

White Rabbit Switch Basics



4 December 2024
CERN

Adam Wujek
WR Collaboration

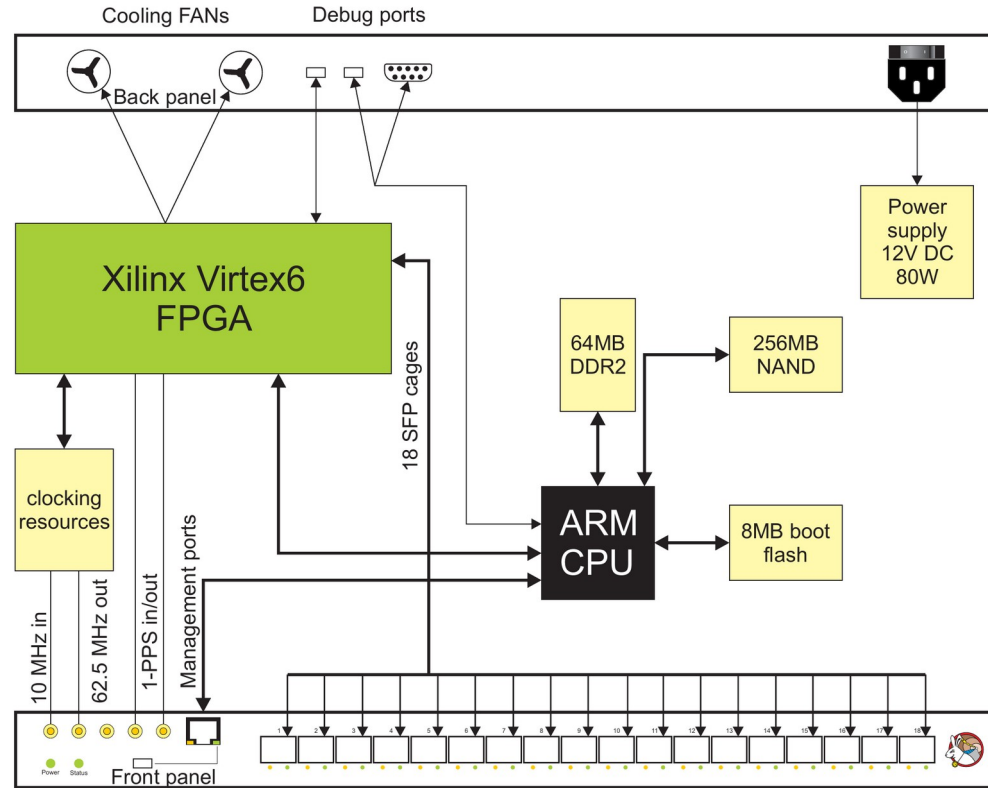
White Rabbit Switch Overview

- Central element of WR network
- 1U height
- 1 management port (100Mbit !)
- Serial console
(2-3 depends on version)
- 18 SFP ports 1GbE:
 - White Rabbit support
 - Ports with 1-12 LPDC
 - No management (may change in the future)
- 5 SMA/SMC connectors (depends on version)



White Rabbit Switch Overview

- ARM CPU
 - Run Linux
 - Handling PTP messages
 - Management
- FPGA
 - Passing traffic between ports
 - Timestamping PTP messages



Basic CLI tools

Console connection

- Mini-USB
 - Front
 - Back (ARM)
- ssh

wr_mon

- The best tool to start with!
- Gives many important information about Switch status and configuration
- Information refreshes every 1s
- Divided into 4 parts:
 - Global values
 - Per port/instance values
 - Servo
 - Temperatures

WR Switch Sync Monitor v7.0 [q=quit,r=refresh,f=freeze,t=toggle servo,c=extra ppsl params]

WR time (TAI) : 2024-11-28 10:11:37.004341 Leap seconds: 37
Switch time (UTC): 2024-11-28 10:11:00.004299 TAI-UTC : +37.000042
PLL mode: BC PLL locking state: LOCKED BMCA: extPortCfg Domain: 0

