



# Linux on RISC-V

Fedora and Firmware Status Update

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# AGENDA



Fedora

Fedora on RISC-V

Bootstrap

Koji

Status

Targets



Firmware

Firmware on RISC-V

Firmware Status

Boot flow

UEFI/EDK2

Server/PC Specs



FYI

Steps to run Fedora Image  
on RISC-V platform



Part I

# Fedora on RISC-V



Bootstrap

Koji

Status

Targets

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# Fedora/RHEL/CentOS



## Fedora

- Focus on **new features and new technology**
- Community-driven, Free
- Short release cycles (approximately 6M)



## RHEL

- Focus on **stability**
- Supported by Red Hat, Comes with subscription
- Slower releases (approximately 9M)



## CentOS

- Focus on **stability**
- Community driven, Free, but lack of official support
- Based on the same code base with **RHEL**



# Fedora focus is on new technology



Fedora is the **pioneer** on new technology.

Fedora is also corporate supported by RedHat. It feeds the RHEL product. Everything that is considered to be stable and useful for demanding enterprises, might be moved in phases towards the RHEL distribution.

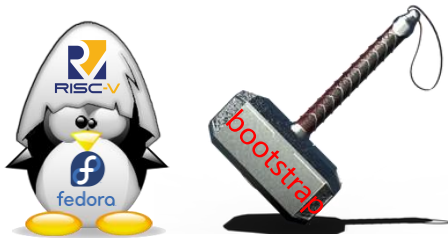
If any new arch wanna get RHEL support, it need to **get Fedora support first.**

# The issue for a new architecture



## Chicken And Egg Situation

Generally, one Fedora release is built upon the previous release. But this can **NOT** be done for a brand new architecture, because we don't have a "previous release" at that point.



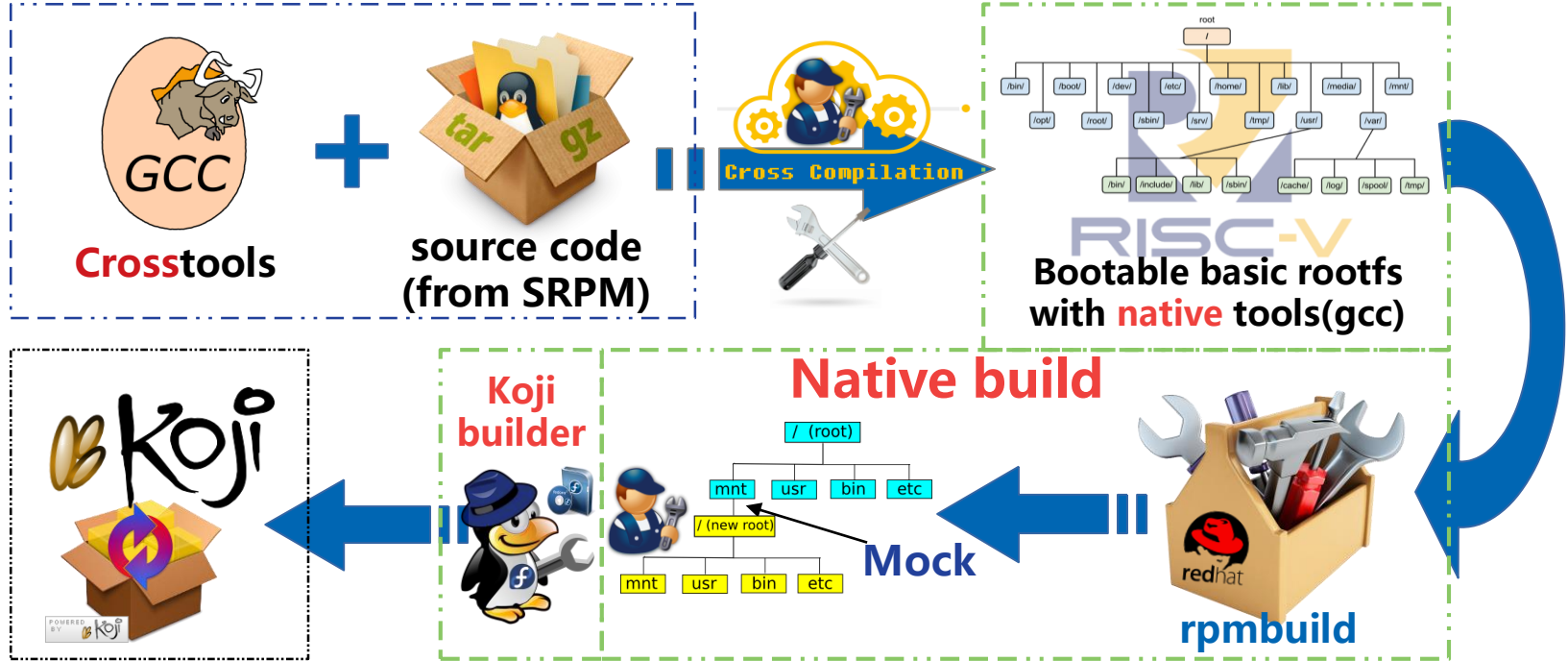
## Breakout

We must **cross-compile** enough software/packages to "**bootstrap**" the new architecture.

# Fedora bootstrap

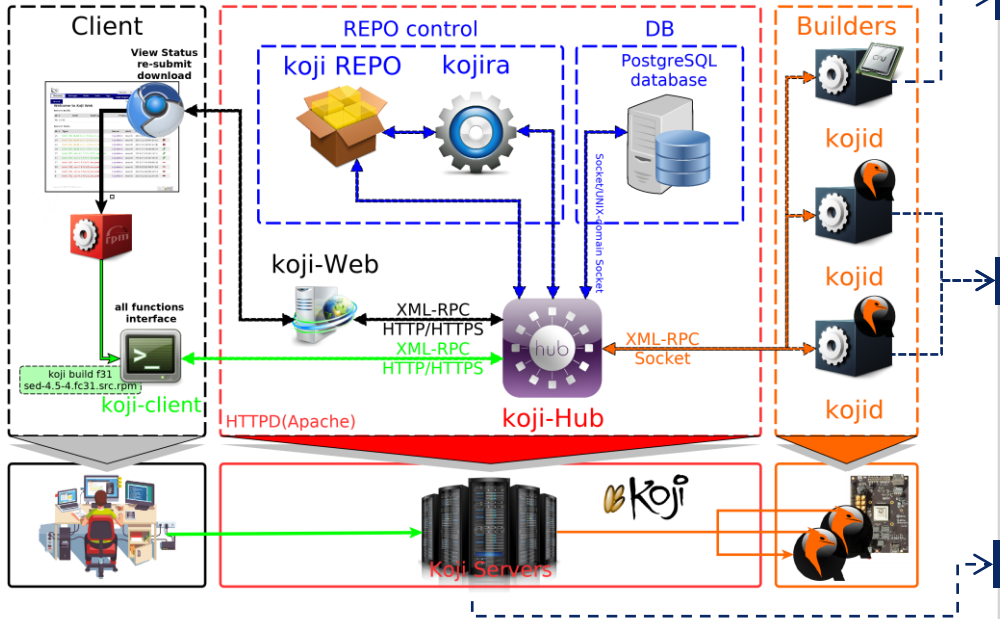


## Fedora Bootstrap



# Koji Build System

Koji builds RPMs for the Fedora Project and EPEL.



