Hardware Features for the WRS-4
1. Power Consumption
2. Airflow & Fans
3. Enclosure complexity
4. Power Supply
5. Interfaces
6. Design Proposal
7. Expansion

**Wait with technical clarifications until the end of the presentation**

**Wait with feedback items until the last session**
Analysis of main elements

Power consumption estimation

- An estimation of this parameter is necessary in order to determine the features of the power supply and the dissipation and cooling modules.
- Identify the main components of the system in relation to the current they need to operate:
  - SFP+ transceivers (DWDM and Long distance > 80 Kms).
  - Zynq ultrascale+ (PS & PL). Estimated consumption for an architecture with all ports configured at a speed of 10 Gbps described in this document.
  - Other components and ICs.

<table>
<thead>
<tr>
<th>Component</th>
<th>Power Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS of the Zynq</td>
<td>3.0 W</td>
</tr>
<tr>
<td>GTH and PL of the Zynq</td>
<td>11.7 W</td>
</tr>
<tr>
<td>Other circuits (PLLs, expansion board, memories, OCXO clocking, power regulators…)</td>
<td>18 W</td>
</tr>
<tr>
<td>SFP+</td>
<td>18 ports * 1.2 W = 22 W</td>
</tr>
<tr>
<td>Total Power Estimation</td>
<td>54.7 W</td>
</tr>
</tbody>
</table>

(Max: 80W)
The most common solution for cooling L2 switches and time providers is usually the use of fans and heatsinks.

Simple formula to calculate the CFM (Cubic Feet per Minute) needed to dissipate certain power as a function of the difference in temperature between the inside and outside parts of the enclosure:

\[
CFM = \frac{3.16 \times P_D}{\Delta T \, ^\circ F}
\]

\[
\Delta T \, ^\circ F = 1.8 \times (\Delta T \, ^\circ C)
\]

In order to dissipate the **55W** calculated previously and allowing only **10\(^\circ C\)** of temperature rise with respect to outside the box, the fans have to generate **9.65** CFM.
The previous result is not a tight requirement since only a conventional and commercial 40x40 mm fan can supply more than 10 CFM.

Other aspects to bear in mind:

- Direct airflow over high performance OCXOs can increase their phase noise. It will be necessary to isolate these critical components from direct airflow.
- Redundancy? (2 or more fans) - Fixed/variable speed.
- Fixed or Hot-swappable? - PWM control & and Tachometer.

Integration of the fan modules: we have considered 3 options.
Analysis of main elements

Fans II

- **Option 1**: Fixed mounted to rear panel.
  - Low cost solution.
  - This option does not allow a quick and easy replacement of a fan in the case it is broken.

- **Option 2**: Hot-swappable to rear panel with manual connection.
  - The fan is fixed to a simple panel that can be screwed and unscrewed easily to rear panel.
  - This way the fan module can be replaced in case of breaking.
  - The connection to the motherboard is made through a connector which has to be manually connected.
Analysis of main elements

Fans III

- **Option 3**: Hot-swappable to rear panel with self-docking connection.
- **Option 3.1**: fully featured bracket and PCB.
  - small complex box to which a fan is fixed and that includes a small PCB with a connector.
  - The connector contains the control signals of the fan and must be easily hot-swappable into the suitable connector situated in the main board of the system.
- **Option 3.2**: simple bracket without PCB.
  - Costs could be reduced: PCB is avoided and the bracket is made simple for several fans.
  - The fans’ wires are directly soldered to the pins of the wire-to-board connectors which will connect directly to the main board.
## Fans IV

<table>
<thead>
<tr>
<th>Options</th>
<th>Redundant</th>
<th>Installation type</th>
<th>Fan type</th>
<th>PCB needed</th>
<th>Cost approx per unit</th>
<th>Enclosure Complexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed mounted to rear panel (option 1) - one fan</td>
<td>Yes</td>
<td>Fixed mounted</td>
<td>Basic</td>
<td>No</td>
<td>~10€</td>
<td>Low</td>
</tr>
<tr>
<td>Hot-swappable to rear panel with hand connection (option 2) - module</td>
<td>Yes</td>
<td>Hot-swappable &amp;</td>
<td>Basic</td>
<td>No</td>
<td>~25€</td>
<td>Medium</td>
</tr>
<tr>
<td>Hot-swappable to rear panel with self-docking connection with PCB</td>
<td>Yes</td>
<td>Hot-swappable &amp;</td>
<td>Fully featured</td>
<td>Yes</td>
<td>~65€</td>
<td>High</td>
</tr>
<tr>
<td>Hot-swappable to rear panel with self-docking connection without PCB</td>
<td>Yes</td>
<td>Hot-swappable &amp;</td>
<td>Fully featured</td>
<td>No</td>
<td>~35€</td>
<td>Medium</td>
</tr>
<tr>
<td>Hot-swappable to rear panel with self-docking connection without PCB</td>
<td>Yes</td>
<td>Hot-swappable &amp;</td>
<td>Fully featured</td>
<td>No</td>
<td>~60€</td>
<td>Medium</td>
</tr>
</tbody>
</table>