Grand Master Id		stepsRemoved	Grand Master Info		timeSource	accuracy	LogVar		
7c:bc:84:ff:fe:a0:02:c6		3rd hop	6(GM)		0x20(GNSS)	0x21(100ns)	47360		
HAL		PPSI							
Iface	Freq	Instl	Name	Confg	MAC of peer port	PTP/EXT/PDETECT	States	PrConf	VLANs
+ wr1	Lock	0	wrt1-1	slave	7c:bc:84:a0:02:ab	SLAVE /NR:IDLE	/EXT_ON	R-wH/W	
-*wr12		1	wrt2-1	master	00:00:00:00:00:00	DISABLED /NR:IDLE	/NONE	R-wH/W	
-*wr13		2	wrt3-1	master	00:00:00:00:00:00	DISABLED /NR:IDLE	/NONE	R-wH/W	
-*wr14		3	wrt4-1	master	00:00:00:00:00:00	DISABLED /NR:IDLE	/NONE	R-wH/W	
-*wr15		4	wrt5-1	master	00:00:00:00:00:00	DISABLED /NR:IDLE	/NONE	R-wH/W	
-*wr16		5	wrt6-1	master	00:00:00:00:00:00	DISABLED /NR:IDLE	/NONE	R-wH/W	
-*wr17		6	wrt7-1	master	00:00:00:00:00:00	DISABLED /NR:IDLE	/NONE	R-wH/W	
-*wr18		7	wrt8-1	master	00:00:00:00:00:00	DISABLED /NR:IDLE	/NONE	R-wH/W	
-*wr19		8	wrt9-1	master	00:00:00:00:00:00	DISABLED /NR:IDLE	/NONE	R-wH/W	
-*wr110		9	wrt10-1	master	00:00:00:00:00:00	DISABLED /NR:IDLE	/NONE	R-wH/W	
-*wr111		10	wrt11-1	master	00:00:00:00:00:00	DISABLED /NR:IDLE	/NONE	R-wH/W	
-*wr112		11	wrt12-1	master	00:00:00:00:00:00	DISABLED /NR:IDLE	/NONE	R-wH/W	
-*wr113		12	wrt13-1	master	00:00:00:00:00:00	DISABLED /NR:IDLE	/NONE	R-wH/W	
-*wr114		13	wrt14-1	master	00:00:00:00:00:00	DISABLED /NR:IDLE	/NONE	R-wH/W	
-*wr115		14	wrt15-1	master	00:00:00:00:00:00	DISABLED /NR:IDLE	/NONE	R-wH/W	
-*wr116		15	wrt16-1	master	00:00:00:00:00:00	DISABLED /NR:IDLE	/NONE	R-wH/W	
-*wr117		16	wrt17-1	master	00:00:00:00:00:00	DISABLED /NR:IDLE	/NONE	R-wH/W	
-*wr118		17	wrt18-1	master	00:00:00:00:00:00	DISABLED /NR:IDLE	/NONE	R-wH/W	

Iface: +/- SFP Ln DB; PrConf-Protocol confg: V-Eth over VLAN, U-Udp, R-Ethernet; a-ext autoneg; Profile: W-WR, L-HA

----- Synchronization status -----
Servo state: wr1:White-Rabbit: TRACK_PHASE

```
+ Timing parameters
meanDelay      :          46.245 nsec      err state:    3
delayMS        :          46.251 nsec      err offset:    3
delayNM        :        1131.273 nsec      err delta:    1
delayAsymmetry :           0.006 nsec
delayCoefficient : +0.000274299999999983 fpa : 1264985474854632
ingressLatency :          281.011 nsec
egressLatency  :          240.245 nsec
semIstaticLatency :          0.000 nsec
offsetFromMaster :          0.011 nsec
Phase setpoint :          0.899 nsec
Skew           :          0.011 nsec
Estimated link len:          9.439 meters
Update counter :        1857762 times
Master PHY delays TX:    238.848 nsec  RX:    278.678 nsec
Slave PHY delays TX:    240.245 nsec  RX:    281.011 nsec
```

----- Temperatures -----
FPGA: 47.88 PLL: 46.31 PSL: 33.88 PSR: 35.00

wr_mon

- Gives many important information about Switch status and configuration:
 - Build version
(Of the tool! Not of the entire firmware.
For the release firmware is the same)
 - Local time
 - WR time
 - Leap seconds
 - Timing mode (actual)
 - PLL locking status
 - BMCA
 - Domain number
 - Details of a selected Grand Master
 - More parameters available after 'c' is pressed:
 - LocalClock details (ID, clockClass, prio1, prio2, etc.)