These Koji servers for RISC-V have been moved to the hardware supplied by SiFive and WD at Fremont.



## 3 HiFive Unleasheds

One of them connects with SSD.



## 142 QEMU VMs(on x86\_64 server)

fedora-riscv-x.gcc1xx.osuosl.org  
managed by libvirt  
(will add more by adding more servers)



## An x86\_64 server for all central infrastructure

Main sever, repository creation and VMs with backup(separate NVMe).



# Status



## Active projects

**Fedora 32/Rawhide**, including debuginfo, debugsource and source packages.



## Fedora Developer Image

has extra packages installed for developers, all common editors, RPM tools, building tools, koji stuff, etc.



Minimal



GNOME



## Repositories

<https://dl.fedoraproject.org/pub/alt/risc-v/>  
<https://mirror.math.princeton.edu/pub/alt/risc-v/>  
<https://isrc.iscas.ac.cn/mirror/fedora-riscv/>



<https://fedoraproject.org/wiki/Infrastructure/Mirroring>



# Targets

## Supported

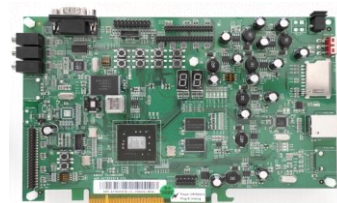


**Virtual: libvirt + QEMU**  
with graphics parameters (Spice).



**Real Hardware: SiFive Unleashed**  
with Expansion Board, PCI-E graphic Card & SATA SSD

## Tested



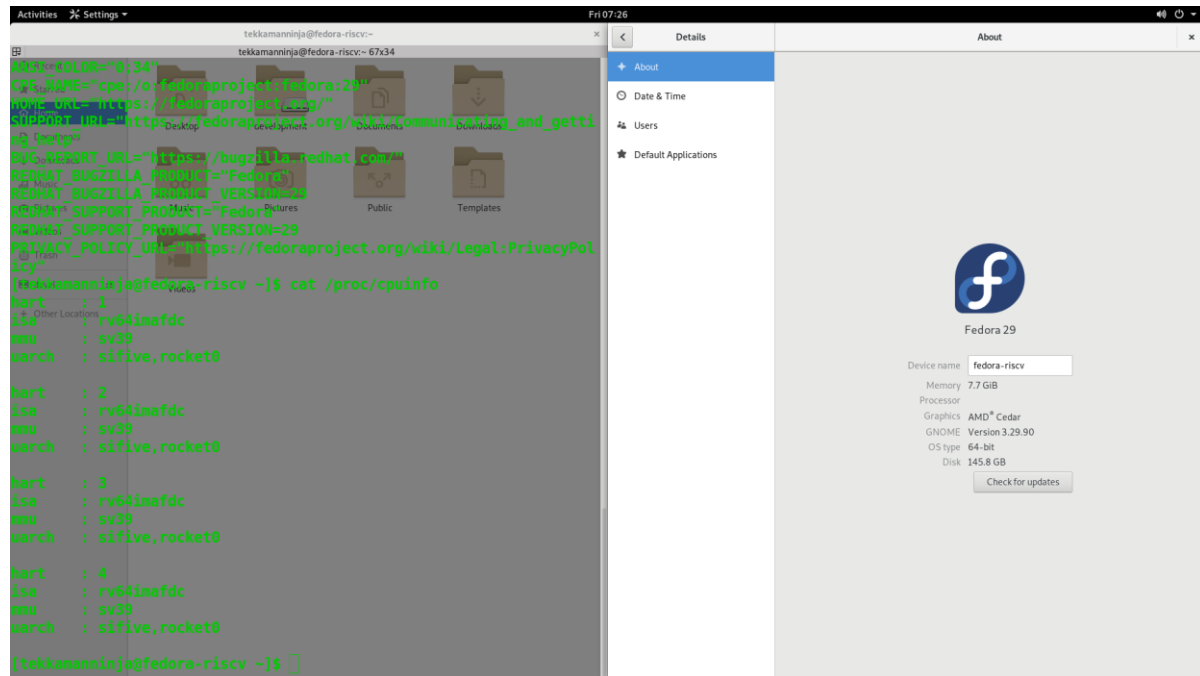
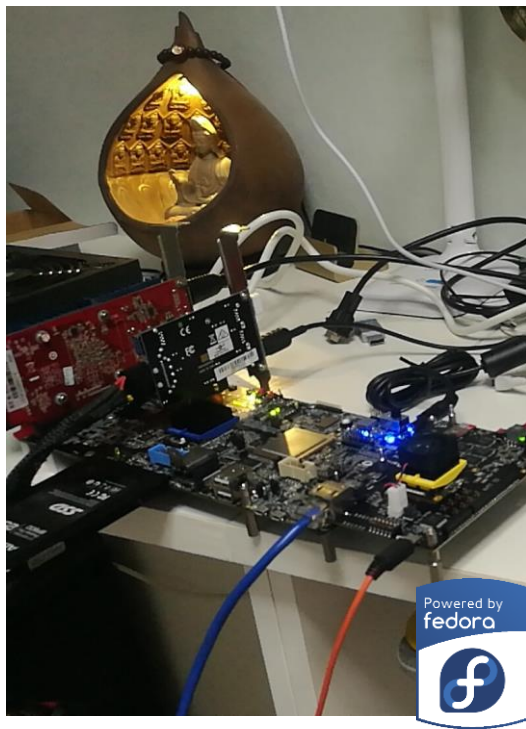
**QEMU for AndeStar V5 & ADP-XC7KFF676**  
Andes QEMU and AndeShape **FPGA** board



