

wueHans: A Full-Stack Open-Source RISC-V Gaming Console and SoC Architecture

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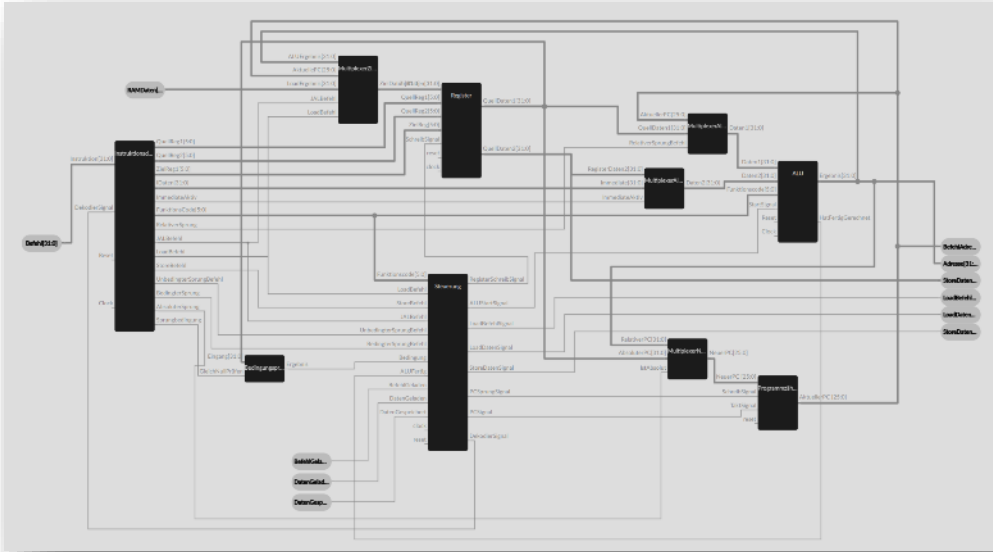
Different consoles



We've built our own!



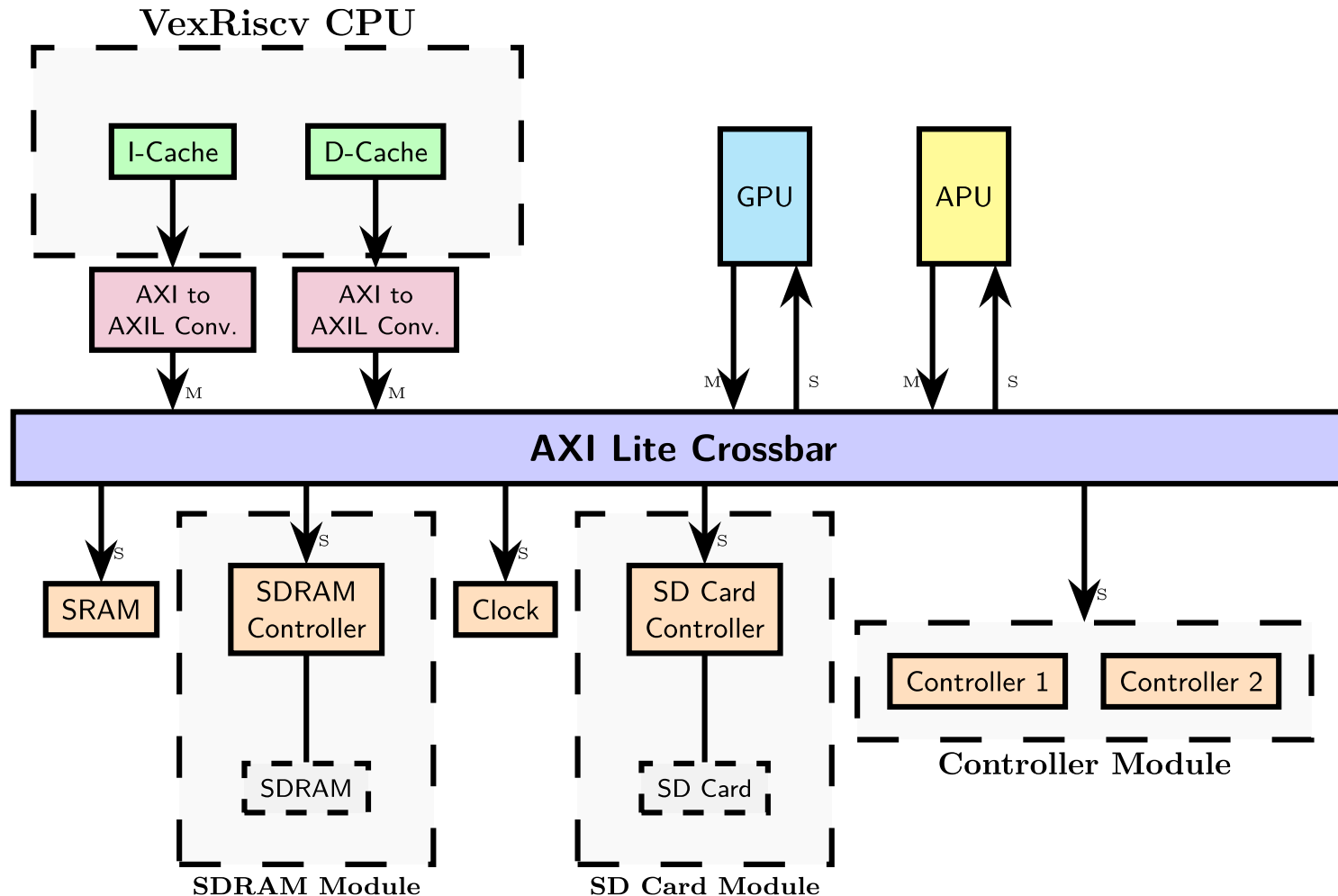
Progress of our console



- Selfmade CPU with custom ISA
- FPGA-based
- Adapted vasm backend [6]
- Custom linker and loader

