



Datacenter Performance. Edge Efficiency.
Accelerating Inference, Everywhere.



Emulation: from C Tests to Tapeout - a Case Study

DVClub World - November 25 2025

Antoine Madec

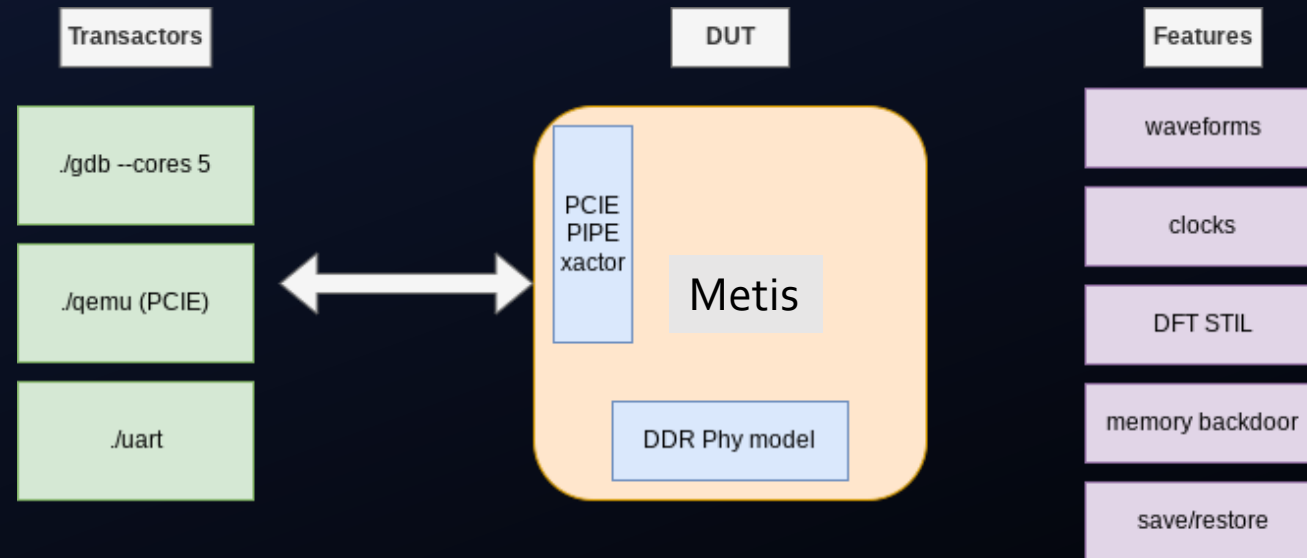
Who am I?

- 14 years in simulation & emulation
- Europe and US
- Technical leader, FAE, manager: always hands-on
- Teams from 3 to 12 people
- Block-level / Top-level
- Automotive, Video Decoder, AI
- Axelera AI: accelerating inference



