### Towards a RISC-V Educational HW Lab

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#### An ARM-based Educational HW Lab

<table>
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<th>Motivating the students</th>
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<td>Basic CPU architecture concepts are hard to engage with</td>
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<td>Using physical devices helps to understand how Hardware works</td>
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<th>A Raspberry Pi-based HW Setup</th>
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<tr>
<td>Raspberry Pi</td>
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<tr>
<td>Affordable</td>
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<td>Versatile</td>
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<td>Peripherals</td>
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#### RISC OS/UCDebug

| GUI and simplified peripheral management is crucial for an initial approach to HW |

**RISC OS**: ARM-developed OS with easy HW access

**UCDebug**: in-house developed tool capable of debugging interrupt handlers

#### PiGARDEN: remote access to Raspberry Pi lab

Pi boards are currently difficult to acquire. PiGARDEN offers:
- Handling of GPIO pins
- Live stream of the peripherals
- Easy file sharing with boards
- Board allocation in time slots

#### Towards RISC-V

##### RISC-V Boards

**SiFive VisionFive**

- **Main Specs:**
  - CPU: StarFive JH7110 (RV64GC)
  - RAM: 4GB / 8GB LPDDR4
  - Storage: FLASH + SD slot + MVNe
  - Connectivity: 4xUSBs + HDMI + 2xRJ45
  - GPIO: 40 pins
  - Price: 65$ - 85$

Board summary/Evaluation: easy to setup, complete CPU user manual, better performance, same GPIO pinout as Raspberry Pi

**Sipeed Lichee RV**

- **Main Specs:**
  - CPU: CPU: Allwinner D1 - Alibaba Xuantie C906 (RV64GCV)
  - RAM: 512MB / 1GB DDR3
  - Storage: FLASH + SD slot
  - Connectivity: USB + HDMI
  - GPIO: 40 pins
  - Price: 25$ - 45$

Board summary/Evaluation: easy to setup, complete and easy to read CPU manual, good quality-price ratio, accessible, small size

##### SW environments

**Operating Systems and development software**

- Linux-based distros available for both boards: Debian & Ubuntu (official)
  - Distro images with GUI, which enables an autonomous setup without an external PC
  - Images of newer versions of Linux kernel without GUI
  ⇒ Board communication through ssh

- GNU development tools available for both boards:
  - **gcc** to generate executable files (compile/link phases)
  - **gdb** to debug user-generated programs

**Completed goals**

- Driver to control GPIO as a kernel module
- Communication interface via I/OCTL to make use of the GPIO from user space (adds overhead due to ioctl cost)
- Driver test programs with simple peripheral devices

**Next steps**

- Recompiling Linux kernel to add a system call to map physical addresses into user space
  ⇒ Manage peripheral controllers directly from user programs
- Testing other OS's such as Haiku OS; currently testing ports to VisionFive2

#### Acknowledgements

This work has been supported by the 6th call of Proyectos de Innov. Docente de la Universidad de Cantabria, grant "Redes de Interconexion, Aceleradores Hardware y Optimizacion de Aplicaciones" (PID2019-105660RB-C22, funded by MCINN/ AEI/10.13039/501100011033), and grant "Planificadores y Redes para Data Centers Sostenibles" (TED2021-131176B-I00, funded by MCINN/ AEI/10.13039/501100011033 and the European Union NextGenerationEU/PRTR). Cristóbal Camarero is under contract through a Ramón y Cajal grant RY2021-033959-I, funded by MCINN/AEI/10.13039/501100011033.

#### Conclusions

OS availability for RISC-V has risen as the ISA garners interest and adoption, although OS support varies between devices. The VisionFive and Lichee RV boards support general Linux distros, such as Debian or Fedora, and purpose-built platforms such as Tina7 or Wafit8. Early results show promise: the boards are capable of running a modern OS autonomously and our tests on managing peripheral devices have been successful. Our next step is to find the desired SW features in an OS that can be booted in a RISC-V board.