- Move to open source RISC-V core
- FPGA-based
- Custom GPU
- 3D-printed case

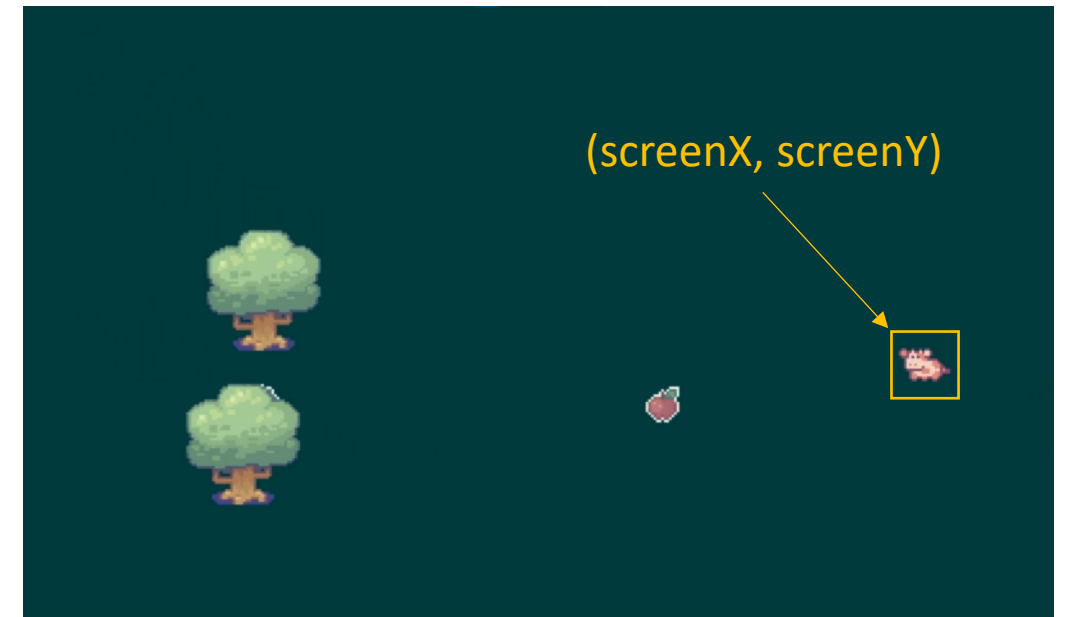
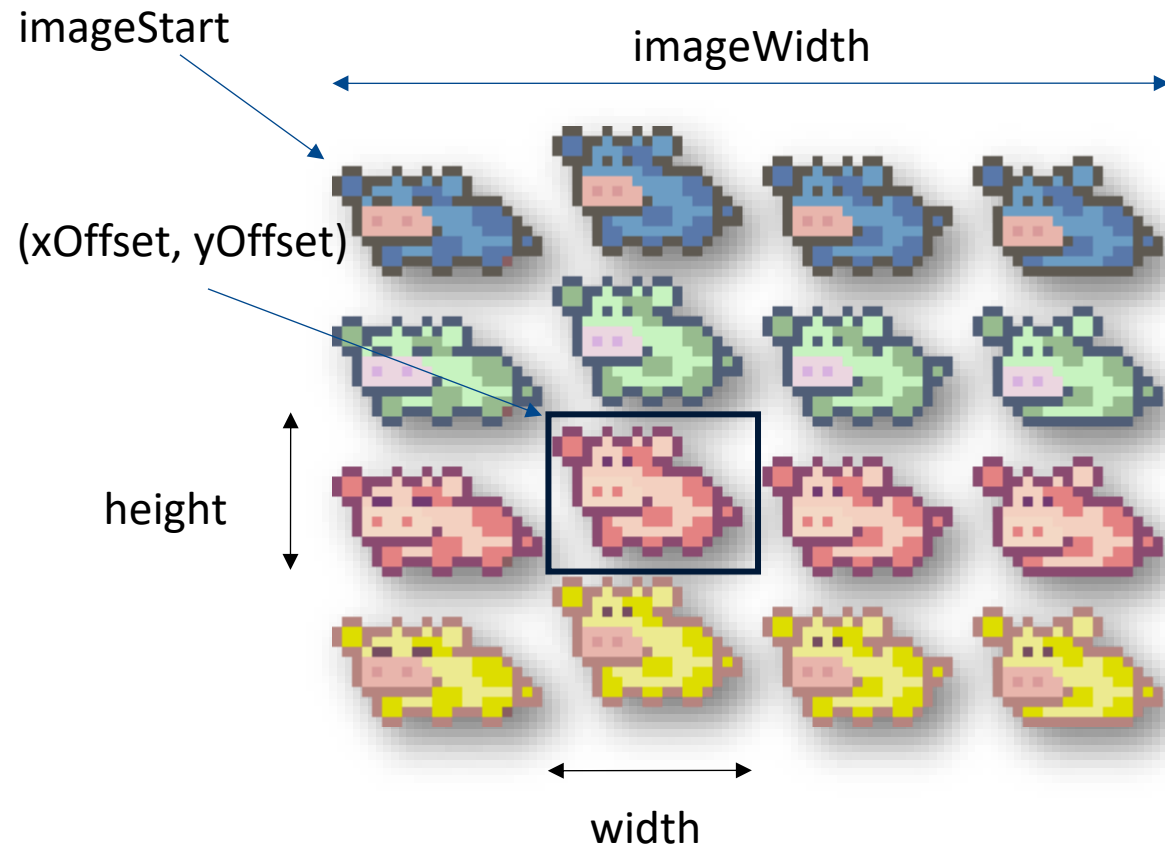
Console Architecture