中国科学院计算技术研究所  
INSTITUTE OF COMPUTING TECHNOLOGY, CHINESE ACADEMY OF SCIENCES

**ICT SERVE Platform: FlameCluster**  
**FPGA** Cloud development platform (with PCI-E SSD and graphic Card)

# Fedora GNOME Image on SiFive Unleashed



# Fedora Developer Image on ICT FlameCluster



FlameCluster =  
SERVE.c + SERVE.v



```
Starting Hostname Service...
[ OK ] Started Permit User Sessions.
Starting Terminate Plymouth Boot Screen...
Starting Hold until boot process finishes up...
[ OK ] Started Terminate Plymouth Boot Screen.
[ OK ] Started Hold until boot process finishes up.

Welcome to the Fedora/RISC-V disk image
https://fedoraproject.org/wiki/Architectures/RISC-V

Build date: Wed Jul  3 20:19:49 UTC 2019

Kernel 4.18.0-ga57318a4-dirty on an riscv64 (hvc0)

The root password is ..riscv...

To install new packages use 'dnf install ...'

To upgrade disk image use 'dnf upgrade --best'

If DNS isn't working, try editing ../etc/yum.repos.d/fedora-riscv.repo...

For updates and latest information read:
https://fedorapeople.org/groups/risc-v/disk-images/readme.txt

Fedora/RISC-V
-----
Koji:                http://fedora-riscv.tranquillity.se/koji/
SCM:                 http://fedora-riscv.tranquillity.se:3000/
Distribution rep.:   http://fedora-riscv.tranquillity.se/repos-dist/
Koji internal rep.: http://fedora-riscv.tranquillity.se/repos/
[ 230.410000] tx_irq = 4
[ 230.410000] rx_irq = 5
fedora-riscv login: root
Password:
[root@fedora-riscv ~]# passwd
Changing password for root

```

Learn more about SERVE:

