Simulating multi-node 32-bit and 64-bit RISC-V Linux and Zephyr systems with Renode

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ANTMICRO

• founded 2009, developing Renode since 2010
• Platinum Founding member of RISC-V Foundation, maintaining RISC-V in Zephyr
• turning ideas into **software-driven** products
• autonomous systems: drones, mining, military, robotics, industrial automation, IoT
ANTMICRO AND RISC-V

- Proof of Concepts (PoC), demonstrators, prototyping, hardware
- Early software adoption (e.g. OS porting, building BSPs, build systems, device management)
- New software development and testing methodologies using Renode
- Custom FPGA blocks, adaptations, processing systems (especially in FPGA SoC)
ANTMICRO’S METHOD

- software-driven
- **high adoption of open source (use, create, support)**
- work with wide variety of systems, look for common denominators
Your IoT product development with Renode™:

GET STARTED
Renode in short

- open source Instruction Set Simulator (ISS) with a multi-layered framework on top
- software agnostic
- “board” emulator - mimic entire platforms
- run multiple nodes
- scriptable, API-oriented
- cores in C
- rest, including peripheral models, in C#, Python or any .NET-compatible language
Renode’s strengths

• full determinism of execution, shared virtual time
• transparent & robust debugging, tracing, analysis, even in multi-node setups
• easy integration with your everyday tools, plugins
• rich model abstractions with additional functionality ‘for free’ + modular platform description format
• automated tests and CI integrations, other collaboration features
Platform description format

- human readable
- modular
- extendible

uart: UART.MiV_CoreUART @ sysbus 0x70001000
clockFrequency: 66000000

cpu: CPU.RiscV @ sysbus
cpuType: "rv32g"

plic: Interrupts.PlatformLevelInterruptController @ sysbus 0x40000000
  IRQ -> cpu@1
  numberOfSources: 31 //based on release notes
Renode Unleashed

• 64-bit is 2x the fun
Renode Unleashed

- 64-bit is 2x the fun
- two 64-bit platforms is 4x?
Renode Unleashed!

- 64-bit is 2x the fun
- two 64-bit platforms is 4x?
- two 64-bit and two types of 32-bit, two each, running two OSs -> ???x
Wireless medium

• capability to simulate entire networks of wireless (and wired) devices in one time domain
• possible to introduce loss functions, disturbances
• can stop all nodes at the same time and debug protocols
• easily integrate with popular tools e.g. Wireshark
Environment simulation

- concept of shared environment
- possibility to simulate sensors and feed constant or changing input values
- test corner cases and dynamic conditions
It Works!

Temperature: 37.000
**Test-driven system development**

- Robot interface for writing tests
- direct API access also there when needed
- extensive introspection, logging, debugging, tracing and hooks available
- integration with GitLab CI, Jenkins, Buildbot...
Execute Command: sysbus gpioInputs.user_switch_1 Toggle
Test IF Uart Is Idle: 5
Should Generate Interrupts On Gpio Both Edges: 5
Create Machine: riskv-interrupt-blinky-gpio_interrups-edge_both.elf-s_134020-d90257b75
Start Emulation
Wait For Line on Uart: CoreTimer and external Interrupt Example.
Wait For Line on Uart: Observe the LEDs blinking on the board. The LED patterns changes every second.
Execute Command: sysbus gpioInputs.user_switch_0 Toggle
Wait For Line on Uart: GPI01
Execute Command: sysbus gpioInputs.user_switch_0 Toggle
Wait For Line on Uart: GPI01
Execute Command: sysbus gpioInputs.user_switch_1 Toggle
MLV.robot

Test Suite Test Log

Test Statistics

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Pass</th>
<th>Fail</th>
<th>Elapsed</th>
<th>Pass / Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical Tests</td>
<td>9</td>
<td>9</td>
<td>0</td>
<td>0.01:08</td>
<td>Pass / Fail</td>
</tr>
<tr>
<td>All Tests</td>
<td>9</td>
<td>9</td>
<td>0</td>
<td>0.01:08</td>
<td>Pass / Fail</td>
</tr>
</tbody>
</table>