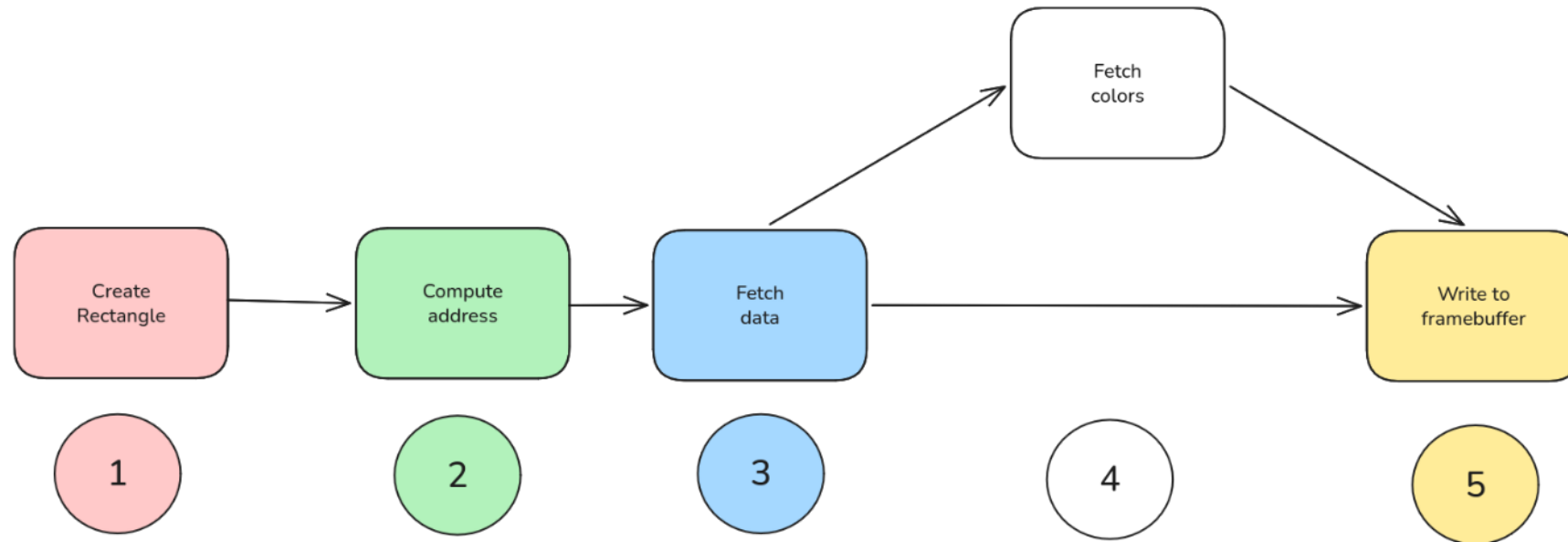


- 50 MHz VexRiscv
- 4 kB I- and D-cache
- 400x240 sprite-based GPU
- 32 kHz, 16-bit audio
- 32 kB SRAM
- 32 MB SDRAM
- Game input with two SNES controllers
- ELF format supported by the bootloader

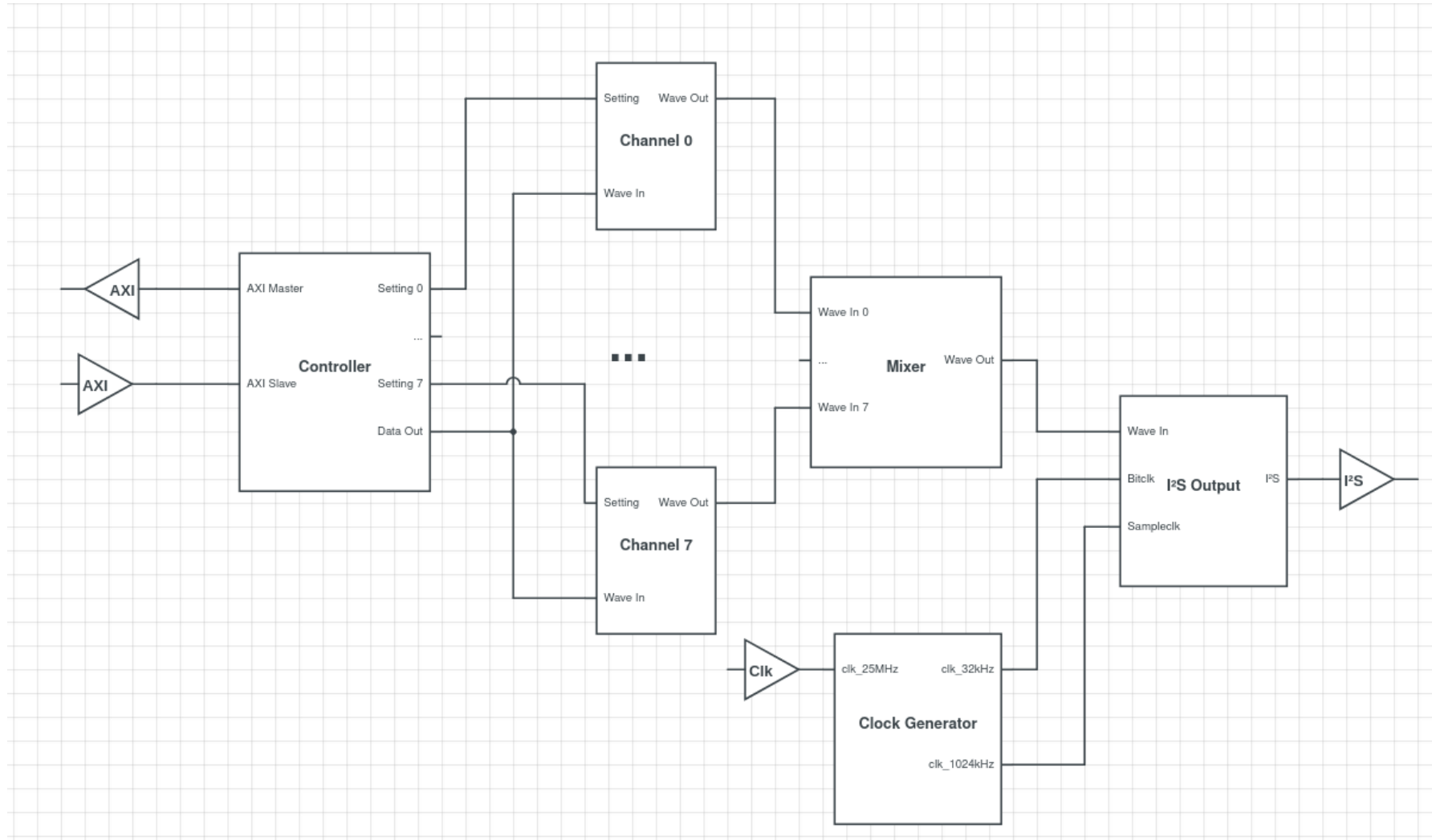
- VexRiscv (CPU) [5]
 - many alternatives, e.g., Neorv, picorv, ...
- ISA extensions:
 - Rv32imf
 - Hardware floating-point support
- Open-Source design
- Memory-mapped registers for
 - GPU
 - Audio
 - ...