The selected option
Enclosure Complexity

Low

Medium (Hybrid)

High

<table>
<thead>
<tr>
<th>Process</th>
<th>Capability</th>
<th>Tool costs</th>
<th>Efficiency</th>
<th>Functionality</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNC punching</td>
<td>Single feature (shapes, countersinks, dimples, louvers..)</td>
<td>100€ - 1,000€</td>
<td>Low quantities and prototypes (manual bending)</td>
<td>Multifunctional tools can be used, requires multiple hits</td>
</tr>
<tr>
<td>Press stamping</td>
<td>Entire part</td>
<td>1,000€ - 100,000€</td>
<td>Mass production quantities</td>
<td>Stamp out the entire part, requires one hit</td>
</tr>
</tbody>
</table>
Based on previous power consumption estimation, the power supply chosen for this new design must provide at least 80W-100W of output power, in order not to cause electrical over-stress in the power supply.

Features found on other L2 switches:
- Redundancy (at least 2 modules).
- Location: mainly rear.
- Hot-swappable.
- Standard: CRPS.
- Enclosure complexity.
- AC-DC and DC-DC.

Taking into account these desired features, we have considered 4 different alternatives.
Analysis of main elements

Power Supply II

- **Option 1: Basic configuration.**
  - Only a fixed internal module.
  - WRS-3: 12VDC @ 6.8A.
  - No redundancy and No hot-swapability.
  - No Vendor lock-in. There are many power supplies with the same configuration.
  - Cost-effective solution. In seller’s web the cost is 70 €.
  - Low enclosure complexity.
Analysis of main elements

Power Supply III

- Option 2: Fixed dual power supply.
  - This option can be considered as an improvement of the previous option, since there is redundancy of power supplies but they are not hot-swappable.
  - No Vendor lock-in. if we have to change the power supplies model, at most only a small change in design will be necessary.
  - Mainly used in switches of a moderate cost. 140€ because now there are two modules.
  - Enclosure complexity.
Option 3: 1U redundant compact module.

- This option is mainly used in servers, therefore their output connectors usually meet the ATX standard and PMBus standard to control and check the status of the power supply.
- Redundancy & hot-swapability (N+1 redundant configuration).
- Type power modules: AC-DC and DC-DC.
- Each vendor has different form factors so if the physical size changes between power supplies. However, up to three redundant compact power supplies, each from different manufacturers, have been found in the market with the same dimensions of 106 mm (W) x 41.5 mm (H).
- Cost: simple configuration 390 €.
Option 4: N+1 Redundant and Independent power supplies. The CRPS standard (Common Redundant Power Supplies):

- This is the option chosen by most manufacturers for the high-end switches available in the market. They are also starting to use the CRPS standard that defines a common form factor and an output connector pin configuration.
- This option is N+1 redundant and hot-swappable. However, unlike the option 3 where we have a compact solution, in this option 4, redundancy management must be implemented on the main board.
- The price for two modules of 550 watts is approximately 310 €.
- The enclosure complexity will be high due to extra parts such as specific cages will be necessary.
## Analysis of main elements