A case study

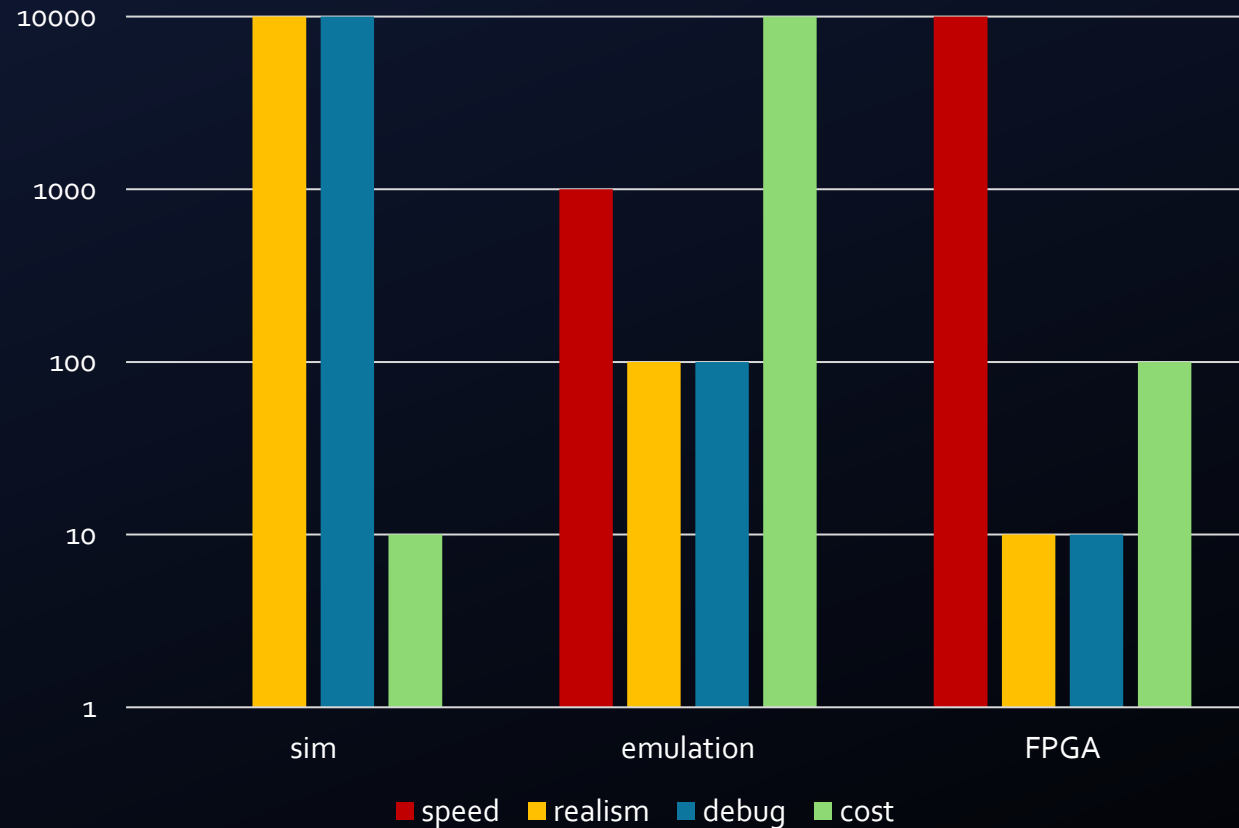
- Just our opinion
 - Depends on the project, the needs
 - Might not work for you
- Key figures about Metis
 - 1 year: from Emulation start to chip bringup
 - multi-CPU
 - **1 day: functional test bringup**
 - DDR: 1 week
 - PCIe: 1 week



Verification platform landscape

Where does emulation fit?

- Simulation at top-level is too slow
 - Emulation, models, etc, are a must
 - The right platform for the right tests for the right interfaces
 - Trade-offs are inevitable
 - Speed
 - Realism
 - Debugability
 - Platform bring-up time
 - Price
- It is our job to choose the right platform



Emulation cloud setup

Why choosing the cloud?

- ICE vs virtual emulation
- Our needs
 - CPU based tests
 - Some PCIe tests
 - Flash/mem models
 - UART, gdb, etc
- Conclusion: virtual emulation
 - Simpler, setup the **Veloce** once
 - Cloud: emulation as a service
 - Subscription model



Building Emulation databases (1)

