# Industrial hardware and QEMU

*LinuxCon Europe 2012, Barcelona*
*Alberto Garcia <agarcia@igalia.com>*

## Introduction

## About me

**Who am I?**

- Alberto Garcia
  - Computer engineer, Coruña University
  - Working at Igalia since 2001
  - Experience in operating systems
  - Debian maintainer
  - Involved in Maemo and MeeGo

## This talk

**How to make the development of device drivers easier:**

- Debug problems that are hard to reproduce
- Foresee points of failure
- Industrial hardware as an example
- Useful for any kind of hardware

## Industrial hardware

## Industrial hardware

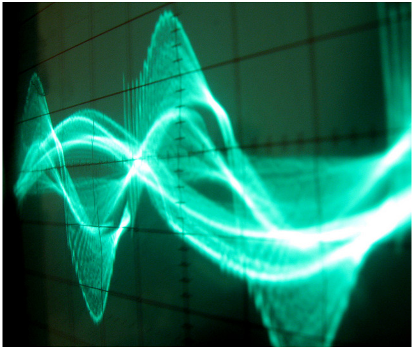
- Used by:
  - Companies: factories, shipyards, robotics, ...
  - Research laboratories
  - Universities

## Typical features

- Simple
- Reliable
- Well-tested technology
- Expensive / hard to find
- Hard to replace
- Sometimes designed ad-hoc

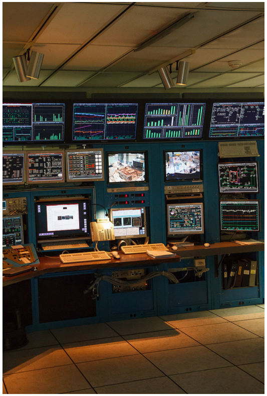
## Types of industrial hardware

- ADCs, DACs
- Waveform Generators
- Time to digital converters
- Communications: serial ports, fieldbus



## What it is used for

- Actuators
- Sensors
- Control systems



## Examples

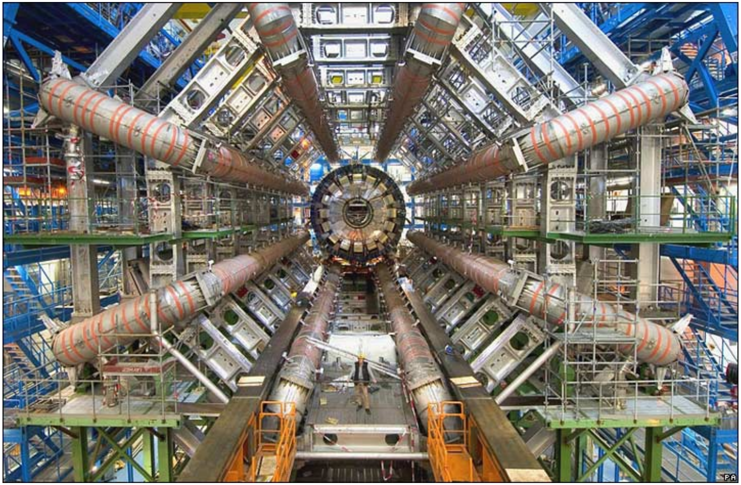
Struck SIS3320-250 8 channel ADC

## Challenges

## Challenges of developing for this hardware

- Limited availability
- Bugs in the production environment cannot be reproduced in the laboratory
- Difficult to debug on-site
  - Narrow time windows
  - Dangerous environment

## Challenges of developing for this hardware



## Debugging

- Is it a problem in the driver or in the device?
- Is the firmware faulty? Is it wrongly loaded?
- Is the hardware damaged?
- How can we reproduce the bug?
- Do we have easy access to the environment?
- Is it remotely located?

## Using virtualization to make things easier

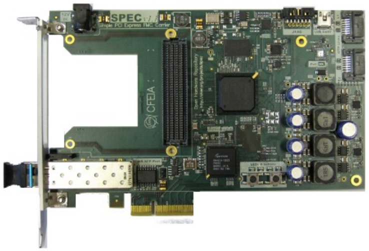
## QEMU

- Machine emulator and virtualizer
- Supports multiple architectures
- Can be accelerated using KVM
- Free software
- Flexible

## How QEMU can help us

- We can emulate the device we're working with
- Even if the hardware doesn't exist yet!
- Useful not just for software:
    - Develop hardware and its driver in parallel
- Simulate hard to reproduce conditions
    - Force hardware errors or other uncommon situations
    - Foresee potential points of failure
    - Make the driver more reliable