WR Switch Sync Monitor v7.0 [q=quit,r=refresh,f=freeze,t=toggle servo,c=extra pps params]

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PLL mode: BC PLL locking state: LOCKED BMCA: extPortCfg Domain: 0

Grand Master Id		stepsRemoved	Grand Master Info		timeSource	accuracy	logVar
7c:bc:84:ff:fe:a0:02:c6		3rd hop	clockClass	6(GM)	0x20(GNSS)	0x21(100ns)	47360

wr_mon

- Link status (up/down)
- SFP match to local database
- Ports' role configuration (master/slave/auto)
- MAC of a peer
- Protocol status
- Profile/extension configuration
- Used VLAN for PTP/WR
- More parameters available after 'c' is pressed:
 - Configured messages rates (Announce, Sync, delayReq/delayResp)

Grand Master Id					stepsRemoved	Grand Master Info		timeSource	accuracy	logVar
7c:bc:84:ff:fe:a0:02:c6					3rd hop	6(GM)		0x20(GNSS)	0x21(100ns)	47360
HAL	PPSI									
Iface	Freq	Inst	Name	Config	MAC of peer port	PTP/EXT/PDETECT States		PrConf	VLANs	
+ wr11	Lock	0	wri1-1	slave	7c:bc:84:a0:02:ab	SLAVE	/WR:IDLE	/EXT_ON	R-wH/W	
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-*wri3		2	wri3-1	master	00:00:00:00:00:00	DISABLED	/WR:IDLE	/NONE	R-wH/W	
-*wri4		3	wri4-1	master	00:00:00:00:00:00	DISABLED	/WR:IDLE	/NONE	R-wH/W	
-*wri5		4	wri5-1	master	00:00:00:00:00:00	DISABLED	/WR:IDLE	/NONE	R-wH/W	
-*wri6		5	wri6-1	master	00:00:00:00:00:00	DISABLED	/WR:IDLE	/NONE	R-wH/W	
-*wri7		6	wri7-1	master	00:00:00:00:00:00	DISABLED	/WR:IDLE	/NONE	R-wH/W	
-*wri8		7	wri8-1	master	00:00:00:00:00:00	DISABLED	/WR:IDLE	/NONE	R-wH/W	
-*wri9		8	wri9-1	master	00:00:00:00:00:00	DISABLED	/WR:IDLE	/NONE	R-wH/W	
-*wri10		9	wri10-1	master	00:00:00:00:00:00	DISABLED	/WR:IDLE	/NONE	R-wH/W	
-*wri11		10	wri11-1	master	00:00:00:00:00:00	DISABLED	/WR:IDLE	/NONE	R-wH/W	
-*wri12		11	wri12-1	master	00:00:00:00:00:00	DISABLED	/WR:IDLE	/NONE	R-wH/W	
-*wri13		12	wri13-1	master	00:00:00:00:00:00	DISABLED	/WR:IDLE	/NONE	R-wH/W	
-*wri14		13	wri14-1	master	00:00:00:00:00:00	DISABLED	/WR:IDLE	/NONE	R-wH/W	
-*wri15		14	wri15-1	master	00:00:00:00:00:00	DISABLED	/WR:IDLE	/NONE	R-wH/W	
-*wri16		15	wri16-1	master	00:00:00:00:00:00	DISABLED	/WR:IDLE	/NONE	R-wH/W	
-*wri17		16	wri17-1	master	00:00:00:00:00:00	DISABLED	/WR:IDLE	/NONE	R-wH/W	
-*wri18		17	wri18-1	master	00:00:00:00:00:00	DISABLED	/WR:IDLE	/NONE	R-wH/W	

