ENABLING LOW-POWER, SMARTPHONE-LIKE GRAPHICAL UIS FOR RISC-V SOCS

5th RISC-V Workshop, Mountain View, CA

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EMBEDDED SYSTEMS

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- 20+ people
- innovations in technology
- main business in services
- own platforms & tools
- IoT, CPU/GPU, HMI, FPGA

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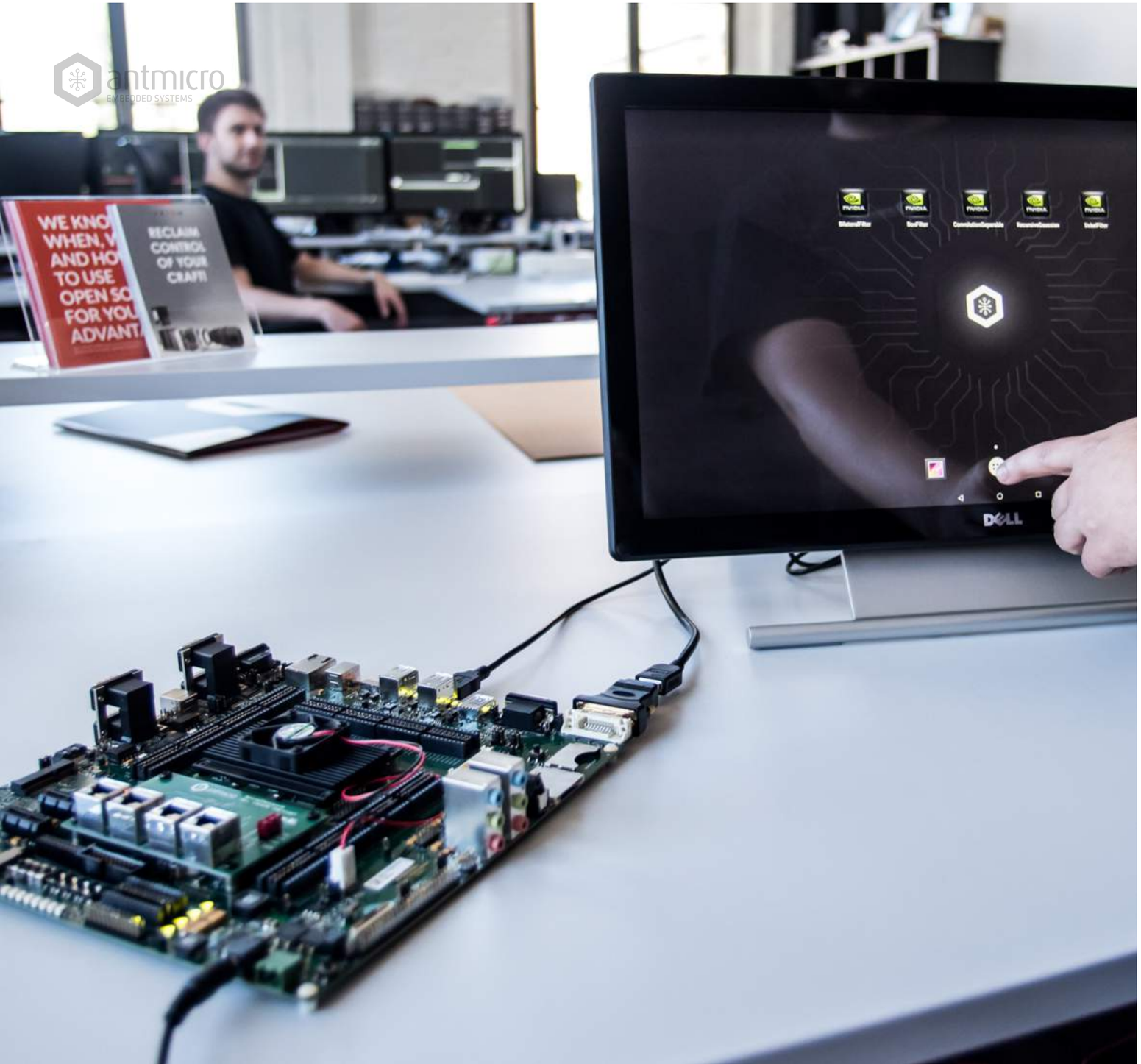
AXIOM
OPEN SOURCE
4K CAMERA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RECLAIM
CONTROL
OF YOUR
CRAFT!
DELL

GUIs

PREMISE

- industrial/embedded GUIs mostly look bad
- terrible user experience
- designed by engineers, hard to improve
- for better UIs have to jump to Android/Linux, no middle ground
- people care about what they can see and touch
- what if we could have needs drive relevant HW?