Getting and modifying RTL sources

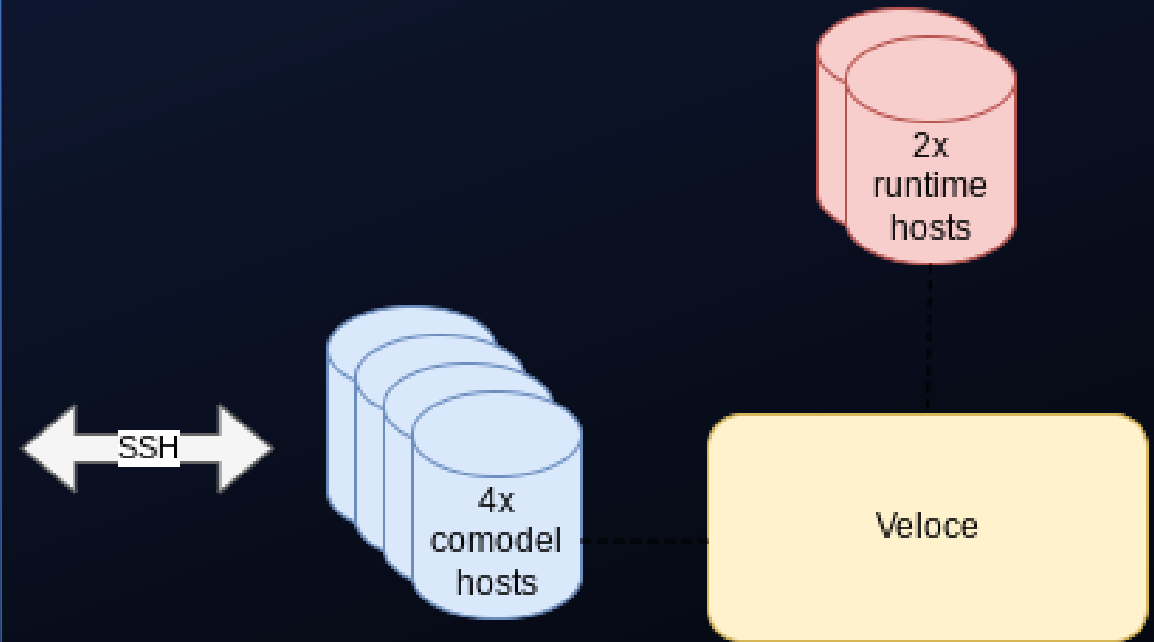
- Getting files
 - Easy tool to fetch files is critical
 - Same tool for sim, emu and synthesis
 - Different targets: emulation/simulation/RTL
- Emulation models
 - RAMs/ROMs/OTP
 - Flashes: Siemens Softmodels
 - RNG ring oscillators: \$urandom with XRTL
 - Matrix multiplication: save AVB

- Don't model
 - PLL -> drive output clock directly
 - Analog sensors -> use simulation
 - PHYs (DDR, PCIe) -> Siemens Virtualab
 - Use sim to test PHY programming
 - PHYs aren't real, just models
 - Impact of performance
- **Do not be afraid to experiment to speed up your process**

Building Emulation databases (2)

Taking advantage of the Cloud

- 4 comodels and 2 runtime servers
 - Ssh == accessible from our Network
 - Administered by our IT
- Nightly CI
 - Running on gitlab
 - 10h builds / 2h tests
- Release system
 - Built by the nightly CI
 - Users: copy/paste in the morning
 - Top platforms with different stubs
 - 3 to 24 boards



The human factor

Emulation is a cross-team effort

- Love thy EDA consultant
 - Trust: being fair / demanding
- **FW/DV communication is critical**
 - FW and DV: a gradient in Verification
 - Running C code on CPUs
 - DV can write C driver
 - FW can debug waveforms
 - Bringup will run C code on CPUs, not SV
 - Weekly meetings, daily chats
 - Using the same Git repo
- Other users
 - Architects: perf and compliance tests
 - Application SW
 - DFT



"I see ourselves as one big Verification team composed of people with different skillsets"

- Jovin Langenegger

Engineering Manager - AI Embedded Software

Runtime (1)