Address	Name
0x00000000	SDRAM
0x02000000	GPU
0x02000100	Audio
0x02000200	Controller
0x02000300	Counter
0x02002000	Color table
0x02010000	Bootloader
0x80000000	SD-Card

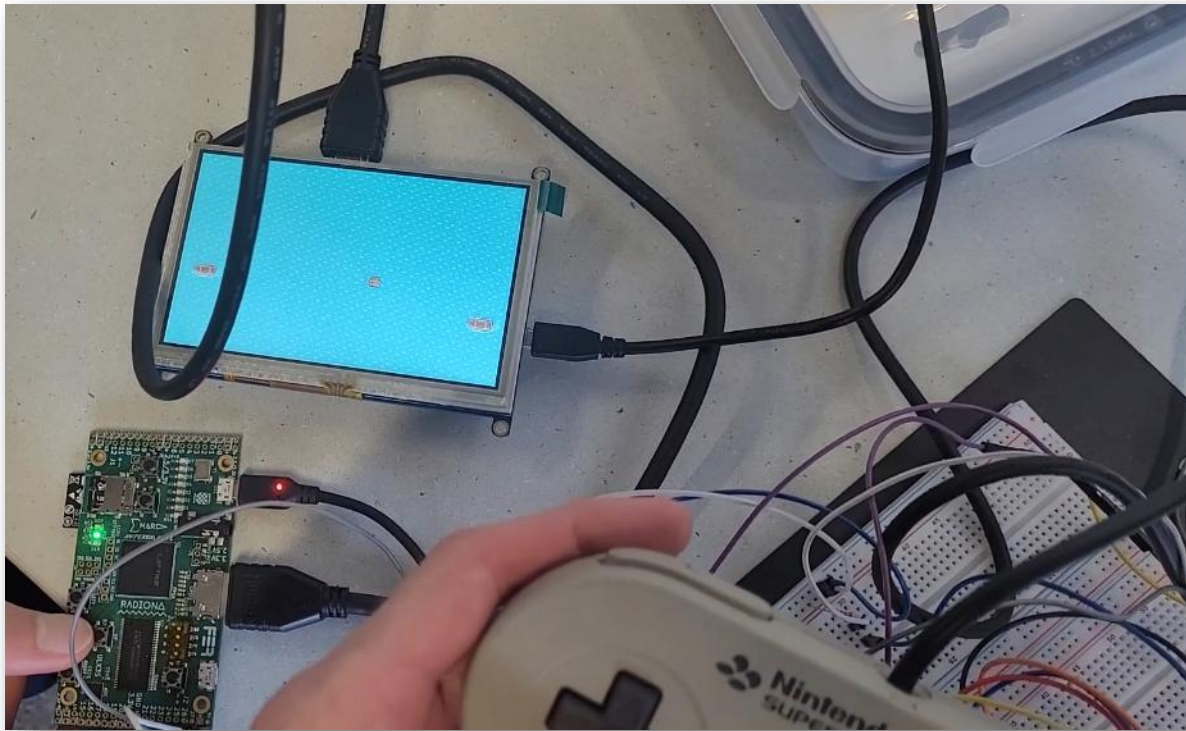
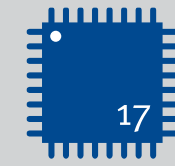