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TODAY

As much a graphics design problem
as it is a user experience problem.

ORIGINS

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ORIGINS

- GUI produced in close cooperation with designers familiar with Web/mobile development
- needed possibility to remotely load GUI via WiFi from base station
- mobile-like experience was extremely important
- end result (on STM32F4) is really good, current work focuses on issues outside the GUI

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STARTING POINT

- get best of both worlds (good looks as well as better security, lower power, boot speed etc.)
- we do not need to reinvent the wheel - we have the example of mobile UIs
- with the right approach and tools, embedded GUIs can be beautiful too

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LESS IS MORE

"I would have written a shorter letter,
but I did not have the time."

-- Blaise Pascal

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SMALL IS BEAUTIFUL

- smaller system (RTOS rather than Linux/Android)

is easier to verify and understand

- boots immediately
- less prone to bugs
- easier to update and maintain

OUR INSPIRATIONS

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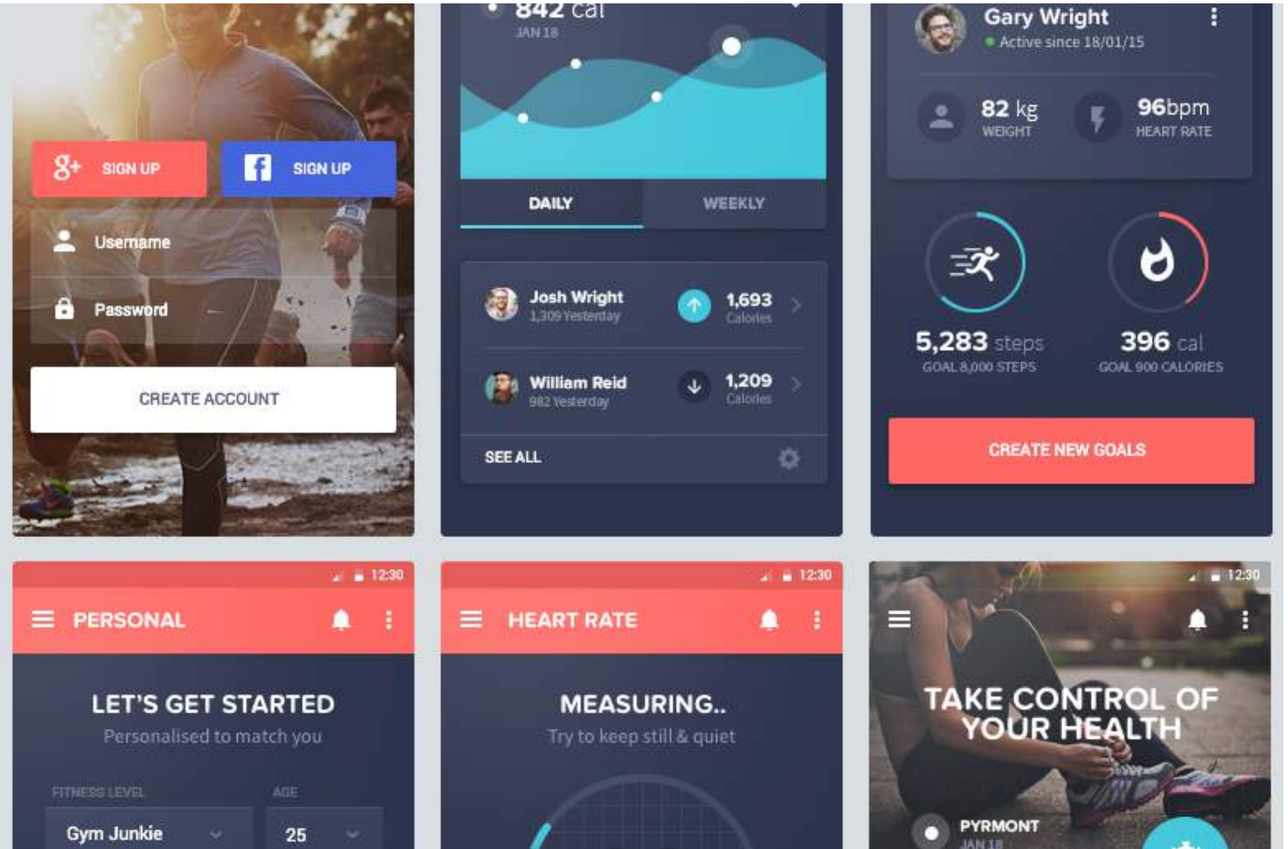
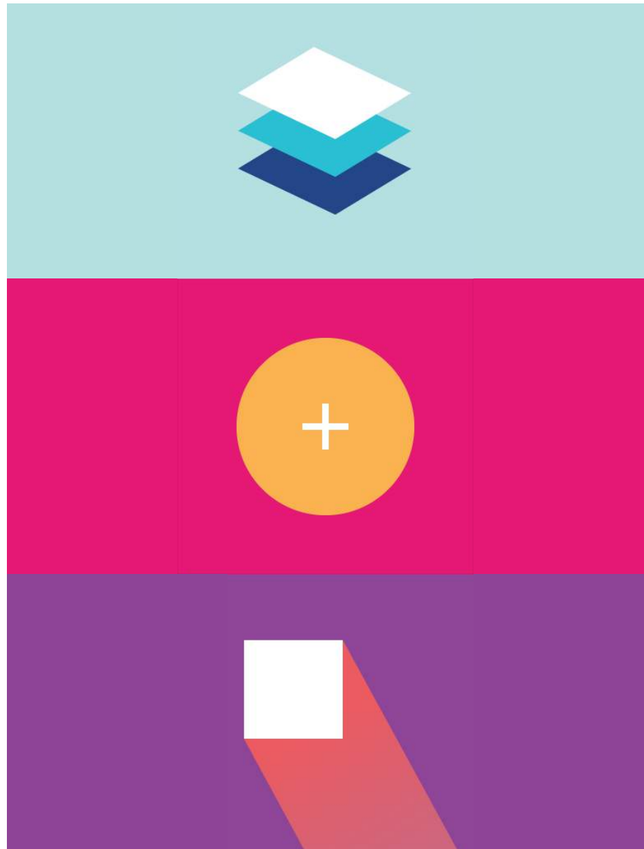
OUR INSPIRATIONS





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ANTMICRO GUI LIBARY - MAIN FEATURES

- mobile-like look & feel on MCUs (using minimal HW infrastructure)
- object-oriented
- standardised widgets
- ease or programming / design via e.g. XML parsed GUIs
- possibility of remote updates