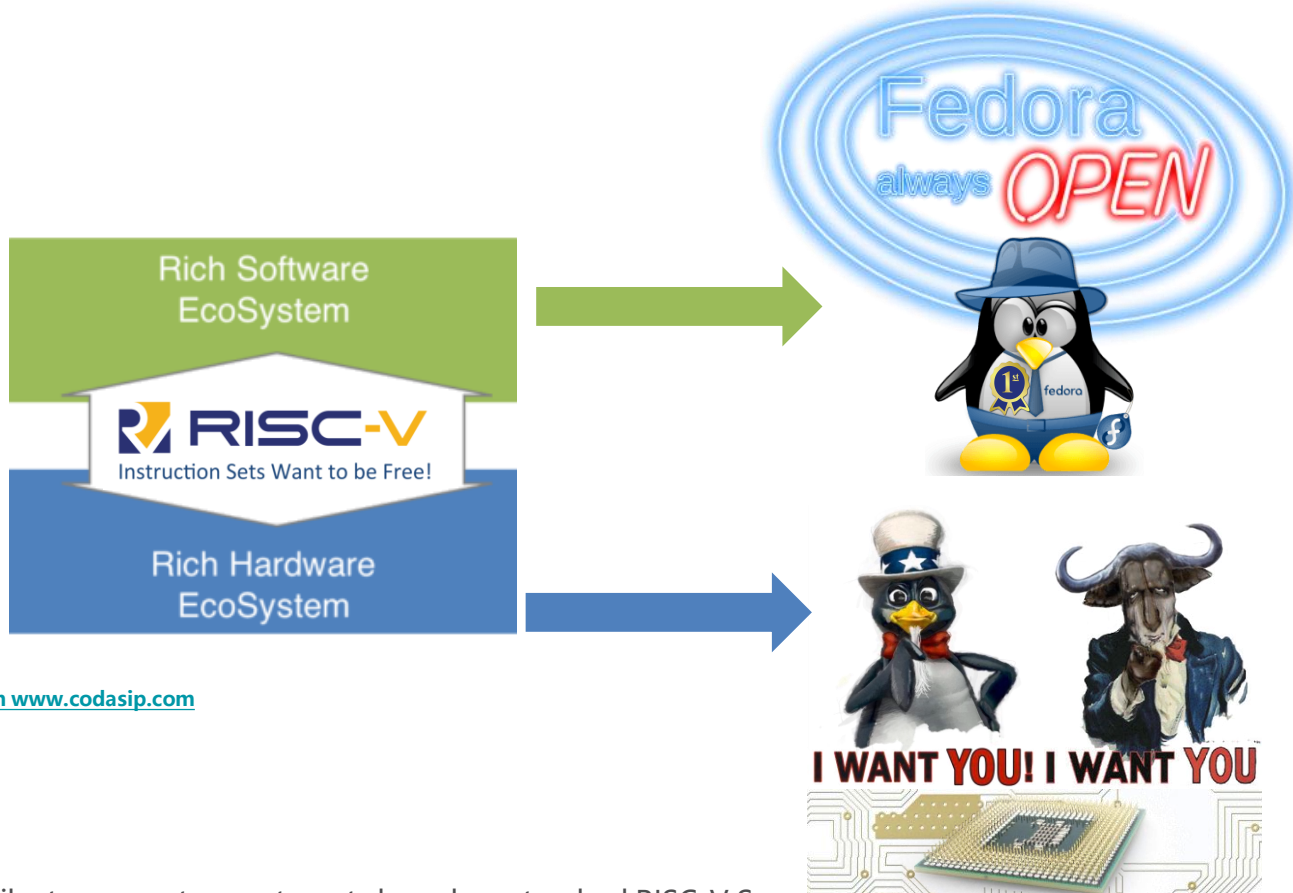
<https://code.ihub.org.cn/projects/373>

<https://github.com/ict-accel-team/SERVE.r>

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# Fedora on RISC-V

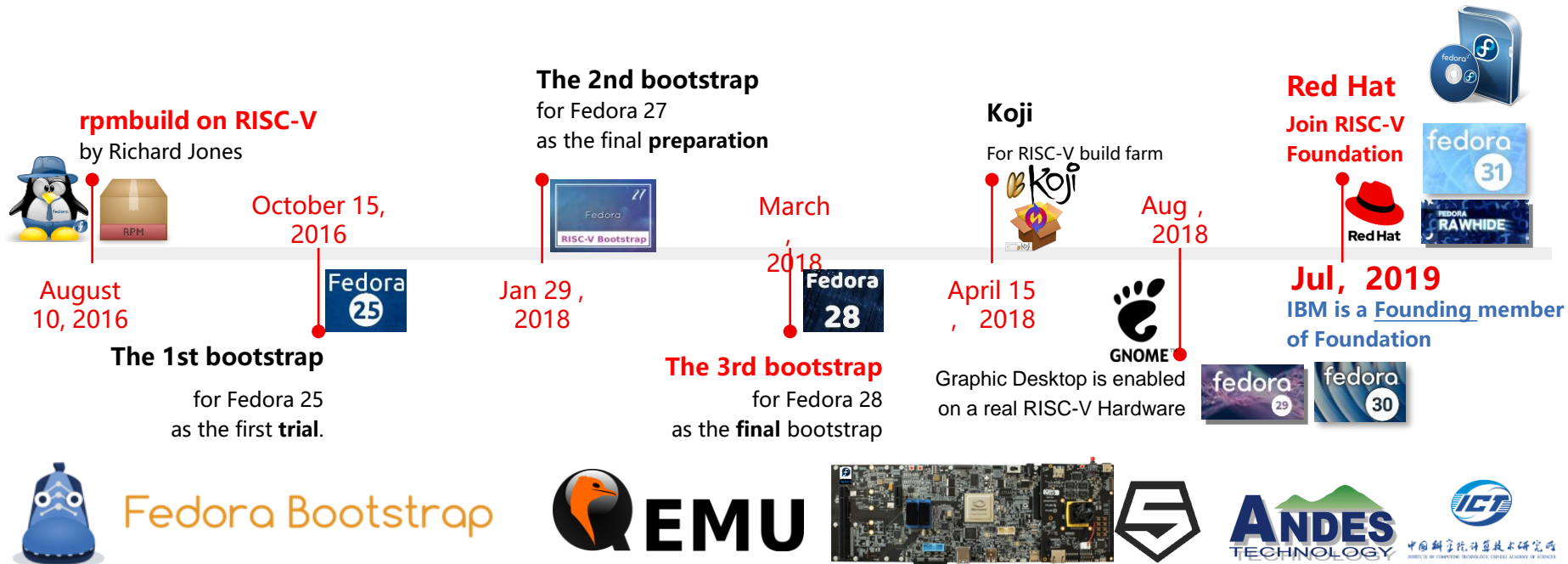


[From www.codasip.com](http://www.codasip.com)

We would like to support more targets based on standard RISC-V Spec.

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# Summary



Since Fedora has an **upstream first policy** and it also applies to Fedora/RISC-V.

We need all the key patchsets for **toolchain**, **Linux kernel** and **glibc** to be merged, then we can do the **final** bootstrap on RISC-V.

## Info Source:

Most of info comes from Richard Jones and his weblog: <https://rwmj.wordpress.com/>

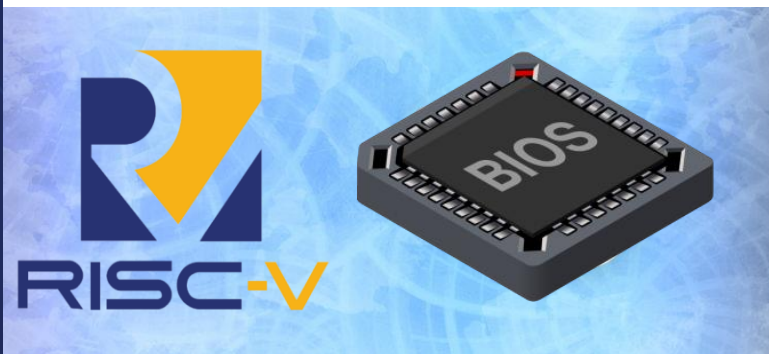
RISC-V Koji maintainer: David Abdurachmanov **#RISCVSUMMIT** | [tmt.knect365.com/risc-v-summit/](https://tmt.knect365.com/risc-v-summit/)





## Part II

# Firmwares on RISC-V



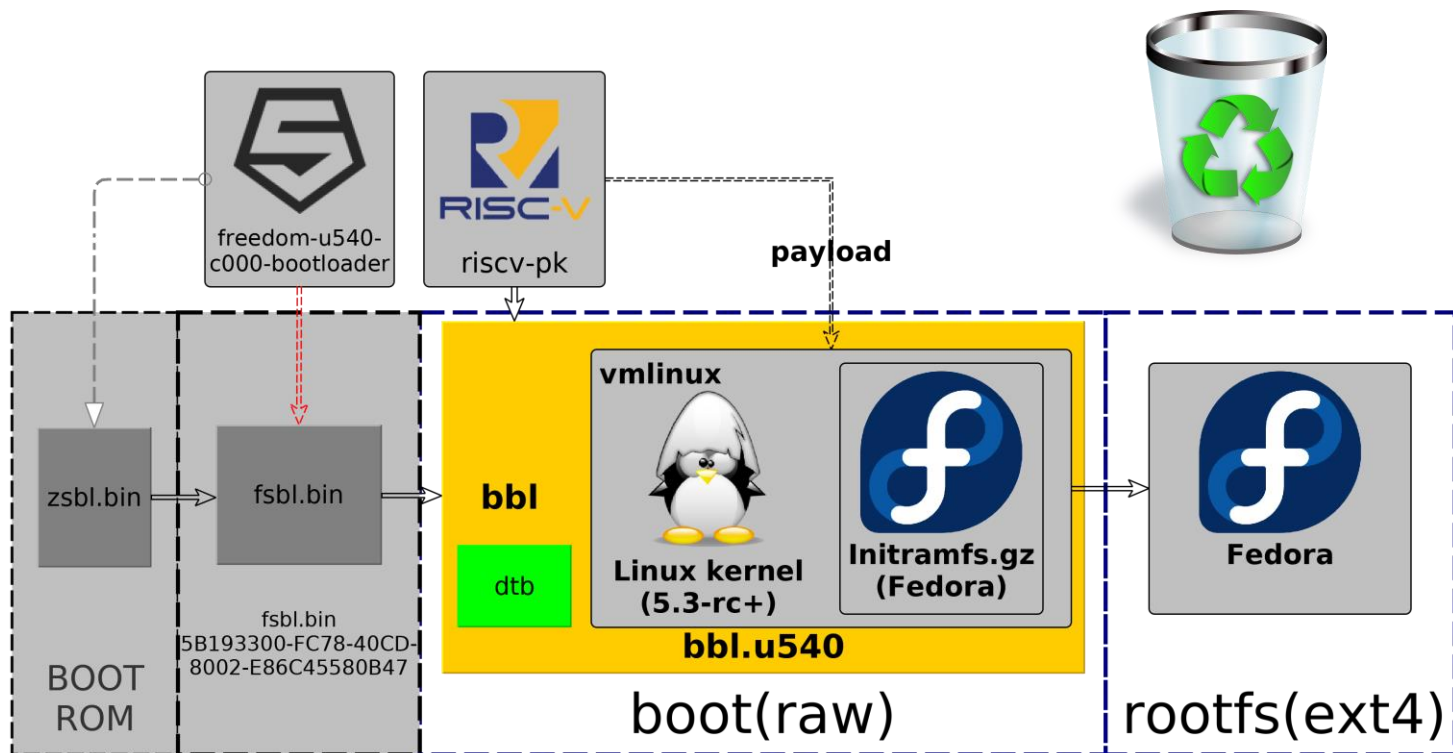
Firmwares Status

Boot flow

UEFI/EDK2

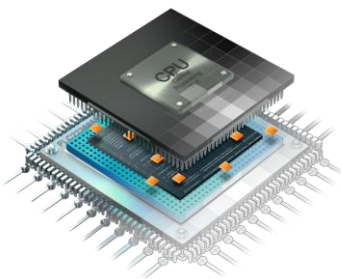
Server/PC Specs

# The DATED boot flow for Fedora on RISC-V(abandoned)





# The Status of RISC-V Firmware



## U-boot

The upstream u-boot can boot Fedora image, works WELL.