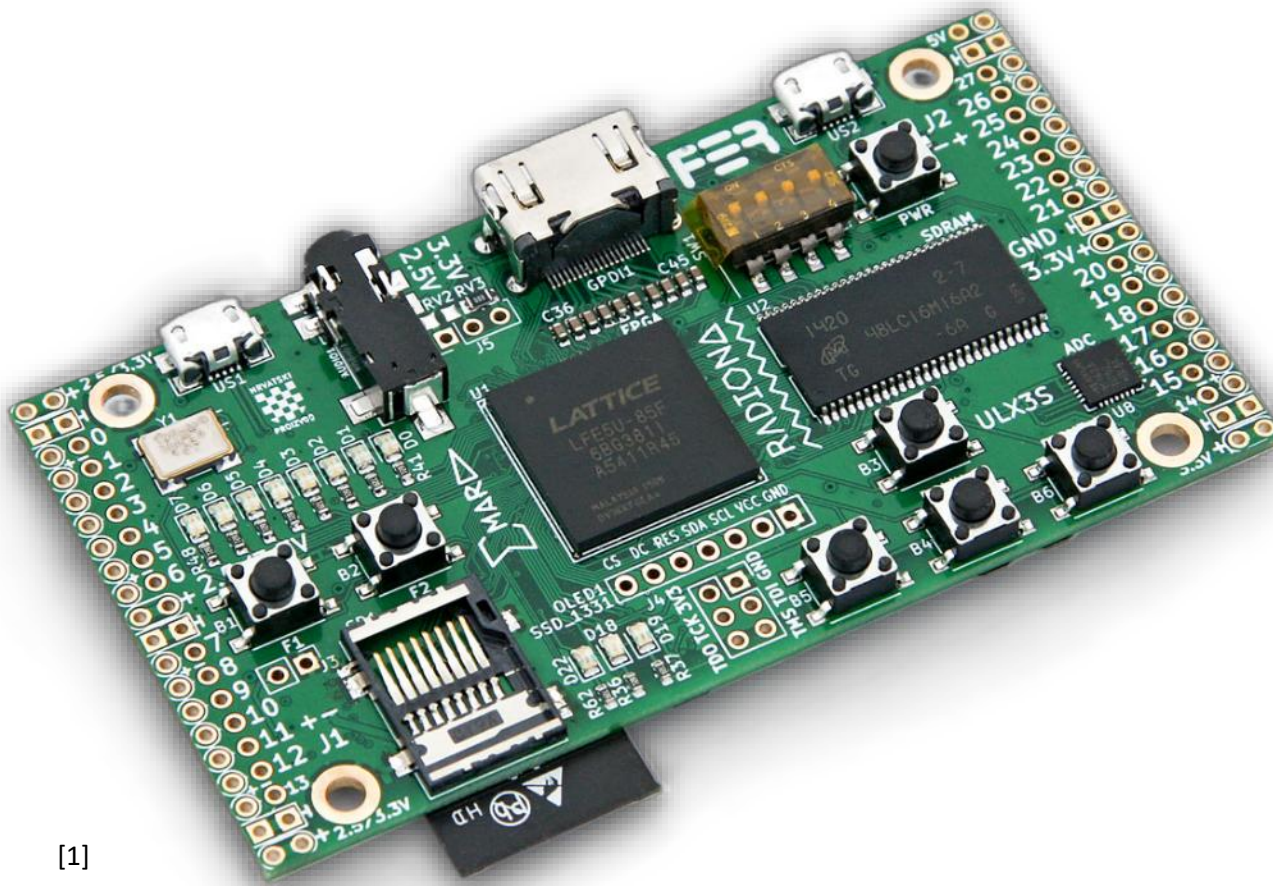


1. Rectangle is created
2. Address of the desired pixels is computed
3. Data is fetched from the AXI Bus
4. Images only store indices to a color table. The correct colors are fetched
5. The final pixels are written to the framebuffer



Prototype

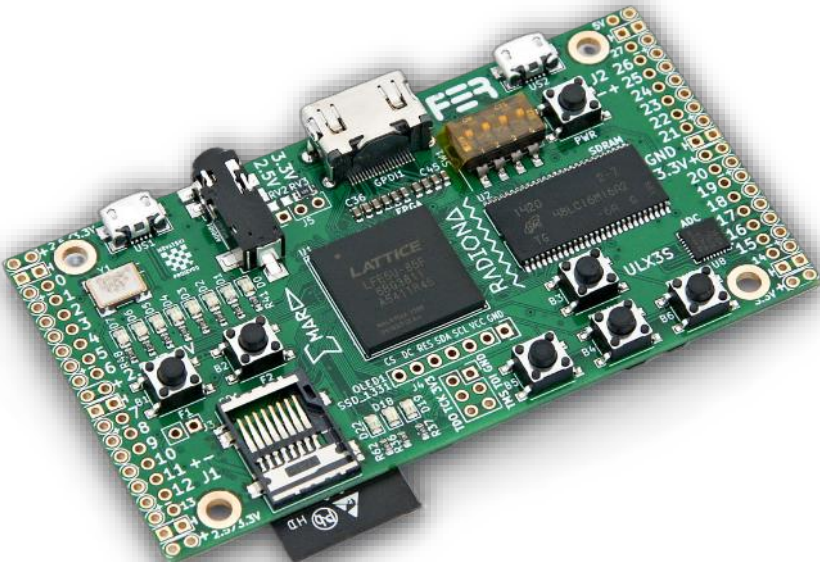




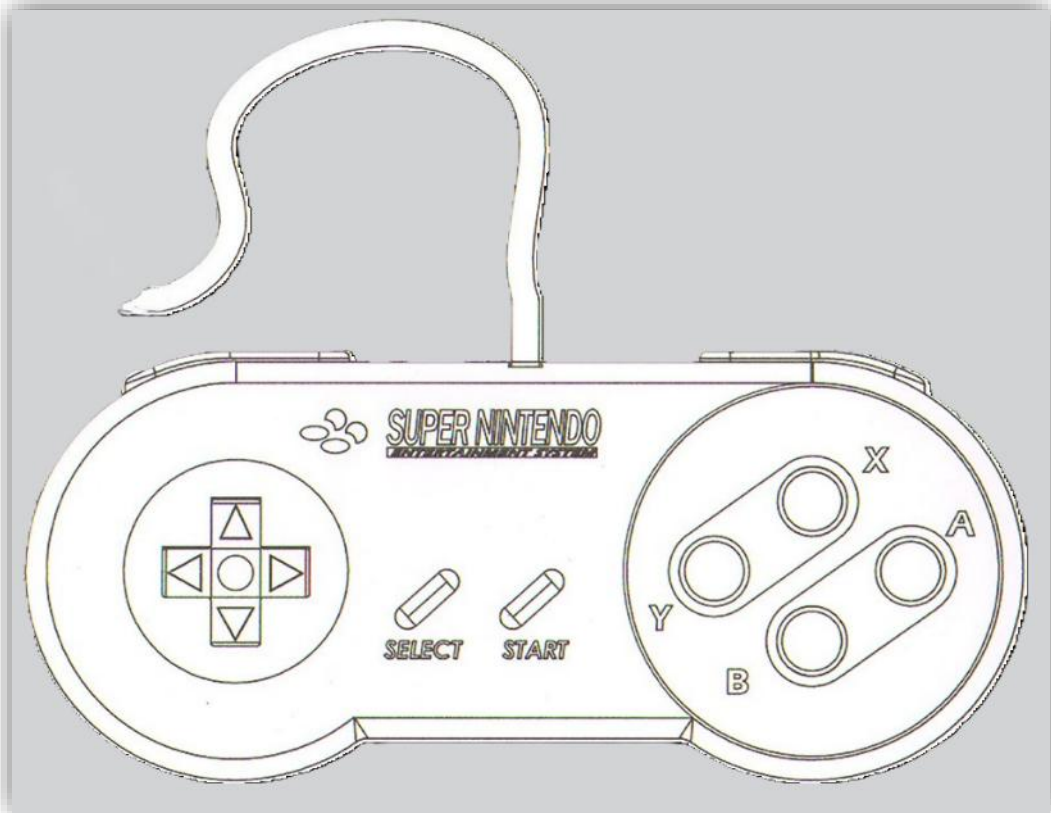
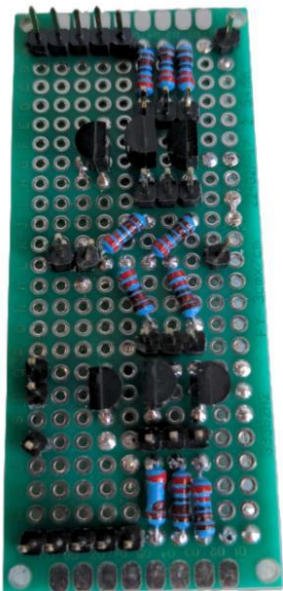
- Lattice ECP5 with 84k LUT
- 32 MB SDRAM
- Micro-SD slot (to store the game)
- Digital video output
- 25 MHz clock

