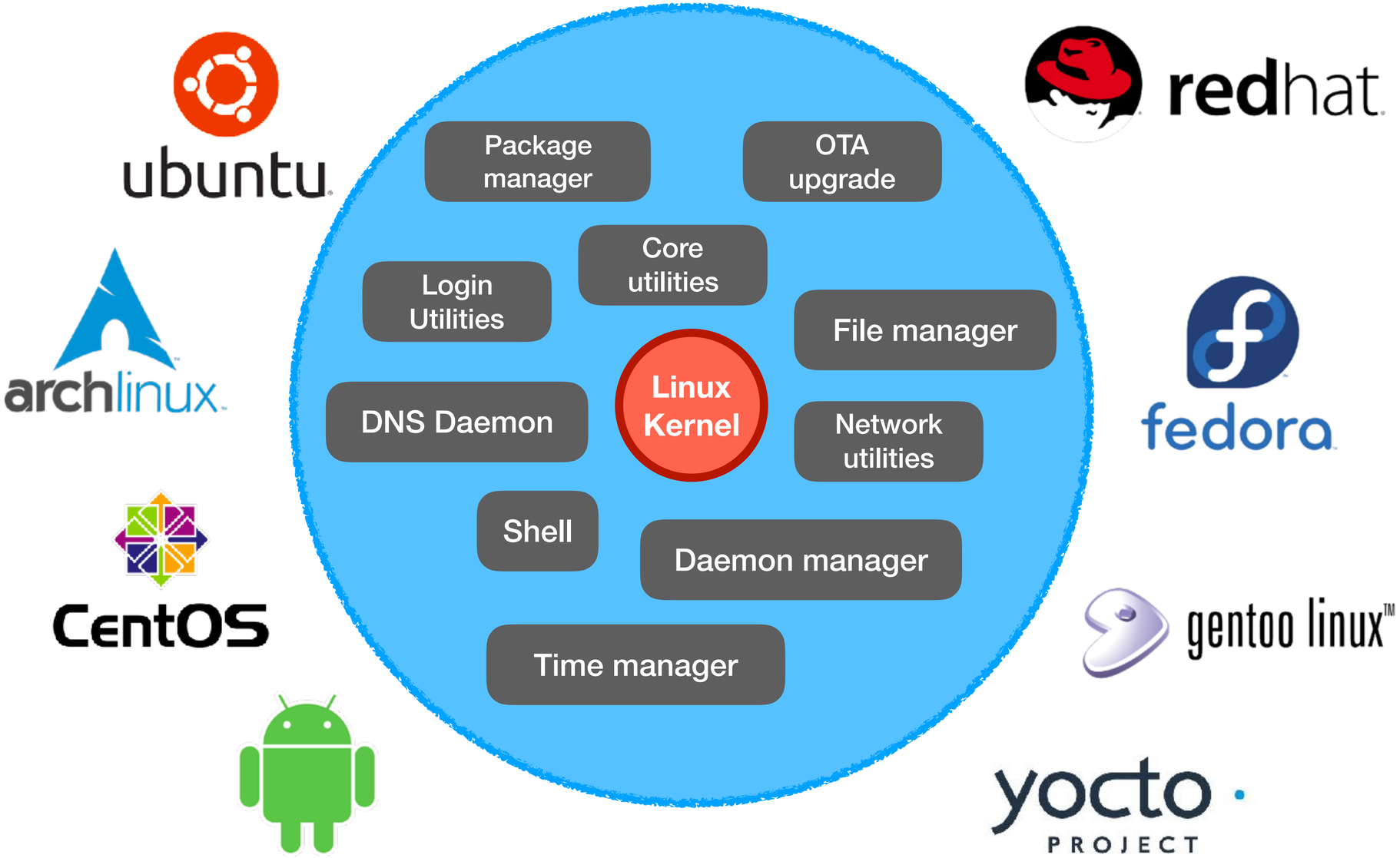
- Cause we are in a Rust conference! Yes, it's fun!
- **Memory-safety in userspace**

- CVE-2017-13089 **wget**: Stack-based buffer overflow in HTTP protocol handling
- A **stack-based buffer overflow** when processing chunked, encoded HTTP responses was found in wget. By tricking an unsuspecting user into connecting to a malicious HTTP server, an attacker could exploit this flaw to potentially **execute arbitrary code**.
- https://bugzilla.redhat.com/show_bug.cgi?id=1505444
- Proof-of-concept: https://github.com/r1b/CVE-2017-13089