## OpenSBI + U-Boot + Linux

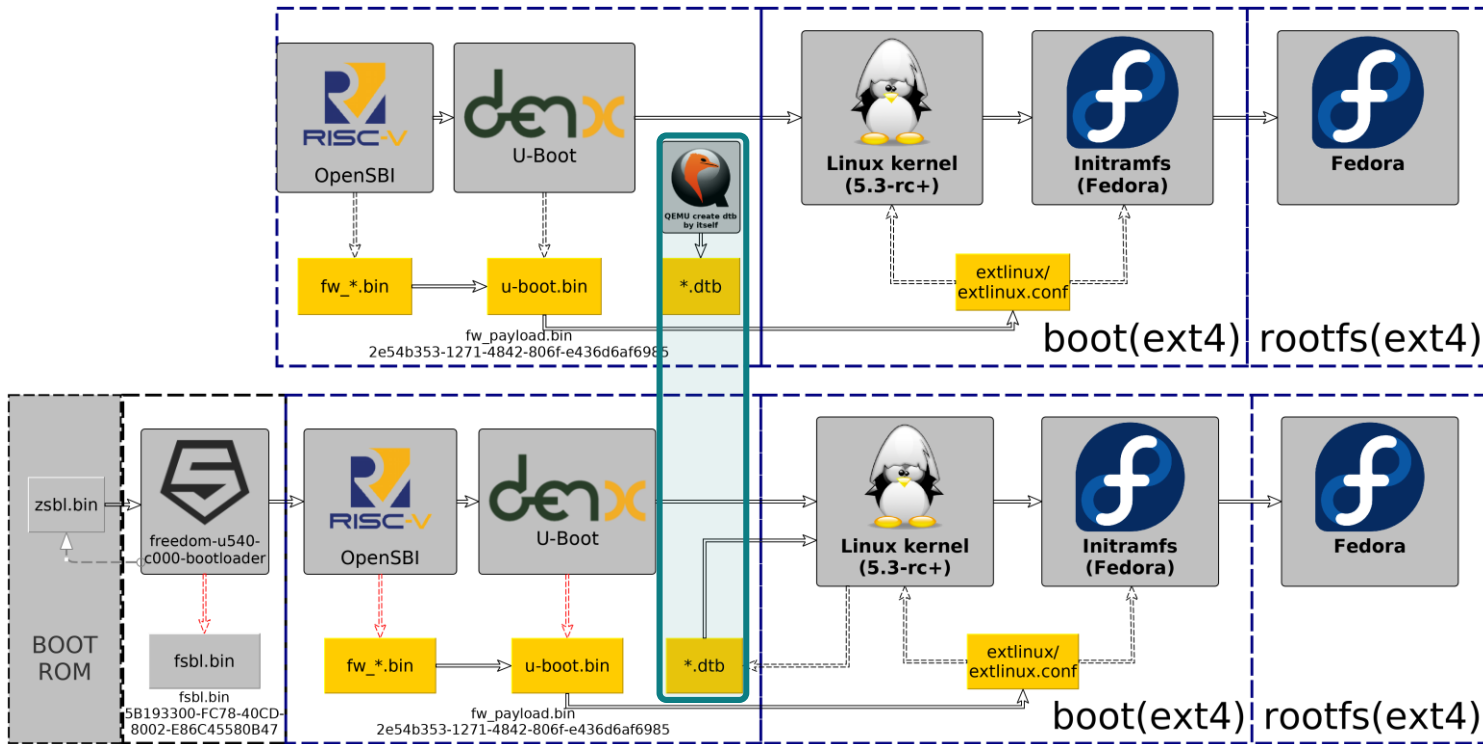
For now, it has become a standard boot flow for Fedora on RISC-V



## GRUB2

The RISC-V support has been merged, the rpm package is built in Koji, The RPM package is already available in Fedora. But we still miss the EFI support in kernel(so called EFI stub kernel ).  
EDK2 support is on the way.

# The current boot flow for Fedora on RISC-V



# The current Build flow for firmware on RISC-V



qemu-system-riscv.dtb



u-boot.bin



fw\_jump.bin

fw\_payload.bin



hifive-unleashed-a00.dtb



u-boot.bin



fw\_\*.bin

fw\_payload.bin

fsbl.bin  
fsbl.bin

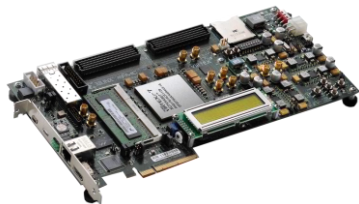
Info:

If you wanna try the firmwares on RISC-V, please check the FYI part at the end of the slide

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# The good progress of RISC-V Firmware



Last year, HPE engineers have made Tianocore successfully boot on SiFive Freedom U500 VC707 FPGA Dev Kit with OpenSBI integrated in edk2 RISC-V port.

Then they were busy on standardizing firmware spec: SMBIOS 3.3.0 already released with new record type (type 44) added, CIM works were done as well with RISC-V processor definitions.

HPE has posted their **V3** patchset for review.

For Now, with V3 patchset, EDK2(+ OpenSBI) can run on QEMU( >V4.1.5, -machine sifive\_u -cpu sifive-u54 ) and **Real Hardware SiFive Unleashed.**

# The Firmwares and extensions on RISC-V: next step



keep updating below specs to reflect the latest RISC-V specs.