Test Execution Log

Full Name: Test Suite
HotSpot Action: .
Source: /home/antmicro/renode-hq-master/renode/tests/platforms/MLV/MLV.robot
Start / End / Elapsed: 2018/04/20 14:10:02.710 / 2018/04/20 14:10:19.109 / 0:00:06.397
Status: 9 critical tests, 9 passed, 0 failed

- Should Blink Led Using Gpio Rising Edge: PASS
- Should Blink Led Using Gpio Falling Edge: PASS
- Should Blink Led Using Gpio Both Edges: PASS
- Should Generate Interrupts On Gpio High Level: PASS
- Should Generate Interrupts On Gpio Both Edges: PASS
- Should Generate Interrupts On Gpio Low Level: PASS
- Should Generate Interrupts On Gpio Both Edges: PASS
- Should Generate Interrupts On Gpio Rising Edge: PASS
- Should Generate Interrupts On Gpio Falling Edge: PASS
- Should Generate Interrupts On Gpio Both Edges: PASS
- Should Generate Interrupts On Gpio High Level: PASS
- Should Generate Interrupts On Gpio Both Edges: PASS
Collaboration tools

• take your work everywhere
• send your setup to your colleague
• share it in a repository
• freeze entire system in a problematic state
RENODE

Renode, version 1.3.0.24449 (8fbb6f2c-281804301213)

(sifive_FE310) (monitor) $ @scripts/single-node/sifive_FE310.resc
(sifive_FE310) (monitor) Load @fe310-save
(sifive_FE310) (monitor) mach set @
(sifive_FE310) showAnalyzer sysbus.uart0
(sifive_FE310) (monitor) Save @fe310-save
(sifive_FE310) (monitor)

SiFive- FE310: sysbus.uart0

++++ Booting Zephyr OS v1.10.0-rc1 ++++
shell> select kernel
kernel > cycles
cycles: 69768330 hw cycles
kernel > cycles
cycles: 69768330 hw cycles
kernel > cycles

SiFive- FE310: sysbus.uart0

++++ Booting Zephyr OS v1.10.0-rc1 ++++
shell> select kernel
kernel > cycles
cycles: 69768330 hw cycles
kernel > cycles

14:34:09.4256 [WARNING] gpioInputs: Unhandled write to offset 0x0, value 0x0.
14:34:09.4256 [WARNING] gpioInputs: Unhandled write to offset 0x9, value 0x0.
14:34:09.4256 [WARNING] gpioInputs: Unhandled write to offset 0x10, value 0x0.
14:34:09.4256 [WARNING] gpioInputs: Unhandled write to offset 0x19, value 0x0.
14:34:09.4256 [WARNING] gpioInputs: Unhandled write to offset 0x20, value 0x0.
14:34:09.4256 [WARNING] gpioInputs: Unhandled write to offset 0x29, value 0x0.
14:34:09.4256 [WARNING] gpioInputs: Unhandled write to offset 0x30, value 0x0.
14:34:09.4256 [WARNING] gpioInputs: Unhandled write to offset 0x39, value 0x0.
14:34:09.4256 [WARNING] gpioInputs: Unhandled write to offset 0x40, value 0x0.
Security

• testing real implementations in realistic conditions and teamwork between stakeholders are key to security
• we can assert some level of security at the chip level - Renode is being used for that too - but ultimately security is also a matter of implementation
Multi-node security
Interested? Talk to us if:

- you want to adopt a software-driven point of view and methodology - and RISC-V!
- you want to be ready for multi-node, test-driven development and building secure systems
- you’d like to get your RISC-V hardware simulated and customers enabled with tooling
THANK YOU
FOR YOUR ATTENTION!