C tests

- Building SW test
 - Bin to hex files: in sim and emu
 - Backdoor loading of the memories
 - Can also load the ELF through GDB
 - slower, more realistic
 - bringup preparation
- Building the TCL runtime script
 - Bash script
 - generates TCL script: templates
 - calls velrun (EDA specific)
 - misc: flash, snapshots (Linux boot), etc
- Pass/Fail
 - **GPIO[2]**: test is finished
 - **GPIO[3]**: pass/fail

```
./run --help
./run --list

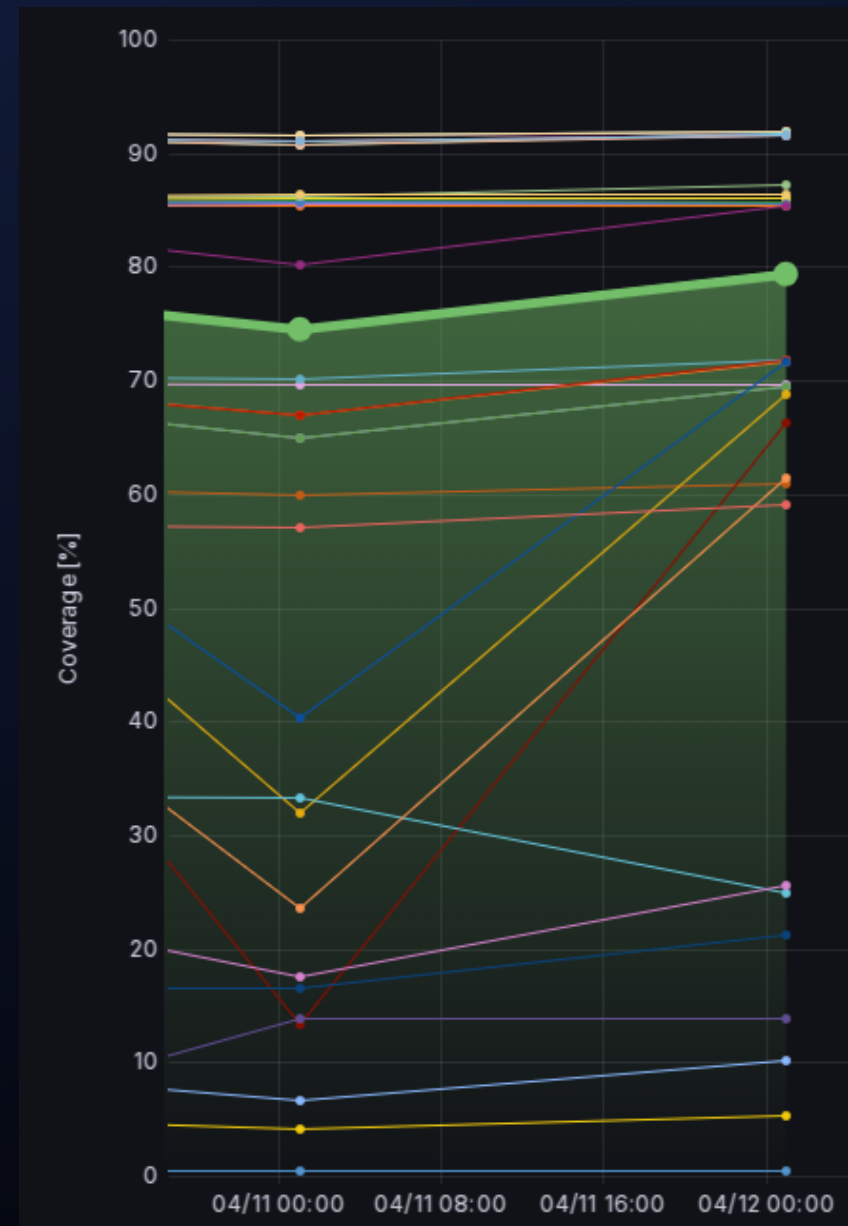
./run test_hello_world
./run test_hello_world --clock fast
./run test_hello_world --dump_cpu_instructions
./run test_hello_world --xwaves noc
./run test_hello_world --no_printf
./run test_hello_world --coverage

./run test_hello_world --interactive
```

Runtime (2)

CI

- MR pipeline
 - Simulation runs
 - Same SW build flow
 - Same top platforms (stubs)
 - Emulation sanity check
 - Cannot run full compilation
- Nightly CI
 - Back-to-back test
 - Start TCL server when starting emulation
 - Saves overhead of start/finish
 - Test as fast as 5s
 - Gather IO toggle coverage
 - on top instances
 - merge emulation + simulation coverage
 - good integration metric