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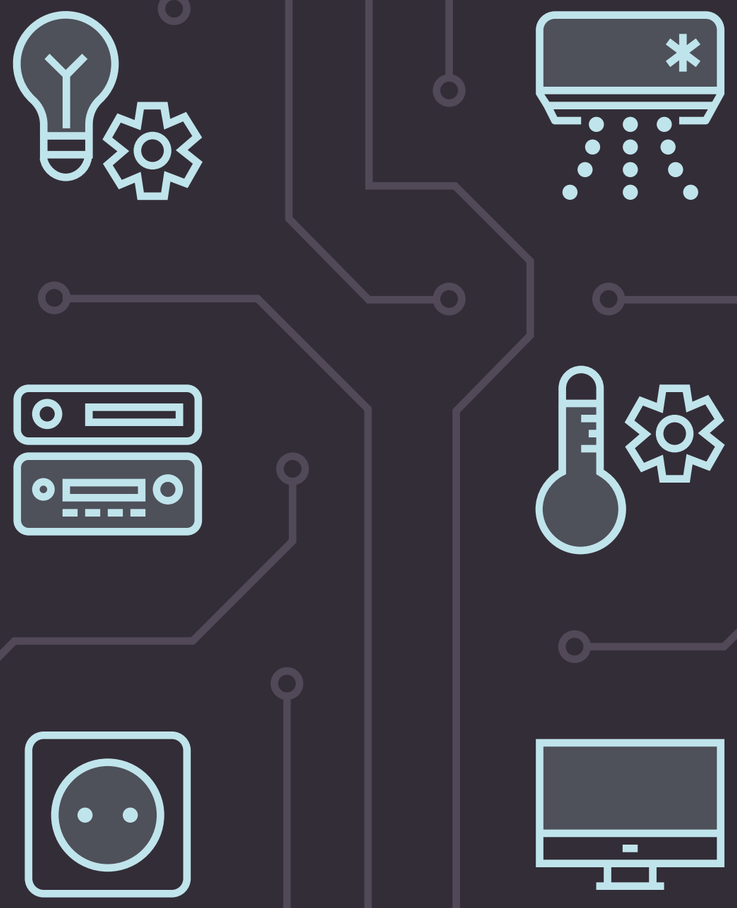
POTENTIAL APPLICATIONS

- smart home control devices
- smartwatches
- coffee makers
- HVAC control displays
- ticket/validation/parking machine
- smart appliances
- 3D printers
- smart intercoms



TECHNICALITIES

- written in C++
- support for layers, formats
- own font engine with kerning, anti-aliasing
- main event loop is outside library
- full control over drawing
- PNG support & manipulation (e.g. format conversion) using libpng
- JPEG support using libjpeg

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PROGRAMMATIC GUI CREATION

```
Manager* DispMan;
DispMan = &Manager::GetInstance();
...
Manager::Initialize(LCD_WIDTH, LCD_HEIGHT, 2, 2, false);
DispMan->AddImageContentToContainer(
   "icon", new ImageContent(
        ImageContent::FromPNG("/rom/images/icon.png")
    )
);
DispMan->ShowPopup("Hello world!", "Welcome to the GUI library", 1000);
```

XML PARSING

- build a GUI from XML and quickly rearrange things
- can load XML from outside e.g. via WiFI on startup
- facilitates work with graphics designers
- can express the essence of the GUI in understandable form

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XML PARSING

```
<screen id="sleepScreen" onSlideToRight="ChangeScreen(start,ANIMATE_RIGHT)" >
   <button x="10" y="10" height="60" width="340" class="sleepButton"/>
   ...
</screen>
```

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'PARETO' CSS

```
button { icoFont: symbol }
button.sleepButton {
  backgroundColor: #FFFFFFFF
  frameColor: #00000000
  icoColor: #FF808080
  icoChar: #E054
}
#sleepScreen { backgroundColor: #DDDDDDFF }
```

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CALLBACKS

- there are some built-in callbacks like ChangeScreen
- new ones can be coded in C++ and then used in XML
- could embed a JS engine in future to make it fully dynamic

```
onSlideToRight="ChangeScreen(start,ANIMATE_RIGHT)"
```

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INTERACTIONS & ANIMATIONS

- presses
- slides
- long-presses for additional action on element
- slides between screens are animated
- scrolling lists (showing list end)
- -> modelled after smartphone UIs

PLATFORMS

- initially developed for eCos RTOS
- no hard dependency, but requires some infrastructure e.g. threads, libraries
- initial port for FreeRTOS
- libc/POSIX-compatible - runs 1:1 on Linux/Mac (e.g. for the "PC simulator")