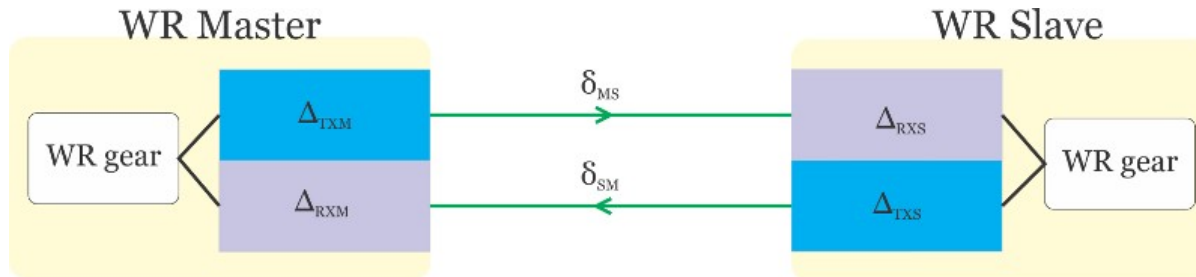
Iface: +/- SFP in DB; PrConf-Protocol config: V-Eth over VLAN, U-UDP, R-Ethernet; a-ext autoneg; Profile: W-WR, L-

wr_mon

In slave mode servo status:

- Servo state (e.g., TRACK_PHASE)
- meanDelay $((\delta_{MS} + \delta_{SM}) / 2)$
- delayMS (δ_{MS})
- delayMM (includes deltas)
 $\delta_{MS} + \delta_{SM} + \Delta_{RXM} + \Delta_{TXM} + \Delta_{RXS} + \Delta_{TXS} + (\epsilon_S + \epsilon_M)$
- delayAsymmetry $(\delta_{MS} - \delta_{SM}) =$
constantAsymmetry + $[\alpha / (\alpha + 2)] * \text{meanDelay}$
- delayCoefficient (α)
- ingressLatency
- egressLatency
- semistaticLatency (0 for LPDC ports)
- offsetFromMaster
- estimated(!) link length
- Phase setpoint
- Skew ($\text{delayMS} - \text{delayMS}_{\text{prev}}$)
- Update counter
- Used calibration values (RX/TX deltas)

underline - configured values



----- Synchronization status -----
 Servo state: wr1:White-Rabbit: TRACK_PHASE

```

+-- Timing parameters -----
| meanDelay      :          46.245 nsec      err state:    3
| delayMS       :          46.251 nsec      err offset:   3
| delayMM      :         1131.273 nsec      err delta:    1
| delayAsymmetry :           0.006 nsec
| delayCoefficient : +0.000274299999999983  fpa : 1264985474854632
| ingressLatency :          281.011 nsec
| egressLatency :          240.245 nsec
| semistaticLatency:           0.000 nsec
| offsetFromMaster :           0.011 nsec
| Phase setpoint :           0.899 nsec
| Skew          :           0.011 nsec
| Estimated link len:          9.439 meters
| Update counter :         1857762 times
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```

----- Temperatures -----
 FPGA: 47.88 PLL: 46.31 PSL: 33.88 PSR: 35.00

wrs_version

- Print details about switch's hardware version
 - Vendor of device
 - Serial number
 - HW Version (SCB, LJD)
- Version of this tool is used as the version of WRS firmware (e.g., by SNMP, LLDP)
- Provides the best answer for questions:
 - “Which version of WRS HW do you use?”
 - “Which version of WRS firmware do you use?”

```
# wrs_version -t
software-version: v7.0-54-gaf6c9b58-0
built-by: Adam Wujek
build-date: Nov 26 2024 14:34:30
backplane-version: 3.30
fpga-type: LX240T
manufacturer: 7S
serial-number: 706
scb-version: 3.4
gateway-version: 7.0
gateway-build: 26/11/24.01
wr_switch_hdl-commit: d9ee230
general-cores-commit: 2be7073
wr-cores-commit: 667ac5a
features:
```

wrs_sfp_dump

- Detailed information about used SFPs:
 - Vendor Name
 - Product Name
 - Vendor Serial
 - TX wavelength
 - Include SFP's monitoring data (DOM; if enabled in dot-config)
 - Temperature
 - Voltage
 - Bias Current
 - TX/RX power
 - Can read data from HAL or directly from SFP
 - Reading directly via I2C, when HAL is running can corrupt SFP's EEPROM! Disable monit and HAL first!
 - Can write SFP's EEPROM
 - e.g., fix corrupted EEPROM
- See wrs_sfp_dump --help for details