Runtime (3)

Debug

- Avoid waveforms when possible
 - Too slow
 - Logs: XRTL + \$write()
 - CPU traces
 - Codelink?
 - fw_trace_utils
 - EDA agnostic
 - no license
 - Adapt to any CPU
- Xwaves (EDA specific)
 - Great for performance debugging
 - Add relevant signals at compile time
- Switch to simulation
 - For short tests
 - Same platforms, same tools
 - Slower, easier waveform debugging

<pre>clk_gen_setup_plls(); // Configure canonical settings for clocks in clock g clk_gen_set_canonical_settings(); #endif // FORCE_DEFAULT_CLOCKS #endif // PLATFORM_VELOCE #endif // CLOCKS_CONFIG_CANONICAL // First core: Initialization. #ifndef NO_INIT_BSS_AND_TLS _init_bss(); #endif _init_printf(); _thread_init(); _multicores_init(); // Signal to other cores. init_complete = 1; populate_stack_var(); } else { // Other cores: Wait for initialization to complete. while (init_complete == 0); populate_stack_var(); _thread_worker_main(); // Previous function should not return. while (1); } // only single-threaded programs should ever get here. int ret = main(); exit(ret); }</pre>		<table><tr><th></th><th>Prev</th><th>Next</th><th>Main</th><th>List</th><th>Source</th><th>Sync</th><th>Reload</th><th>Quit</th></tr><tr><td>23</td><td>2577730777</td><td>ipipe:0</td><td>@00000000007007298-000b517</td><td>ab=000000000070bd298</td><td></td><td></td><td></td><td></td></tr><tr><td>22</td><td>2577790777</td><td>ipipe:0</td><td>@0000000000700729c-47853503</td><td>ab=000000000070c1088</td><td></td><td></td><td></td><td></td></tr><tr><td>21</td><td>2580550805</td><td>ipipe:0</td><td>@000000000070072a0-0000c100</td><td>zero=00000000000000000</td><td></td><td></td><td></td><td></td></tr><tr><td>20</td><td>2580550805</td><td>ipipe:0</td><td>@000000000070072a2-000b6517</td><td>ab=000000000070bd2a2</td><td></td><td></td><td></td><td></td></tr><tr><td>19</td><td>2583325833</td><td>ipipe:0</td><td>@000000000070072a6-47653503</td><td>ab=000000000070c1090</td><td></td><td></td><td></td><td></td></tr><tr><td>18</td><td>2585950859</td><td>ipipe:0</td><td>@000000000070072aa-00009502</td><td>ra=000000000070072ac</td><td></td><td></td><td></td><td></td></tr><tr><td>17</td><td>2588875888</td><td>ipipe:0</td><td>@000000000070071a4-f1402573</td><td>ab=00000000000000000</td><td>populate_stack_var</td><td></td><td></td><td></td></tr><tr><td>16</td><td>2591650916</td><td>ipipe:0</td><td>@000000000070071a8-00004599</td><td>al=00000000000000000</td><td></td><td></td><td></td><td></td></tr><tr><td>15</td><td>2591665916</td><td>ipipe:0</td><td>@000000000070071aa-000b57463</td><td>zero=00000000000000000</td><td></td><td></td><td></td><td></td></tr><tr><td>14</td><td>2591665916</td><td>ipipe:0</td><td>@000000000070071ae-00004581</td><td>al=00000000000000000</td><td></td><td></td><td></td><td></td></tr><tr><td>13</td><td>2594425944</td><td>ipipe:0</td><td>@000000000070071b0-0000a829</td><td>zero=00000000000000000</td><td></td><td></td><td></td><td></td></tr><tr><td>12</td><td>2597230972</td><td>ipipe:0</td><td>@000000000070071ca-40b505b3</td><td>al=00000000000000000</td><td></td><td></td><td></td><td></td></tr><tr><td>11</td><td>2597245972</td><td>ipipe:0</td><td>@000000000070071ce-00000585</td><td>al=00000000000000001</td><td></td><td></td><td></td><td></td></tr><tr><td>10</td><td>2600006000</td><td>ipipe:0</td><td>@000000000070071d0-000b6617</td><td>a2=000000000070bd1d0</td><td></td><td></td><td></td><td></td></tr><tr><td>9</td><td>2600066000</td><td>ipipe:0</td><td>@000000000070071d4-51863603</td><td>a2=000000000070c10a8</td><td></td><td></td><td></td><td></td></tr><tr><td>8</td><td>2602796027</td><td>ipipe:0</td><td>@000000000070071d8-000b6697</td><td>a3=000000000070bd1d8</td><td></td><td></td><td></td><td></td></tr><tr><td>7</td><td>2602856028</td><td>ipipe:0</td><td>@000000000070071dc-5186b683</td><td>a3=000000000070c1400</td><td></td><td></td><td></td><td></td></tr><tr><td>6</td><td>2605571055</td><td>ipipe:0</td><td>@000000000070071e0-000009c6</td><td>al=00000000000020000</td><td></td><td></td><td></td><td></td></tr><tr><td>5</td><td>2605586055</td><td>ipipe:0</td><td>@000000000070071e2-0000995b2</td><td>al=000000000070e1880</td><td></td><td></td><td></td><td></td></tr><tr><td>4</td><td>2605586055</td><td>ipipe:0</td><td>@000000000070071e4-0000050e</td><td>ab=00000000000000000</td><td></td><td></td><td></td><td></td></tr><tr><td>3</td><td>2605586055</td><td>ipipe:0</td><td>@000000000070071e6-0000995b6</td><td>ab=000000000070c0e40</td><td></td><td></td><td></td><td></td></tr><tr><td>2</td><td>2608391083</td><td>ipipe:0</td><td>@000000000070071e8-00000e10c</td><td>zero=00000000000000000</td><td></td><td></td><td></td><td></td></tr><tr><td>1</td><td>2608391083</td><td>ipipe:0</td><td>@000000000070071ea-000008082</td><td>zero=00000000000000000</td><td>populate_stack_var 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a4, 0x802 add a2, a2, a4 add a2, a2, a4 lw a3, 0x0(a2) sbllw a1, s0, a1 or a1, a1, a3 sw a1, 0x0(a2) auipc a1, 0xb6 ld a1, 0x44(a1) jalr a1 bnez s1, 0x70072c0 <_init+0xc6> auipc a0, 0xb6 ld a0, 0x4b8(a0) jalr a0 auipc a0, 0xb6 ld a0, 0x4b6(a0) jalr a0 auipc a0, 0xb6 ld a0, 0x478(a0) sw s0, 0x0(a0) auipc a0, 0xb6 ld a0, 0x476(a0) jalr a0 auipc a0, 0xb6 ld a0, 0x49c(a0) jalr a0 auipc a1, 0xb6 ld a1, 0x49a(a1) jalr a1 auipc a0, 0xb6 ld a0, 0x450(a0) lw a1, 0x0(a0) beqz a1, 0x70072c8 <_init+0xcce> auipc a0, 0xb6 ld a0, 0x44(a0) jalr a0 auipc a0, 0xb6 ld a0, 0x44a(a0) jalr a0 li a0, 0x0 ret ret</pre>	