[1]

Prototype - Controller



Level shifter

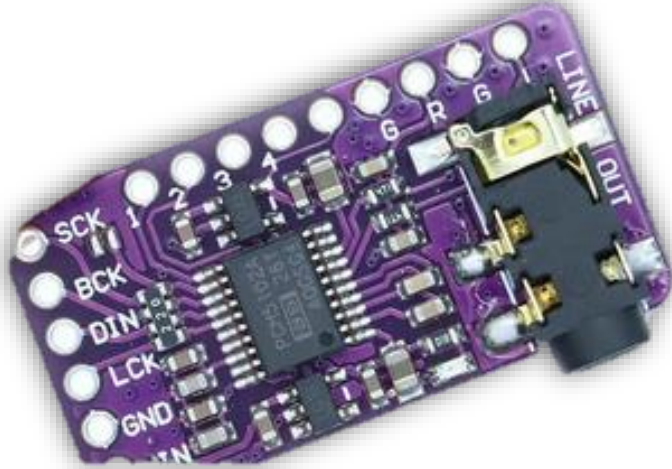


3.3 V

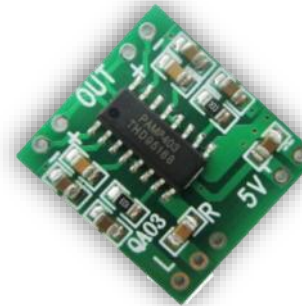


5 V

Prototype - Audio



Digital-Analog converter

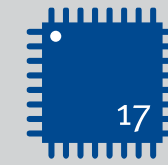


Amplifier

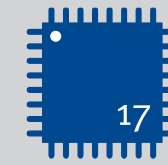


Speakers

Prototype - Case



Prototype - "Workstation"



Prototype



EDA Tools:

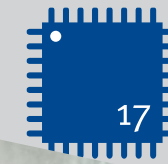
- Simulation: Icarus Verilog, GTKwave and Surfer
- Synthesis: Yosys, nextpnr, fujprog
- All tools bundled in the oss-cad-suite [3]
- Build system with CMake for hardware and software



Software:

- Support for C and C++ with the *newlib* [4] standard library
- Virtual prototype for testing and debugging
- Hardware Abstraction Library
- Software template that can be used to quickly start developing
- Bootloader

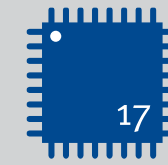
Game Jam



- One weekend spent at the university
- High interest especially of Games-Engineering students
- Low barrier of entry for any game developer