```
wrch2#wrs_sfp_dump -p 3 -d -L
Reading SFP eeprom from HAL
===== port 3 =====
Identifier: 03
Extended Identifier: 04
Connector: 07
Transceiver: 0040000000070403
Encoding: 01
Nominal Bit Rate: 1300 Megabits/s
Length (9m): 20km
Length (9m): 20000m
Length (50m): 0m
Length (62.5m): 0m
Length (copper): 0m
Vendor Name: FS
Company ID: 000000
Vendor Part Number: GE-LC-1490
Vendor Revision:
TX Wavelength: 1490
Options: 1A00
Bitrate (MAX): 00
Bitrate (MIN): 00
Vendor Serial: C1904080513
Date Code: 190412
Temperature: 46.520 C
Voltage: 3.208 V
Bias Current: 14.624 mA
TX power: 0.233 mW
RX power: 0.331 mW
```

WRS configuration

WRS configuration file

- WRS uses Kconfig format used by Linux kernel for configuration
- Kconfig contains description of configuration options, constraints, default values etc.
- dot-config is the file with configuration
- Format {key}={value}
- .config sometimes used as temporary file with configuration

```
menu "Local Network Configuration"
choice
    prompt "Management port configuration (eth0)"
    default ETH0_DHCP

config ETH0_DHCP
    bool "DHCP forever"
    help
        Try DHCP on management port (eth0) forever.

config ETH0_DHCP_ONCE
    bool "Try DHCP, if fail use static address"
    help
        Try DHCP on management port (eth0) for a while, then configure
        static IP. Useful, when you move switch between various development
        enviroments.

config ETH0_STATIC
    bool "Static address"
    help
        Use static address on management port (eth0). Don't try to DHCP.

endchoice
```

```
#
# Local Network Configuration
#
# CONFIG_ETH0_DHCP is not set
CONFIG_ETH0_DHCP_ONCE=y
# CONFIG_ETH0_STATIC is not set

[...]

# CONFIG_GLOBAL_PROFILE_PTP is not set
CONFIG_GLOBAL_PROFILE_HA_WR=y
# CONFIG_GLOBAL_PROFILE_TELECOM is not set
# CONFIG_GLOBAL_PROFILE_CUSTOM is not set
CONFIG_PTP_OPT_BMCA_STANDARD=y
# CONFIG_PTP_OPT_BMCA_EXT_PORT_CONFIG is not set
# CONFIG_TIME_FM is not set
CONFIG_TIME_FM=y
# CONFIG_TIME_BC is not set
# CONFIG_TIME_CUSTOM is not set
CONFIG_PTP_OPT_DOMAIN_NUMBER=0
CONFIG_PTP_OPT_PRIORITY1=128
CONFIG_PTP_OPT_PRIORITY2=128
```

WRS configuration editing

- Manual change
- Extremely discouraged, can cause errors in configuration
- wrs_menuconfig (on WRS)
- make menuconfig (from wr-switch-sw repo)
- wrs_nconfig (on WRS)
- make nconfig (from wr-switch-sw repo)
- May work better on some terminals

```
White Rabbit Switch configuration
Arrow keys navigate the menu. <Enter> selects submenus --- (or empty submenu ---). Highlighted letters are hotkeys. Pressing
<Y> includes, <N> excludes, <M> modularizes features. Press <Esc><Esc> to exit, <?> for Help, </> for Search. Legend: [*] built-in
[ ] excluded <M> module <-> module capable

(7.0) Firmware version
() Hardware version
() Additional info about dot-config
Source for a run-time replacement of dot-config (Try to get the URL to a dot-config via DHCP) ---
Source for a run-time replacement of leap seconds file (Use local leap seconds file) --->
(wrs_release_br2_config) Configuration file for Buildroot
External source of Time of Day at boot --->
Local Network Configuration --->
Global PTP configuration (profile, timing mode, BMCA and external port config, ...) --->
Port PTP/Timing configuration --->
SFP and Media Timing Configuration --->
PPS generation --->
PTP Port Assignment (Generate ppsl.conf based on the PORTxx_INSTyy_z parameters) --->
Management configuration --->
External clk2 clock signal configuration --->
NIC throttling configuration --->
[ ] Enable 50ohm termination for 1-PPS input
Custom boot script configuration --->
LLDP options --->
Radius-vlan options --->
[*] Read SFPs' Diagnostic Monitoring
[*] Disable web interface
Developer options --->
RTU HP mask --->
v(+)