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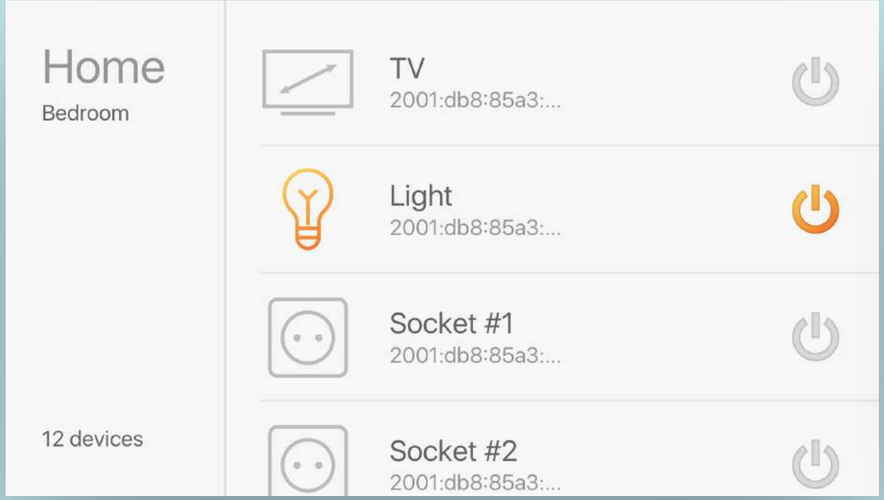
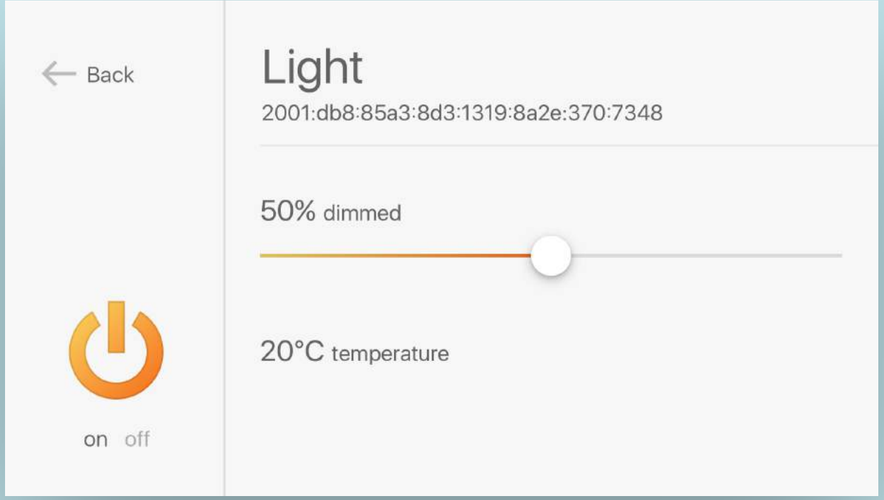
SMART DISPLAY