### Power Supply VI

<table>
<thead>
<tr>
<th>Options</th>
<th>Redundant</th>
<th>Hot-swappable</th>
<th>Vendor lock-in</th>
<th>Standard</th>
<th>Output</th>
<th>Input</th>
<th>PM Bus</th>
<th>Cost approx</th>
<th>Enclosure Complexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic configuration (e.g. WRS-3/18) (option 1)</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>12V, 6.8A (81W max)</td>
<td>100 - 240 VAC</td>
<td>No</td>
<td>~ 70 €</td>
<td>Low</td>
</tr>
<tr>
<td>Fixed dual Power supply (e.g. Advantech ESP-9110) (option 2)</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>12V, 7A (84W max)</td>
<td>100 - 240 VAC</td>
<td>No</td>
<td>~ 140 € (two units)</td>
<td>Low</td>
</tr>
<tr>
<td>1U Redundant compact module (e.g. Zyppy) (option 3)</td>
<td>Yes and there are dummy modules for a cost-effective solution</td>
<td>Yes</td>
<td>Yes, although there are other manufacturers using ATX connectors but with different form factors and dimensions.</td>
<td>- Form factor: No - Connectors: Yes (ATX)</td>
<td>12V, 5V, 3.3V, 5Vsb from 200W</td>
<td>100 - 240 VAC / -48V VDC</td>
<td>Yes</td>
<td>~ 390 € (per module that includes two power supplies)</td>
<td>Low</td>
</tr>
<tr>
<td>CRPS (e.g. Artesyn, Supermicro...) (option 4)</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>- Form Factor: Yes (CRPS) - Connectors: Yes (CRPS)</td>
<td>12V from 550W</td>
<td>100 - 240 VAC / -48V VDC</td>
<td>Yes</td>
<td>~ 310 € (two power supplies without adding extra components)</td>
<td>High</td>
</tr>
</tbody>
</table>
## Front panel

<table>
<thead>
<tr>
<th>Interface</th>
<th>CERN Proposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data ports</td>
<td>Number: 18&lt;br&gt;Speed: 1 and/or 10 Gbps</td>
</tr>
<tr>
<td>Management ports</td>
<td>2x Ethernet (1x RJ45 and 1x SFP)</td>
</tr>
<tr>
<td>Serial ports</td>
<td>1xi USB Mini-B (add RJ45 if space allows)</td>
</tr>
<tr>
<td>Other ports</td>
<td>1x USB (for firmware update)</td>
</tr>
<tr>
<td>Timing interfaces (SMA connectors)</td>
<td>- IN_1: 10 MHz&lt;br&gt;- OUT_1: 10 MHz&lt;br&gt;- IN_2: 1 PPS&lt;br&gt;- OUT_2: 1 PPS&lt;br&gt;- IN_3: AUX&lt;br&gt;- OUT_3: 62.5 MHz&lt;br&gt;- OUT_4: AUX (abscal)</td>
</tr>
<tr>
<td>Port Status</td>
<td>LEDs&lt;br&gt;1: Link / WR mode / Calib&lt;br&gt;2: Synced / Activity / Speed</td>
</tr>
<tr>
<td>General Status</td>
<td>OLED display</td>
</tr>
<tr>
<td>Buttons</td>
<td>- Reset&lt;br&gt;- Flash (from USB)</td>
</tr>
</tbody>
</table>

### Non-stackable SFPs (Up to 18 ports and without display)

![Non-stackable SFPs](image)

### Doubled-stackable SFPs (Possibility of having 18 ports or more and one display)

![Doubled-stackable SFPs](image)
Timing connectors

SMA connectors: widely used
Levels: Same as WRS-3 to ensure compatibility* (LVCMOS-3.3V)

- Output
  - PPS/10MHz: mandatory
  - AUX (needed for absolute calibration)
  - 62.5MHz (optional*)
- Input
  - PPS/10MHz in: mainly for GM (and auto-calibration)
  - AUX (optional*)

*: To be discussed in last section

Optional: on-board U.F.L
(Delays depend on cable)
Integration of future hardware modules in order to update or improve the performance of the WRS-4:
  ○ For example to allow better oscillators OCXO and DDS for IpGBT.

Needed features that the connector should have:
  ○ Numerous I/O available.
  ○ Support for a wide range of signaling standards.
  ○ High-speed signals, supporting up to 10 Gbit/s transmission.
  ○ System configurable I/O functionality.
  ○ Enough space for integrating holdover oscillators with heights reaching more than 30 mm. Limitation in height (44.45mm) for the 1U enclosures.
• **Option 1:** The WRS-4/18 with the same features as WRS-3/18:
  
  - **Enclosure:** Basic option with depth: 221 mm.
  - **Fans:** Fixed and non-hot-swappable.
  - **Power supply:** Non-redundant and non-hot-swappable.
  - **Board:** A single PCB to reduce the cost of assembly and improve the dissipation.
  - **FPGA / ZYNQ:** Zynq Ultrascale+ XCZU17EG-1FFVC1760E.
Design proposals