<e>lect < <Exit> < <Help> < <Save> < <Load>
```

```
White Rabbit Switch configuration .config - White Rabbit Switch configuration
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VLANs --->

F1Help F2SynInfo F3Help 2 F4ShowAll F5Back F6Save F7Load F8SynSearch F9Exit
```

WRS configuration editing

- Web interface
- Not recommended!
- Disabled by default
- Not maintained
- A number of serious security vulnerabilities
 - CVE-2023-22577

White-Rabbit Switch Manager

Dashboard PPSi Setup VLAN Setup Endpoint Mode Switch Management About

MAIN MENU

- Dashboard
- Network Setup
- PPSi Setup
- Endpoint Mode
- VLAN Setup
- Switch Management
- Advanced Mode

User: [admin](#) ([logout](#))

DASHBOARD

Switch Info	
Hostname	192.168.1.10
IP Address	192.168.1.10
Mac Address	02:34:56:78:9A:BC
Kernel Version	2.6.39-wr-switch
Firmware Version	v4.1.1-324-gd64227f+
Hardware Version	scb: v000backplane: v3.30
FPGA Version	UNKNOWN
Manufacturer	Seven Solutions
Serial Number	UNKNOWN
Kernel Compiled Date	#1 Mon Nov 17 11:00:54 CET 2014

WRS Services	
White-Rabbit Date	98.184298000 TAI 1970-01-01 00:01:38.184298000 TAI 1970-01-01 00:01:03.184298000 UTC
PPSi	[on]
Net-SNMP Server	[on] (port 161)
NTP Server	

White-Rabbit OHR

White Rabbit Project - Open Hardware and Source Project [White-Rabbit OHR](#)

LIGHTTPD php

WRS configuration editing

- Custom tools, e.g., CERN: Controls Configuration Data Editor (CCDE)
- Step 1: Web interface for DB, it generates WR Switch config in JSON format
- Step 2: Switch config is generated from JSON format by generator:
<https://gitlab.cern.ch/white-rabbit/wrs-config-generator>

Switch Configuration

Switch browser

Switch	Version
wrs-test4	3.4 / 5.0
wrs-test1	3.4 / 5.0
wrs-test2	3.4 / 5.0.1
wrs-test3	3.4 / 5.0

Version browser

Hardware	Firmware
3.4	5.0
3.4	5.0.1
3.3	5.0.1

Basic | Advanced | Ports

Host name: wrs-test1 **Generate**

Timing mode: Grand Master Boundary Clock Free-running Master

Hardware Version: 3.4 | Firmware Version: 5.0

NTP server: ip-time-1.cern.ch | Syslog server: be-co-tracing

Additional details

Computer Name	Location	Responsible	Operational Support
wrs-test1			

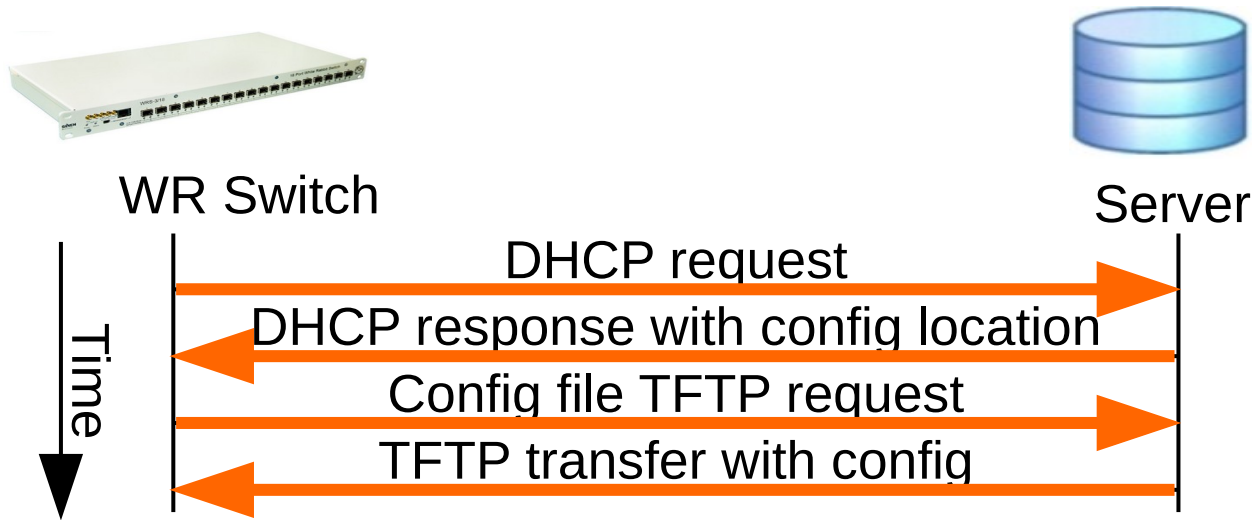
HCP Image Path	HCP Server	OS	OperationDiamon	Layout	MTF
/white_rabbit/config-	CS.CERN.CH	LINUX			

Description: TEST SWITCH FOR DIAMON INTEGRATION.

Remove switch | **Discard changes** | **Save switch**

dot-config file handling

- Local on a switch
- Retrieved from a network at boot (via TFTP, FTP or HTTP)
- Path to a config provided in a DHCP response



Runtime reconfiguration

- Change of many parameters requires a restart
- There are number of parameters that can be changed in runtime:
 - Related to PTP (ppsi_conf):
 - priority1, priority2
 - extension (WR/L1S)
 - sync interval
 - delayReq interval
 - diagnostics level
 - Calibration values:
 - RX/TX delays (wrsw_hal_conf, new in v8.0)
 - DelayCoefficient a.k.a. alpha (ppsi_conf)
 - delayAsymmetry (ppsi_conf, new in v8.0)
 - VLANs (wrs_vlans)
 - Related to switching core (rtu_stat)
 - Static paths
 - Port mirroring
 - PPS-in-out delay (wrsw_hal_conf)
 - More to be implemented in the future
 - For details see: ppsi_conf --help; wrsw_hal_conf --help; wrs_vlans --help; rtu_stat --help

Initial configuration

Initial configuration

Steps required at initial configuration:

- dot-config source:
 - Local
 - Download at each boot (default)
- Management port configuration (IP)
 - Default: try DHCP, if fail set 192.168.1.254
- Setup root password (default: none)
- Switch role
 - Grandmaster
 - Boundary Clock (default)
- Ports' roles assignment
 - dynamic (BMCA)
 - static (external port configuration) (default)
 - Static role assignment
- SFP/fiber local database