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OUR WORK WITH

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MATERIAL DESIGN

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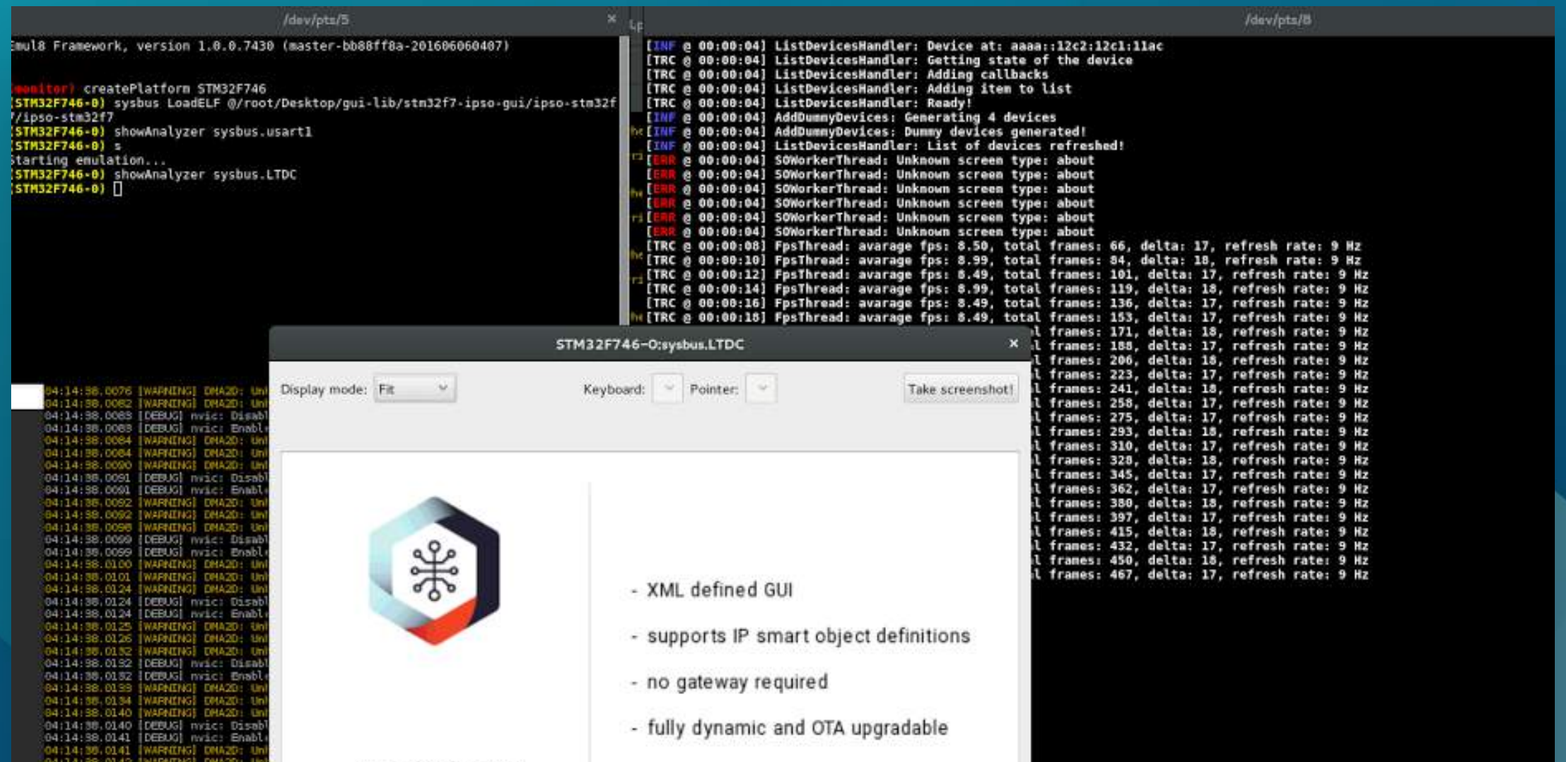
EMUL8

- we can also run the GUI in our emulation framework, Emul8
- support for STM32F4/7 boards



XILINX ZYNQ

- no GPU, not even a framebuffer
- 'proper' GPU takes up lots of valuable FPGA fabric
- ARM CPU makes it ideal platform to start prototyping
- we would have liked to prototype on the SiFive Freedom ;)