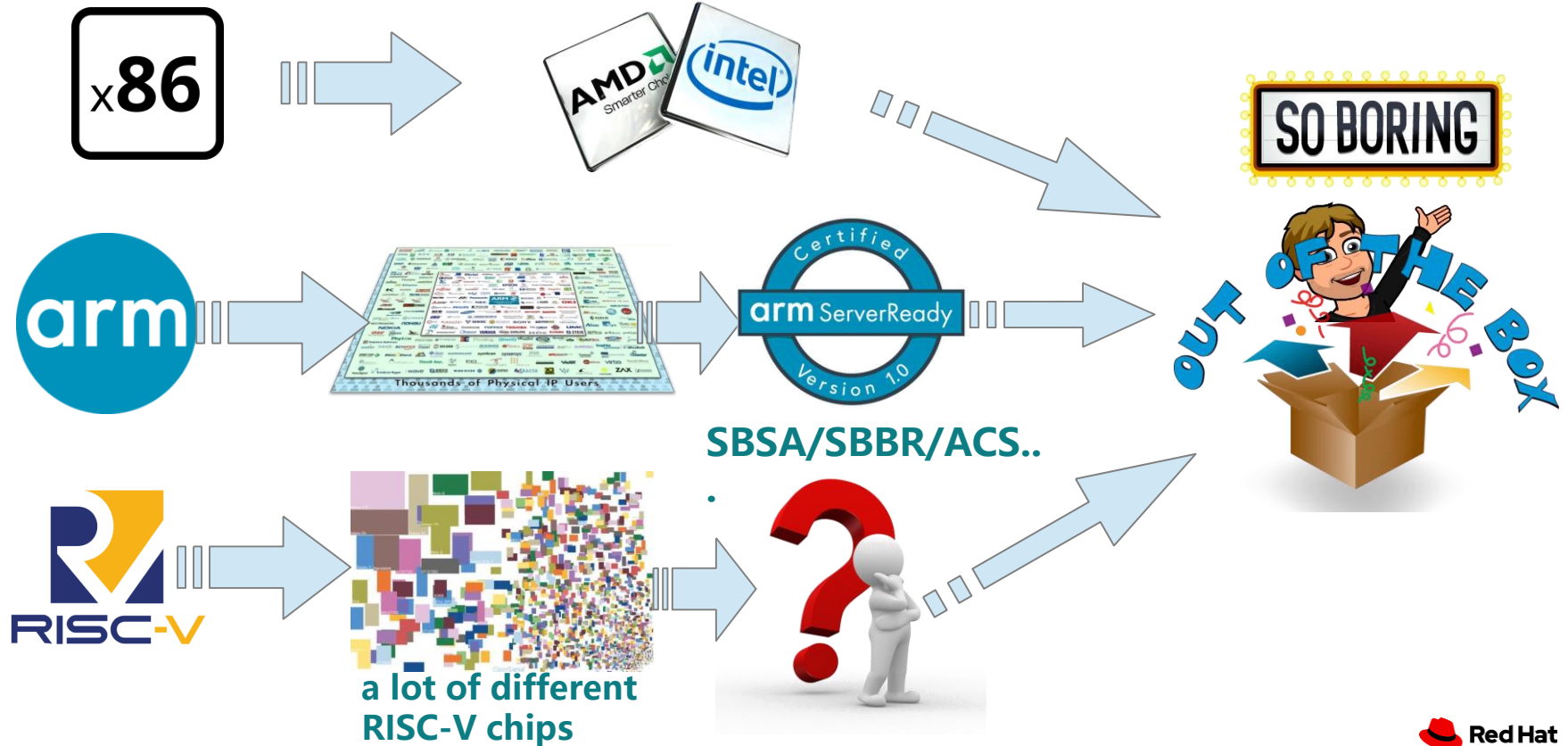
- UEFI spec
- Platform Initialization spec



Also working on below specs:

- **ACPI tables** for RISC-V processor
- Evaluate the works done in RISC-V TEE WG for drafting EFI Management Mode spec of RISC-V processor.
- specs for (**H**)ypervisor, (**V**)ector and (**P**)acked-SIMD

# Goal: make Server/PC BORING

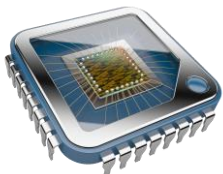


SBSA/SBBR/ACS..

a lot of different  
RISC-V chips

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# We need some specs for RISC-V server/PC



## <RISC-V PC/Server Base System Architecture>

like the SBSA:

- Define minimal **architectural** features
- Define minimal server SoC features

## <RISC-V PC/Server Base Boot Requirements>

like the SBBR

- Define minimal **firmware** platform
- Enables mainstream general purpose OS

## <RISC-V PC/Server Architectural Compliance Suite (ACS)>

like the ACS

- SBSA and SBBR **verification**

For Embedded system, we also need some specs, like EBBR of Arm.

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## Acknowledgments



Hewlett Packard  
Enterprise



Red Hat



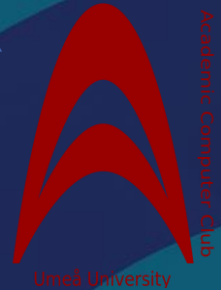
Abner Chang  
Gilbert Chen

Al Stone  
Andrea Bolognani  
Charles Wei  
DJ Delorie  
John Feeney  
Mark Salter  
Richard Jones

David Abdurachmanov

Alistair Francis  
Anup Patel  
Atish Kumar Patra

Mikael Frykholm  
Stefan O'Rear



... and countless other individuals and companies, who have contributed to RISC-V specifications and software eco-system!

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# Thank you

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## Part III

# FYI:

## Steps to run Fedora Image on RISC-V platform



Bootstrap

Devel Info/tools




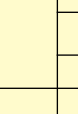

OpenSBI/U-boot

EDK2

Fedora Image



# Fedora bootstrap(aarch64 vs RV64)

fedora 	Fedora Bootstrap 		fedora WIKI 		
<b>Build System</b>	<b>Stage</b>	 <b>AArch64</b>	<b>Stage</b>	 <b>RISC-V RV64</b>	
<b>Host (x86)</b>		<b>Simulator(ARM model)</b>	<b>1</b>	<b>QEMU</b>	
		<i>QEMU</i>		<b>HiFive Unleashed</b>	
		<i>FPGA</i>		<i>Spike</i>	
	<b>1</b>	<b>Bootable Rootfs</b>		<b>2</b>	GNU cross-compiler toolchain
					Berkley Bootloader
				<b>3</b>	
basic rootfs					
<b>Target (Native)</b>	<b>2</b>	<b>rpmbuild</b>	<b>3</b>	<b>b</b>	
				Cross-compile and install "rpm" packages & dependencies	
	<b>3</b>	<b>mock</b>		<b>4</b>	install pre-build RPMs
					rebuild RPMs from SRPMs <b>natively</b>
				install the new RPMs	
				build <b>stage4 image</b>	
				<a href="#">RISC-V Autobuilder on QEMU</a>	
	<b>4</b>		koji (builders) Distribution bootstrap		
	<b>5</b>		Rebuild in koji		
	<b>6</b>	<b>koji-shadow</b>			