```
.config - White Rabbit Switch configuration

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[*] Read SFPs' Diagnostic Monitoring
[*] Disable web interface
Developer options --->
RTU HP mask --->
VLANs --->
```

Initial configuration (advanced)

Advanced steps at initial configuration:

- For Grandmaster
 - Connect 1-PPS and 10MHz
(for Low-Jitter version might be separate connector for 10MHz)
 - Leap seconds source
 - External source of Time of Day
 - Configure extra PTP parameters if needed
- Management/monitoring
 - Logging server
 - SNMP „password”
 - LLDP
 - SFP diagnostics
- VLANs
- Authorization of devices on WR ports (radius)
- Custom boot script (if needed)

```
.config - White Rabbit Switch configuration

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NIC throttling configuration --->
[ ] Enable 50ohm termination for 1-PPS input
Custom boot script configuration --->
LLDP options --->
Radius-vlan options --->
[*] Read SFPs' Diagnostic Monitoring
[*] Disable web interface
Developer options --->
RTU HP mask --->
VLANs --->
```

More info

WRS: User manual:

<https://ohwr.org/project/wr-switch-sw/-/wikis/uploads/d1f78666704fb292982453e1429b9f10/wrs-user-manual-v7.0.pdf>

WRS: Developer manual:

<https://ohwr.org/project/wr-switch-sw/-/wikis/uploads/1a5a73c1528ccfe7e739e0dfc8e0ecd1/wrs-developer-manual-v7.0.pdf>

WRS: Failures and Diagnostics:

https://ohwr.org/project/wr-switch-sw/-/wikis/uploads/7b9d6bcb88a793067d9150b972c64e08/wrs_failures-v7.0.pdf

WRS: Radius Vlan:

<https://ohwr.org/project/wr-switch-sw/-/wikis/uploads/5f86a996d29a2fb21a389c27da7781db/wrs-radiusvlan-v6.1.pdf>

Questions?