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11	2597245972	ipipe:0	@000000000070071ce-00000585	al=00000000000000001																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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9	2600066000	ipipe:0	@000000000070071d4-51863603	a2=000000000070c10a8																																																																																																																																																																																																																																																																																																																																																																																																																																																	
8	2602796027	ipipe:0	@000000000070071d8-000b6697	a3=000000000070bd1d8																																																																																																																																																																																																																																																																																																																																																																																																																																																	
7	2602856028	ipipe:0	@000000000070071dc-5186b683	a3=000000000070c1400																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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2	2613971139	ipipe:0	@000000000070072b0-49c53503	ab=000000000070c10c8																																																																																																																																																																																																																																																																																																																																																																																																																																																	
2	2616596165	ipipe:0	@000000000070072b4-00009502	ra=000000000070072b6																																																																																																																																																																																																																																																																																																																																																																																																																																																	
3	2619536195	ipipe:0	@000000000070b64ca-00004501	ab=00000000000000000	main																																																																																																																																																																																																																																																																																																																																																																																																																																																
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5	2625116251	ipipe:0	@000000000070072b6-000b6597	al=000000000070bd2b6																																																																																																																																																																																																																																																																																																																																																																																																																																																	
6	2625176251	ipipe:0	@000000000070072ba-49a5b583	al=000000000070c10d0																																																																																																																																																																																																																																																																																																																																																																																																																																																	
7	2627771277	ipipe:0	@000000000070072be-00009582	ra=000000000070072c0																																																																																																																																																																																																																																																																																																																																																																																																																																																	
8	2630696306	ipipe:0	@000000000070b64cc-00001101	sp=000000000070e1840	exit																																																																																																																																																																																																																																																																																																																																																																																																																																																
9	2630756307	ipipe:0	@000000000070b64ce-00000e06	zero=00000000000000000																																																																																																																																																																																																																																																																																																																																																																																																																																																	