- **Option 2:** The WRS-4/18 with redundant power but non-hot-swappable modules.
  - **Enclosure:** Basic option with depth: 310 mm. In this option, a bigger enclosure is necessary to include two power supplies.
  - **Fans:** Fixed and non-hot-swappable. Configurable airflow direction.
  - **Power supply:** Redundant and non-hot-swappable.
  - **Board:** A single PCB to reduce the cost of assembly and improve the dissipation.
  - **FPGA / ZYNQ:** Zynq Ultrascale+ XCZU17EG-1FFVC1760E.
• **Option 4**: The fully featured WRS-4/18.
  
  ○ **Enclosure**: Complex design to contain hot-swappable fans and power supplies. (Quantities)
  
  ○ **Fans**: Redundant and hot-swappable. Configurable airflow direction.
  
  ○ **Power supply**: Redundant and hot-swappable (two units).
  
  ○ **Board**: A single PCB to reduce the cost of assembly and improve the dissipation. In this case the PCB edge will reach the back panel (depth: 310 mm), so that the fan connector on the main board connects with the hot-swappable module.
  
  ○ **FPGA / ZYNQ**: Zynq Ultrascale+ XCZU17EG-1FFVC1760E.
Option 3: WRS-4/18 (redundant & hot-swappable fans and power supplies with basic enclosure)

- **Enclosure**: Basic option with depth: 310 mm and with the possibility of having hot-swappable (self-docking) fans along with redundant and hot-swappable power supplies (independent modules). The design includes sheets used as walls defining a separate airflow for PSU, expansion module and main board.

- **Fans**: Hot-swappable and self-docking with simple bracket and without PCB (3 fans module). Configurable airflow direction.

- **Power supply**: Redundant and hot-swappable (compact module) with semi-standard size.

- **Board**: A single PCB to reduce the cost of assembly and improve the dissipation. In this case the PCB edge will reach the back panel (depth: 310 mm), so that the fan connector on the main board connects with the hot-swappable module. Possibility of expansion board and/or LCD module.

- **FPGA / ZYNQ**: Zynq Ultrascale+ XCZU17EG-1FFVC1760E.
Option 3: WRS-4/18 (redundant & hot-swappable fans and power supplies with basic enclosure)
Design proposals

- **Option 3**: WRS-4/18 (redundant & hot-swappable fans and power supplies with basic enclosure)
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**FMC**
- Possibility of integrating existing FMC boards (e.g. FMC-DDS board).

**ERM8-EM edge connector**
- The expansion board will be at the same level as the main board, enough space to integrate big oscillators.
- Installing expansion boards without opening the enclosure (just slide from the back).
## Design proposals

<table>
<thead>
<tr>
<th>Weighted Region Switches (WRS)</th>
<th>Cost increase percentage (%) regarding the current WR switch (preliminary estimate)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>WRS-3/18</td>
<td>0%</td>
<td>Current WRS design.</td>
</tr>
<tr>
<td><strong>Option 1:</strong> WRS-4/18 (Basic switch)</td>
<td>7%</td>
<td>New WRS with new FPGA and the same features (fan, power supply, enclosure) as in the previous WRS-3/18 version.</td>
</tr>
<tr>
<td><strong>Option 2:</strong> WRS-4/18 (Basic redundant power supply)</td>
<td>16%</td>
<td>New WRS with new FPGA, fixed fans and dual power supply (non-hot-pluggable).</td>
</tr>
</tbody>
</table>
| **Option 3:** WRS-4/18 (redundant & hot-pluggable with basic enclosure) | 47%                             | New WRS with new FPGA, and basic enclosure with:  
- Hot-pluggable and self-docking fans, with separations walls and display  
- Redundant and hot-pluggable power supply (compact module) |
| **Option 4:** WRS-4/18 (Fully featured switch) | 60%                             | New WRS with new FPGA and complex enclosure with:  
- Self-docking and hot-pluggable fans.  
- Redundant and hot-pluggable power supply (independent modules) |
Option 3

- Hot-pluggable and self-docking fans, with separations walls and display
- Redundant and hot-pluggable power supply (compact module)
- Almost all connectors on front-panel

Preliminary design
- Waiting for community feedback
- Expansion connector open to discussion
- Improvement during design process