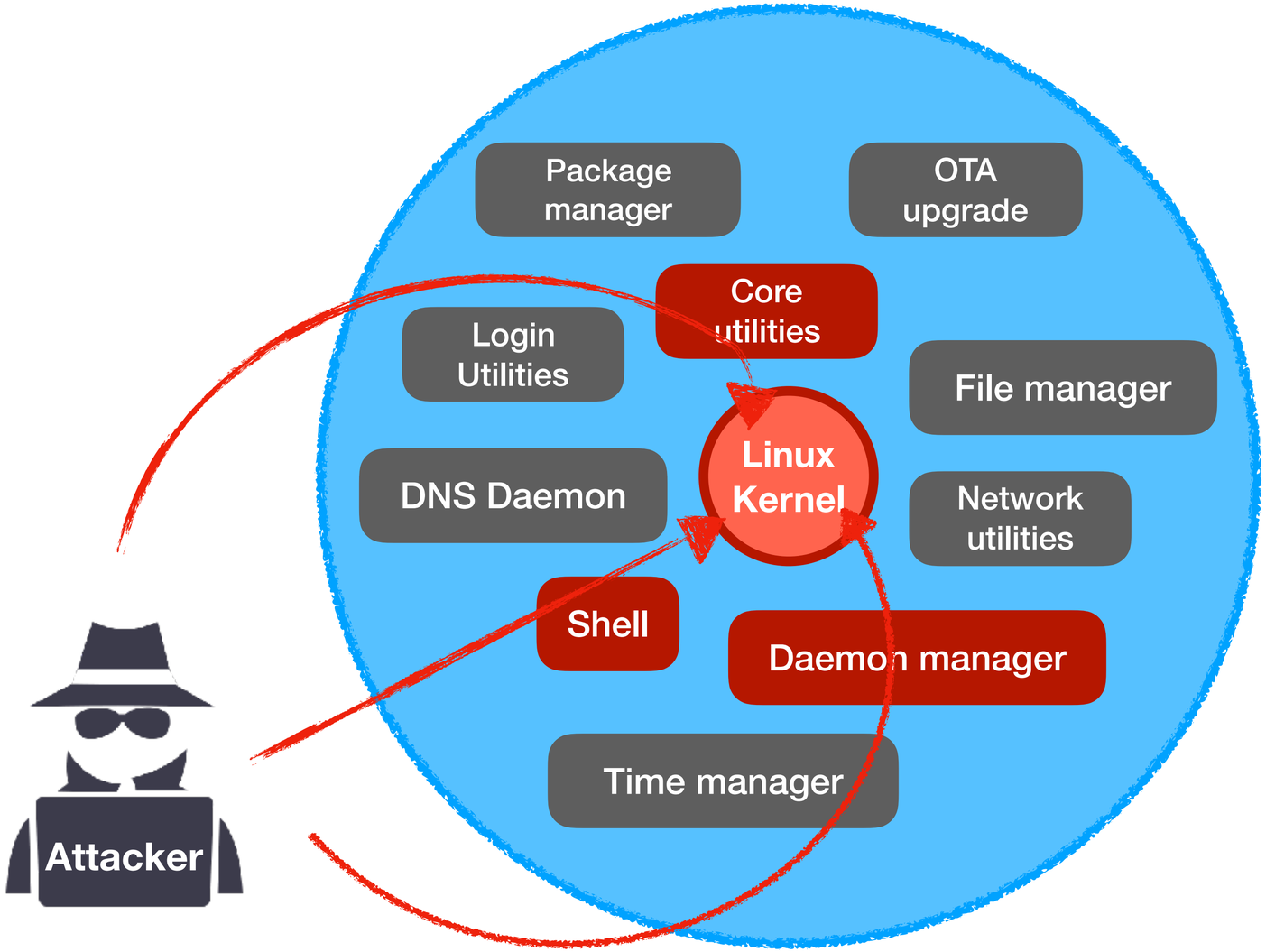
Why LFS in Rust?

- **Cause we are in a Rust conference!**
- Memory-safety in userspace
- **Capabilities and "pitfall" of system programming in Rust**

Linux Userspace



Security of Linux Userspace



Linux Distros

- A Linux distribution (often abbreviated as distro) is an operating system made from a **software collection**, which is based upon the **Linux kernel** and, often, a **package management system**.

- **Server**: CentOS, Federa, RedHat, Debian
- **Desktop**: Ubuntu
- **Mobile**: Android
- **Embedded**: OpenWRT, Yocto
- **Enthusiast**: Arch Linux, Gentoo
- **Misc**: ChromeOS, Alpine Linux

Security and Safety?

- Gentoo Hardened: enables several risk-mitigating options in the toolchain, supports PaX, grSecurity, SELinux, TPE and more.
- Kernel hardening patches
- Safety? No.
- User space? GNU.