10	2633516335	ipipe:0	@000000000070b64d0-00000822	zero=00000000000000000																																																																																																																																																																																																																																																																																																																																																																																																																																																	
11	2633516335	ipipe:0	@000000000070b64d2-00000e426	zero=00000000000000000																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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13	2636246362	ipipe:0	@000000000070b64d6-00000b517	ab=000000000070c14d6																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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15	2636306363	ipipe:0	@000000000070b64de-00000450d	ab=00000000000000000																																																																																																																																																																																																																																																																																																																																																																																																																																																	
16	2639036390	ipipe:0	@000000000070b64e0-000004585	al=00000000000000001																																																																																																																																																																																																																																																																																																																																																																																																																																																	
17	2641886418	ipipe:0	@000000000070b64e2-000009482	ra=000000000070b64e4																																																																																																																																																																																																																																																																																																																																																																																																																																																	
18	2647316473	ipipe:0	@000000000070b6678-00001141	sp=000000000070e1830	gpioSetDirection																																																																																																																																																																																																																																																																																																																																																																																																																																																
19	2647376473	ipipe:0	@000000000070b667c-000004641	zero=00000000000000000																																																																																																																																																																																																																																																																																																																																																																																																																																																	
20	2647376473	ipipe:0	@000000000070b667e-000004641	a2=00000000000000010																																																																																																																																																																																																																																																																																																																																																																																																																																																	
21	2650091500	ipipe:0	@000000000070b667e-02c57263	zero=00000000000000000																																																																																																																																																																																																																																																																																																																																																																																																																																																	
22	2650091500	ipipe:0	@000000000070b6682-03030637	a2=00000000003030000																																																																																																																																																																																																																																																																																																																																																																																																																																																	
23	2650151501	ipipe:0	@000000000070b6686-00004254	a3=000000000070c1100																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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Conclusion

Key take-aways

- Emulation: top-level crossroad
 - Factorize tools, code and effort
 - Sim/emu, verif/bringup, FW/DV
 - Work with multiple departments
 - Efficiency > politics
 - FW and DV relationship is critical
 - Make it user friendly
 - releases, run scripts
 - Arch, FW, application SW, DFT
- Our successful choices
 - Leverage CI and Cloud: builds, coverage
 - Know when to rely on EDA tools, when to code it yourself
 - Simulation: close to emulation, complements emulation
 - The right trade-offs: efficiency > realism



Conclusion

- Emulation is now our main top-level DV platform
 - Metis: bringup functional test in 1 day
 - New projects: more users, more complexity





Thank You!