# Development Info:



## IRC

#fedora-riscv (FreeNode)

## Fedora Wiki pages For RISC-V

- **Main Entrance:**  
<https://fedoraproject.org/wiki/Architectures/RISC-V>
- **Instruction of installation:**  
<https://fedoraproject.org/wiki/Architectures/RISC-V/Installing>

## Fedora Main REPO for RISC-V:

<https://dl.fedoraproject.org/pub/alt/risc-v/>

## Koji for RISC-V:

**Domain Name:** fedora.riscv.rocks

- **Nightly build images:** [http://fedora.riscv.rocks/koji/tasks?order=-completion\\_time&state=closed&view=flat&method=createAppliance](http://fedora.riscv.rocks/koji/tasks?order=-completion_time&state=closed&view=flat&method=createAppliance)
- **dist-repos:** <http://fedora.riscv.rocks/repos-dist/>
- **SCM:** <http://fedora.riscv.rocks:3000/>

<sup>28</sup> Current stable Images (support SiFive Unleashed and QEMU out-of-the-box):

Fedora-Developer-Rawhide-20191123.n.0

Fedora-Minimal-Rawhide-20191123.n.1

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# Toolchain



## Cross compiler for RV64:

Since Fedora 29, you can just:

```
"sudo dnf install gcc-riscv64-linux-gnu"
```

you can get the relative package list by

```
"dnf list *-riscv*"
```



## Native compiler for RV64:

"Fedora Developer" Image has extra packages installed for developers, including RPM tools, building tools, koji stuff, etc.

You can use them just like on X86 machine.

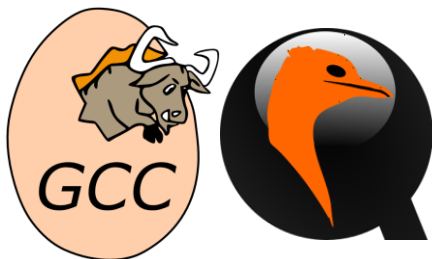


For Building RPM packages and Fedora Images, we only use **native compilation**.

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# QEMU



## QEMU RPM for RISC-V

Since Fedora 29, you can just:

**`“sudo dnf install qemu-system-riscv”`**

But please install the latest version of them by

**`“sudo dnf copr enable @virtmaint-sig/virt-preview”`**



## Build QEMU from source code

The upstream QEMU has supported most of latest RISC-V spec and can work with latest software for RISC-V.



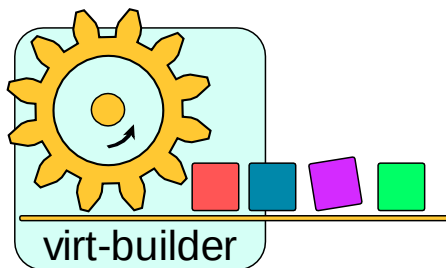
30

If you use dated QEMU(<v4.1.15), it will be incompatible with the latest RISC-V Software(like edk2).

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# VM Tools



## The libvirt project:

a toolkit to manage virtualization platforms, like creating new KVM, list the supported operating system variants, and start/stop/remove a VM.

```
sudo dnf install virt-manager libvirt
```



## Fedora virt-builder:

You can quickly and easily build new virtual machines to practice Fedora on RISC-V .

```
sudo dnf install libguestfs-tools-c
```



# QEMU: u-boot.bin & fw\_payload.bin



## U-boot:

**git://git.denx.de/u-boot.git**

```
make qemu-riscv64_smode_defconfig  
make
```

**<u-boot>/u-boot.bin**

## OpenSBI:

**https://github.com/riscv/opensbi.git**

```
make PLATFORM=qemu/virt \  
FW_PAYLOAD_PATH=<u-boot_source>/u-boot.bin
```

**<opensbi>/build/platform/qemu/virt/firmware/fw\_payload.bin**



Cross compiler:

ARCH=riscv CROSS\_COMPILE=riscv64-linux-gnu-

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# Test on QEMU



## QEMU

```
qemu-system-riscv64 \  
-smp 8 -m 2G -machine virt -nographic \  
-bios fw_payload.bin \  
-device virtio-blk-device,drive=hd0 \  
-drive file=Fedora-Developer-Rawhide-20191030.n.0-sda.raw,format=raw,id=hd0 \  
-object rng-random,filename=/dev/urandom,id=rng0 \  
-device virtio-rng-device,rng=rng0 \  
-device virtio-net-device,netdev=usernet \  
-netdev tap,id=usernet,ifname=tap0,script=no,downscript=no \  
-serial telnet:localhost:7000,server
```

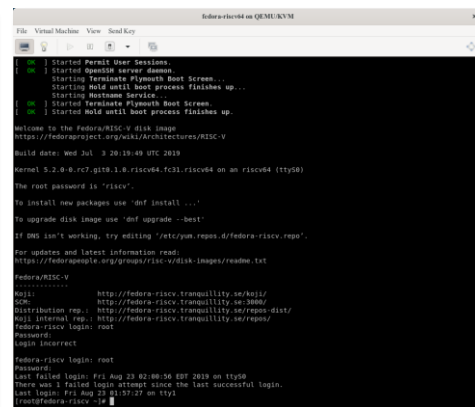
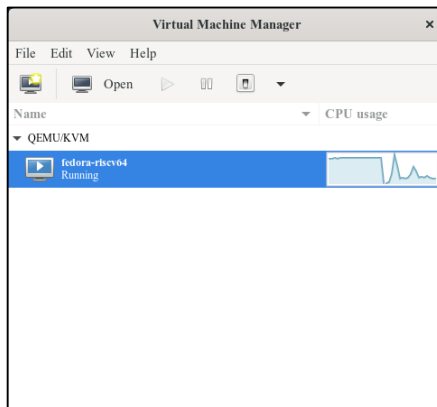
Please set up the network on your host machine correctly for “-netdev”

# Test with Libvirt



## Libvirt

```
virt-install --name fedora-riscv64 --arch riscv64 --vcpus 8 --memory 4096 \  
--os-variant fedora30 \  
--boot loader=/var/lib/libvirt/images/fw_payload.bin \  
--import --disk path=/var/lib/libvirt/images/Fedora-Developer-Rawhide-  
20191030.n.0-sda.raw \  
--network network=default \  
--graphics spice
```