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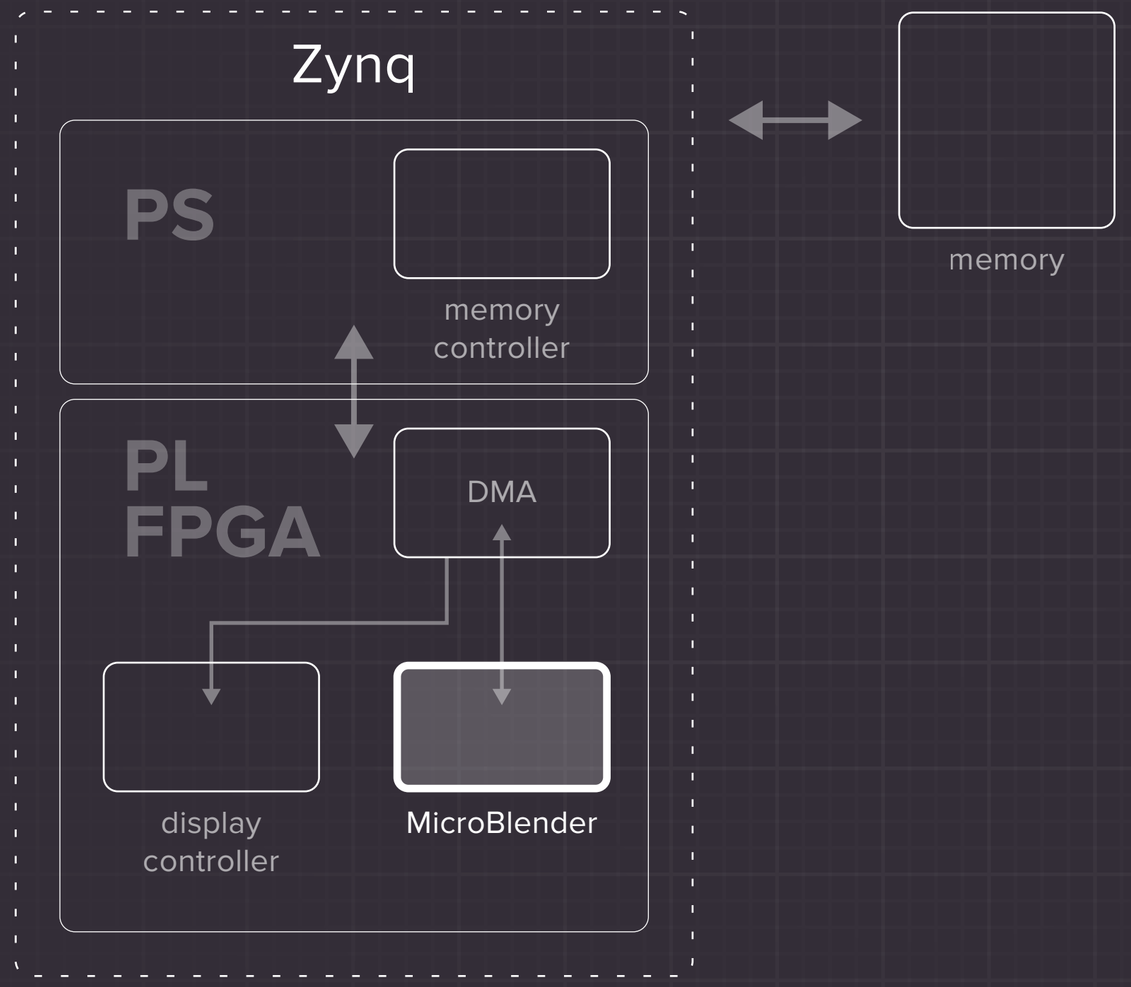

MICRO BLENDER

CHISEL

- easier to parametrize
- much easier communication between HW-SW team
- better understanding of what is going on for SW people

CHISEL

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RISC-V

- RISC-V ultimate target platform
- encourages SW-driven silicon, reuse, co-design
- graphics will be a tough milestone
- our work could enable modern UIs for small RISC-V based platforms

RISC-V

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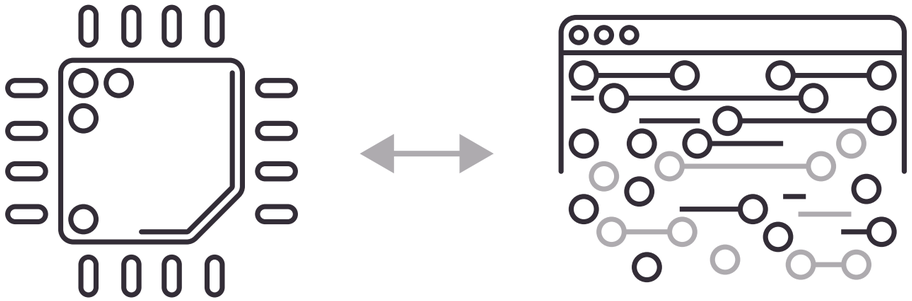
SOFTWARE-DRIVEN IP

- that's how we always work with FPGA IP
- RISC-V makes this feasible for ASICs
- co-design of HW and SW



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SUMMARY

- with minimal graphics infrastructure, we can get great looks and smooth user experience on graphics-less MCU-class platforms
- we can make GUI development simpler at the same time
- software-driven IP (silicon) is possible (and advisable!)

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THANK YOU
FOR YOUR ATTENTION!

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