Basic Components of LFS in Rust

- bootloader
- Linux kernel
- init
- getty
- login
- iproute2
- coreutils

- syslinux
- Linux 4.9.58

MesaLock Linux

- minit
- mgetty
- mlogin
- giproute2
- uutils-coreutils

MesaBox

MesaBox

- MesaBox is a collection of **core system utilities** written in Rust for Unix-like systems.

- Like the well-known BusyBox and Toybox sets of utilities popular on embedded devices, **MesaBox seeks to provide a fully functioning command-line environment**.

Status

Utility	Type	Status
arch	GNU	**Complete**
base32	GNU	**Complete**
base64	GNU	**Complete**
yes	GNU	**Complete**
getty	Login	Simple Version
tar	LSB	Beginning Stages
ping	Networking	Simple Version
cat	POSIX/GNU	**Complete**
chmod	POSIX/GNU	**Mostly Complete (missing --reference)**
head	POSIX/GNU	**Complete**
echo	POSIX	**Complete**
init	POSIX	Simple Version
sh	POSIX	Significant Progress
sleep	POSIX	**Complete**

Add New Tools?

Name and description

```
const NAME: &str = "dummy";
pub const DESCRIPTION: &str = "A dummy utility to demonstrate the framework";


type DummyResult<T> = ::std::result::Result<T, DummyError>;


#[derive(Fail, Debug)]
enum DummyError {
    #[fail(display = "oh no, something wrong")]
    SomethingWrong
}
```

Use failure for error handling

Add New Tools?

clap for command line argument parsing

```
fn create_app() -> App<'static, 'static> {
    util_app!(NAME)
        .arg(Arg::with_name("verbose")
        .short("v")
        .long("verbose")
        .help("Say hello in verbose mode"))
}


pub fn execute<S, T>(setup: &mut S, args: T) -> Result<()>
where
    S: UtilSetup,
    T: ArgsIter,
{
    let app = create_app();
    let matches = app.get_matches_from_safe(args)?;
    let options = DummyOptions::from_matches(&matches);
    let output = setup.output();
    let mut output = output.lock()?;
    let mut dummyer = Dummyer::new(output);
    dummyer.dummy(&options)?;
    Ok(())
}
```

start the tool with input arguments

One more interesting feature in MesaBox

- It can be used as a library.

```rust
fn main() {
    let listener = TcpListener::bind("127.0.0.1:9876").unwrap();

    for stream in listener.incoming() {
        let mut stream = stream.unwrap();

        let mut stdout = stream.try_clone().unwrap();
        let mut stderr = stream.try_clone().unwrap();

        let res = {
            let mut setup =
                UtilData::new(&mut stream, &mut stdout, &mut stderr, iter::empty(), None);

            mesabox::execute(&mut setup, &mut ["head", "-n", "4"].into_iter())
        };
        if let Err(f) = res {
            let _ = writeln!(stderr, "{}", f);
        }
```

Use "head" to handle TcpStream.

Packages of MesaLock Linux

- `brotli`: compression tool written in Rust
- `busybox`: busybox tool set for testing only
- `exa`: replacement for ls written in Rust
- `fd-find`: simple, fast and user-friendly alternative to find
- `filesystem`: base filesystem layout
- `gcc-libs`: GCC library, only libgcc_s.so is used
- `giproute2`: ip tool written in Go
- `glibc`: glibc library
- `init`: init script
- `ion-shell`: shell written in Rust
- `linux`: Linux kernel

Packages of MesaLock Linux

- `mesalock-demo`: some demo projects
- `mgetty`: getty written in Rust
- `micro`: modern and intuitive terminal-based text editor in written Go
- `minit`: init written in Rust
- `ripgrep`: ripgrep combines the usability of The Silver Searcher with the raw speed of grep, written in Rust
- `syslinux`: bootloader
- `tokei`: count your code, quickly, in Rust
- `tzdata`: timezone data
- `uutils-coreutils`: cross-platform Rust rewrite of the GNU coreutils
- `uutils-findutils`: rust implementation of findutils
- `xi-core`: a modern editor with a backend written in Rust
- `xi-tui:` a tui frontend for Xi

Add New Packages?

```yaml
package:
  name: ripgrep
  version: 0.8.0
  description: ripgrep combines the usability of The Silver Searcher with the raw speed of grep
  license: [MIT, Unlicense]
  url: https://github.com/BurntSushi/ripgrep
  skip_check: true

  source:
    - git+https://github.com/BurntSushi/$name.git

  prepare:
    - cd "$name".git && git checkout -B 0.8.0

  build:
    - cd "$name".git && cargo build --release
    - cd "$name".git && cargo test

  install:
    - cd "$name".git && install -D -m744 target/release/rg -t "$pkgdir"/bin/
```