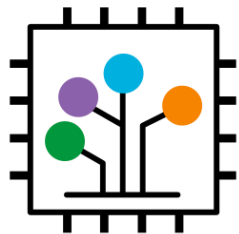
## virt-manager

Please copy the firmware and image to the **right directory** and set up the **correct permission** of these files

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# HiFive Unleashed: u-boot.bin & hifive-unleashed-a00.dtb



devicetree



## DTB

#in Linux kernel tree (5.3-rc+)

make defconfig

make dtbs

arch/riscv/boot/dts/sifive/hifive-unleashed-a00.dtb

**freedom-u540-c000-bootloader** (Native build on QEMU, currently)  
<https://github.com/sifive/freedom-u540-c000-bootloader>

make CROSSCOMPILE=

/fsbl.bin

## U-boot

make sifive\_fu540\_defconfig

make

/u-boot.bin

Cross compiler:

ARCH=riscv CROSS\_COMPILE=riscv64-linux-gnu-

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# HiFive Unleashed: fw\_payload.bin



## OpenSBI

```
make PLATFORM=sifive/fu540 \  
FW_PAYLOAD_PATH=u-boot.bin \  
FW_PAYLOAD_FDT_PATH=<linux source>/arch/riscv/boot/dts/sifive/hifive-  
unleashed-a00.dtb
```

```
/build/platform/sifive/fu540/firmware/fw_payload.bin
```

Cross compiler:

ARCH=riscv CROSS\_COMPILE=riscv64-linux-gnu-

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# HiFive Unleashed: Flash into uSD(fsbl/u-boot)



```
unzstd Fedora-*$BUILD_DATE.n.0-sda.raw.zst
guestfish -a Fedora-*$BUILD_DATE.n.0-sda.raw run : download /dev/sda1 boot.raw
guestfish -a Fedora-*$BUILD_DATE.n.0-sda.raw run : download /dev/sda2 rootfs.raw
```

boot

dd & resize2fs



/(Rootfs)

dd & resize2fs

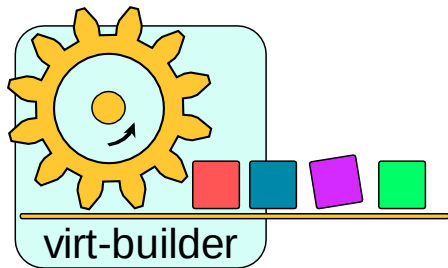


```
dd if=fsbl.bin \
of=/dev/sdx2
```

```
dd if=fw_payload.bin \
of=/dev/sdx3 bs=1024
```

```
sgdisk --clear \
--new 1::+500M --typecode=1:0FC63DAF-8483-4772-8E79-3D69D8477DE4 --change-name=1:'_/_boot' \
--new 2::+32K --typecode=2:5B193300-FC78-40CD-8002-E86C45580B47 --change-name=2:'_/_fsbl' \
--new 3::+8M --typecode=3:2E54B353-1271-4842-806F-E436D6AF6985 --change-name=3:'_/_opensbi-u-boot' \
--new 4::-0 --typecode=4:0FC63DAF-8483-4772-8E79-3D69D8477DE4 --change-name=4:'_/_/' \
${DISK}
```

# HiFive Unleashed: Flash into uSD(Fedora Image)



## Flash Fedora Image

```
$ sudo virt-builder \  
    --source https://dl.fedoraproject.org/pub/alt/risc-v/repo/virt-builder-  
images/images/index \  
    --no-check-signature \  
    --arch riscv64 \  
    --format raw \  
    --hostname testing.riscv.rocks \  
    --output /dev/sdc \  
    --root-password password:fedora_rocks! \  
    fedora-rawhide-developer-20191123.n.0  
$ sudo sync
```

# SiFive U540: EDK2 Source



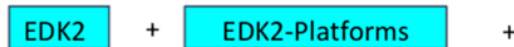
Before **OpenPlatformPkg** (< 2015)



With **OPP** (2015-2017)



Merge into **EDK2**



## EDK2

**REPO:** <https://github.com/changab/edk2-staging-riscv>

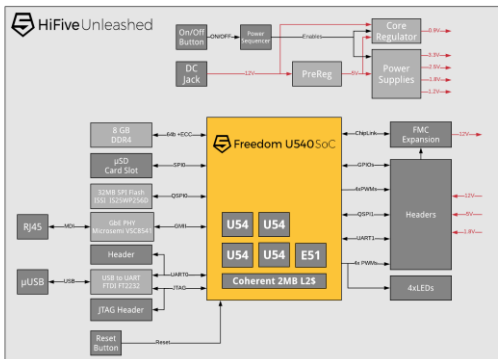
**branch:** RISC-V-V2-v3

## edk2-platform(submodule of edk2)

**REPO:** <https://github.com/gilbert225/edk2-platforms>

**branch:** devel-riscv-v2-PATCHv5

# SiFive U540: EDK2 build procedure



## Build commands:

```
cd $(UEFI_SRC_DIR)
git submodule init ; git submodule update
#make sure that you got opensbi submodule
export PATH=$(CROSS_TOOL_DIR_RV64):${PATH}
export GCC5_RISCV64_PREFIX=riscv64-linux-gnu-
source ./edksetup.sh --reconfig
make -C BaseTools/
build -a RISC64 -t GCC5 \
-p Platform/SiFive/U5SeriesPkg/FreedomU540HiFiveUnleashedBoard/U540.dsc
```









# HiFive Unleashed: Flash into uSD(fsbl/edk2)



## QEMU(latest, >4.1.15)

```
qemu-system-riscv64 -cpu sifive-u54 -smp cpus=5,maxcpus=5 -m 4096 -machine sifive_u -nographic -bios U540.fd -serial telnet:localhost:7000,server
```



boot	FSBL	OpenSBI-EDK2	/(Rootfs)
	 	 	

```
dd if=fsbl.bin \  
of=/dev/sdx2
```

```
dd if=U540.fd \  
of=/dev/sdx3 bs=1024
```

```
sgdisk --clear \  
--new 1::+1G --typecode=1:0FC63DAF-8483-4772-8E79-3D69D8477DE4 --change-name=1:'_boot' \  
--new 2::+32K --typecode=2:5B193300-FC78-40CD-8002-E86C45580B47 --change-name=2:'_fsbl' \  
--new 3::+16M --typecode=3:2E54B353-1271-4842-806F-E436D6AF6985 --change-name=3:'_opensbi-edk2' \  
--new 4::-0 --typecode=4:0FC63DAF-8483-4772-8E79-3D69D8477DE4 --change-name=4:'_' \  
${DISK}
```