Current Games



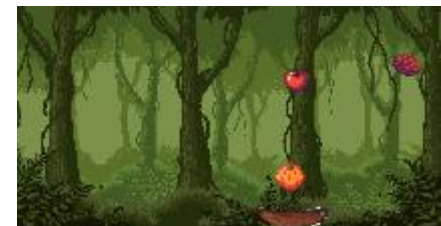
Cow Shooter



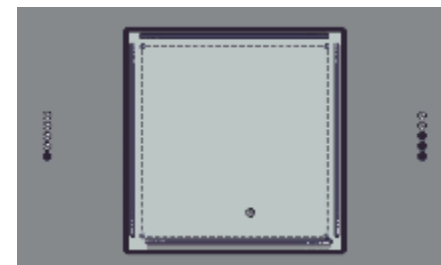
Hans Tower Defense



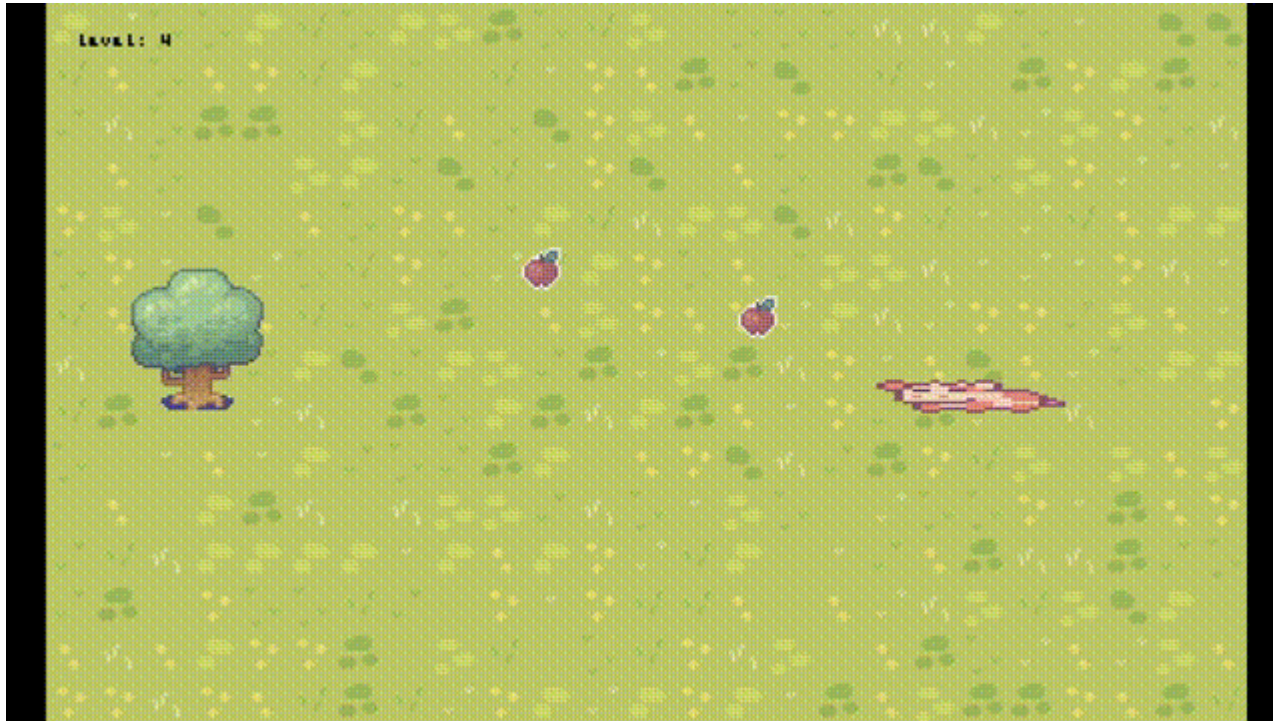
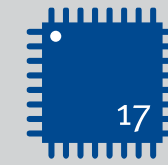
Hans The Gatherer



Hans Tennis



Current Games



Cow Shooter



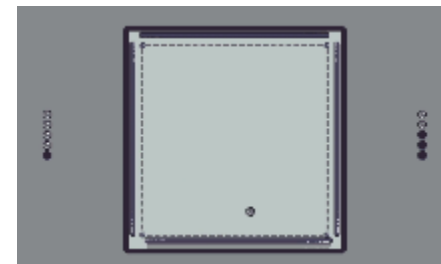
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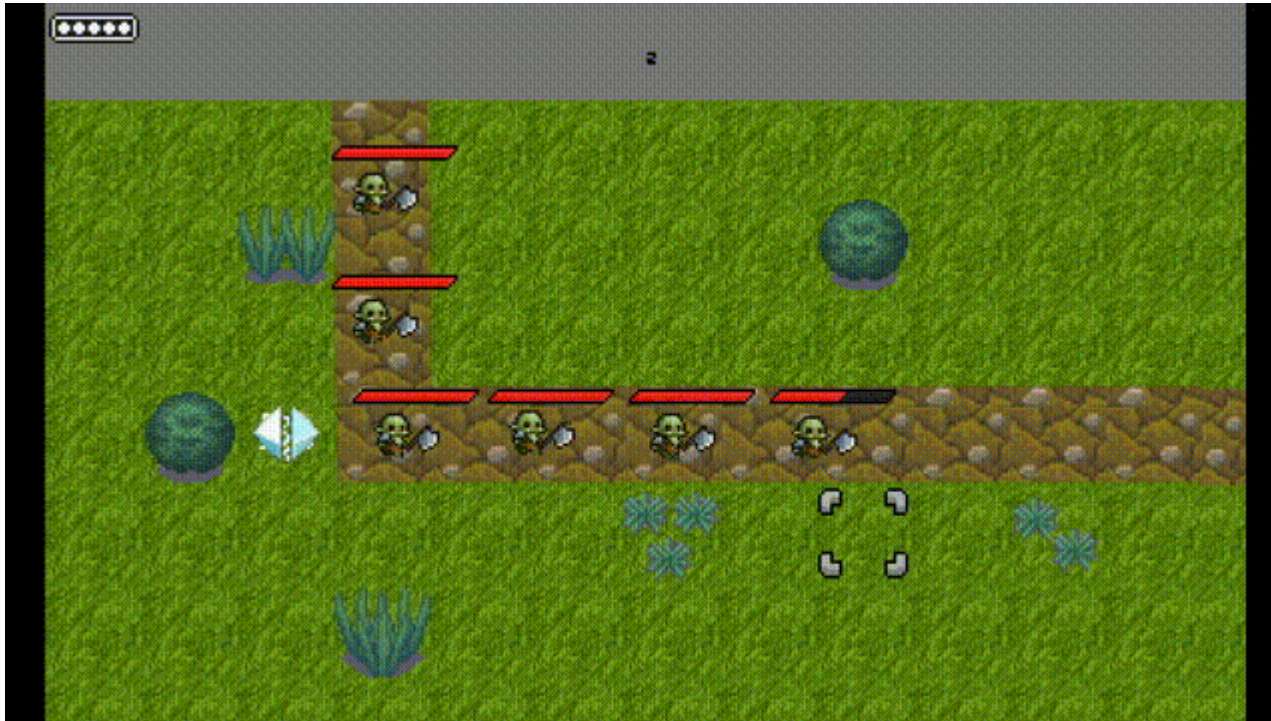
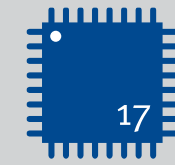
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Current Games