- build.yml
- name, version, description, license, url, skip_check
- source, prepare, build, install
- mkpkg will automatically build and package tools

Rust in System Programming

- **<u>The `nix` library is very useful.</u>**
  - unistd.h, mount.h, fcntl.h, stdlib.h
  - handle PTY, network interface, users/groups, ioctl, mount, kmod
- **<u>Signal in Rust is unsafe.</u>**
  - **`SIGUSR1, SIGUSR2, SIGTERM, SIGQUIT, SIGINT, SIGHUP, SIGTSTP, SIGSTOP`**...

Rust in System Programming

- **<u>Rust standard library only provides APIs with high-level abstraction.</u>**
  - `std::net` v.s. `socket2/net2` v.s. `libpnet` v.s. `libc`
- You have to use `libc` in the end.

Structs

AddrParseError	An error which can be returned when parsing an IP address or a socket address.
Incoming	An iterator that infinitely `accept`s connections on a `TcpListener`.
Ipv4Addr	An IPv4 address.
Ipv6Addr	An IPv6 address.
SocketAddrV4	An IPv4 socket address.
SocketAddrV6	An IPv6 socket address.
TcpListener	A TCP socket server, listening for connections.
TcpStream	A TCP stream between a local and a remote socket.
UdpSocket	A UDP socket.

Structs

Domain	Specification of the communication domain for a socket.
Protocol	Protocol specification used for creating sockets via `Sock`
SockAddr	The address of a socket.
Socket	Newtype, owned, wrapper around a system socket.
Type	Specification of communication semantics on a socket.

bind
listen
accept
local_addr
peer_addr
try_clone
take_error
set_nonblocking
shutdown
recv
peek
recv_from
peek_from
send
send_to
ttl
set_ttl
unicast_hops_v6
set_unicast_hops_v6
only_v6
set_only_v6
read_timeout
set_read_timeout
write_timeout
set_write_timeout
nodelay
set_nodelay
broadcast
set_broadcast
multicast_loop_v4
set_multicast_loop_v4
multicast_ttl_v4

Rust in System Programming

- **<u>Handling string for CLI in Rust is very difficult.</u>**
  - String, &str
  - CString, &CStr
  - OsString, &OsStr
- **<u>Low-level system operation in Rust is very difficult.</u>**
  - E.g., netlink: used to transfer information between the kernel and user-space processes.

Rust in System Programming

- **<u>Testing and code coverage in Rust are non-trivial tasks.</u>**
  - Integration test framework for CLI: `assert_cmd, assert_fs`
  - **tarpaulin**: a code coverage reporting tool for the Cargo build system
  - **gcov**: a source code coverage analysis and statement-by-statement profiling tool

`ptrace`-based code coverage profiling tool

`llvm-gcov`-based code coverage profiling tool

Quick Start

```
$ docker run -it mesalocklinux/mesalock-linux
```

2. : /root (ssh)

```
:/root# cat /etc/issue
MesaLock Linux \r (\l)

:/root#
```

- Live ISO
- Docker image
- rootfs
- x86_64, arm in the near future

Contributing

- https://github.com/mesalock-linux/mesalock-distro
- You can get involved in various forms:
  - Try to **use** MesaLock Linux, report issue, enhancement suggestions, etc
  - **Contribute**: optimize development process, improve documents, closing issues, etc
  - **Contribute to core packages**: improving minit, mgetty, giproute2, etc
  - **Writing applications** using memory safe programming languages like Rust/Go, and joining the packages
  - **Auditing source code** of the projects and related packages
- You are welcome to send **pull requests** and report **issues** on GitHub.

Thank you!

Day 4: April 23

09:00 12:00 **Build a Secure and Trusted Framework in Rust**

This talk intends to be a long talk (~4 hrs) introducing the Rust TEE ecosystem.

Rust SGX SDK has become the most popular SGX development environment. Previous talks at RustFest, QConSF and QConBJ are all brief talks within 30 minutes and limited Q&As. This time I'd like to present its details and current ecosystems. In addition, we'll include the Rust-trustzone part.

The talk would guide the audience to play Rust on two TEEs: SGX and Trustzone. In the beginning, we'll talk about the trusted computing theory and hardware-assisted trust execution engines. Then we assist the audience with hands-on experiments on Rust+SGX and Rust+Trustzone platforms. At last, we'll discuss about the internals and ecosystems.

Yu Ding &
Mingshen Sun