Cow Shooter



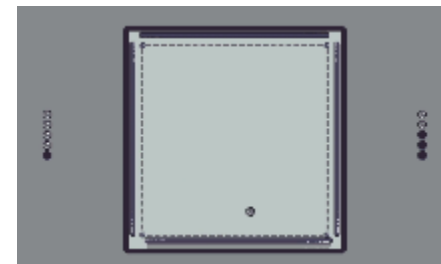
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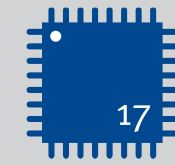
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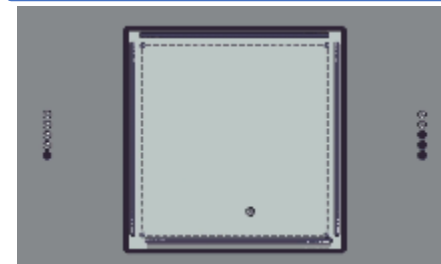
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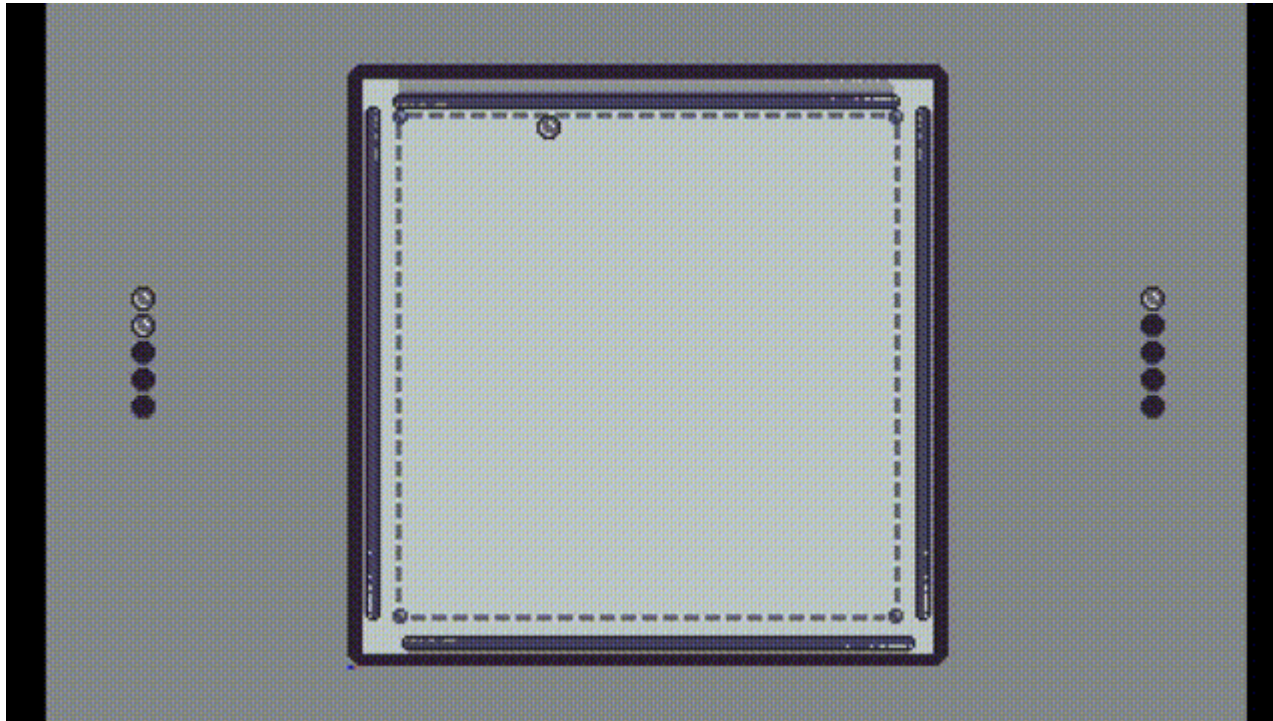
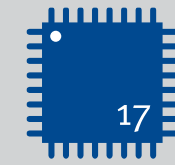
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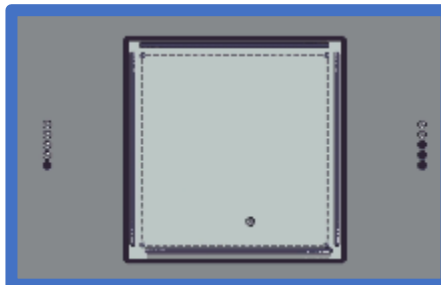
Hans Tower Defense



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Hans Tennis



Next Steps

- Improve the audio
- Multicore RISC-V core
- Extend our GPU to handle 3D
- 2nd Game Jam
- Integrate everything on a single PCB
- Tapeout with the IHP Open-Source PDK



- 1) ULX3S. (2026, May 27). Retrieved from <https://radiona.org/ulx3s>
- 2) Behance. (2019). SolidWorks | SNES Controller - Aonghus Quinn. Behance. Retrieved from https://www.behance.net/gallery/74554165/SolidWorks-SNES-Controller?locale=de_DE
- 3) oss-cad-suite. <https://github.com/YosysHQ/oss-cad-suite-build>
- 4) Newlib. <https://sourceware.org/newlib/>
- 5) VexRiscv. <https://github.com/SpinalHDL/VexRiscv>
- 6) vasm. <http://sun.hasenbraten.de/vasm/>
- 7) Martin Iturbide. [https://commons.wikimedia.org/wiki/File:Nintendo Gamecube Silver.JPG](https://commons.wikimedia.org/wiki/File:Nintendo_Gamecube_Silver.JPG)
(GNU FDL, unmodified)
- 8) Evan-Amos. <https://commons.wikimedia.org/wiki/File:Nintendo-Switch-wJoyCons-BIRd-Standing-FL.png>