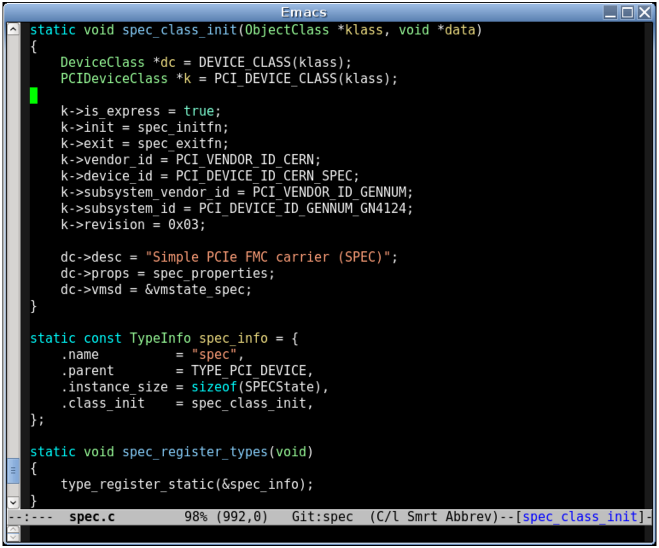
## Hardware we've worked with



Simple PCIe FMC Carrier
(SPEC)

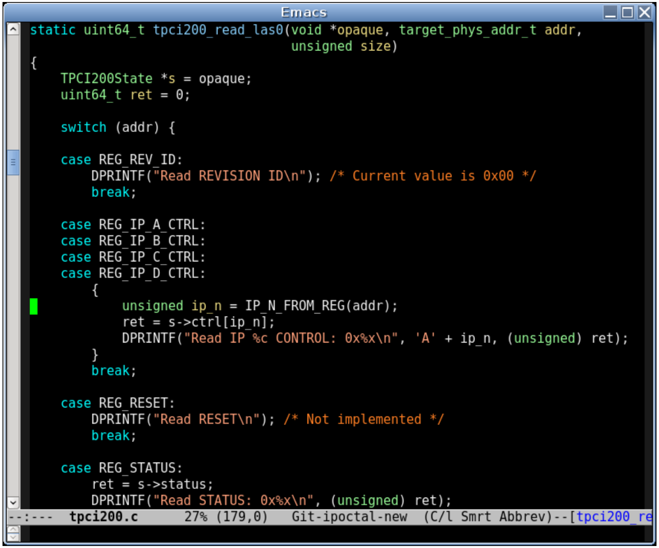
FMC Time to Digital Converter

# How to create new devices in QEMU



```
static void spec_class_init(ObjectClass *klass, void *data)
{
    DeviceClass *dc = DEVICE_CLASS(klass);
    PCIDeviceClass *k = PCI_DEVICE_CLASS(klass);

    k->is_express = true;
    k->init = spec_initfn;
    k->exit = spec_exitfn;
    k->vendor_id = PCI_VENDOR_ID_CERN;
    k->device_id = PCI_DEVICE_ID_CERN_SPEC;
    k->subsystem_vendor_id = PCI_VENDOR_ID_GENNUM;
    k->subsystem_id = PCI_DEVICE_ID_GENNUM_GN4124;
    k->revision = 0x03;

    dc->desc = "Simple PCIe FMC carrier (SPEC)";
    dc->props = spec_properties;
    dc->vmsd = &vmstate_spec;
}

static const TypeInfo spec_info = {
    .name          = "spec",
    .parent        = TYPE_PCI_DEVICE,
    .instance_size = sizeof(SPECState),
    .class_init    = spec_class_init,
};

static void spec_register_types(void)
{
    type_register_static(&spec_info);
}
--:---  spec.c         98% (992,0)   Git:spec   (C/l Smrt Abbrev)--[spec_class_init]-
```

# Emulating the device



```
static uint64_t tpci200_read_las0(void *opaque, target_phys_addr_t addr,
                                  unsigned size)
{
    TPCI200State *s = opaque;
    uint64_t ret = 0;

    switch (addr) {

    case REG_REV_ID:
        DPRINTF("Read REVISION ID\n"); /* Current value is 0x00 */
        break;

    case REG_IP_A_CTRL:
    case REG_IP_B_CTRL:
    case REG_IP_C_CTRL:
    case REG_IP_D_CTRL:
        {
            unsigned ip_n = IP_N_FROM_REG(addr);
            ret = s->ctrl[ip_n];
            DPRINTF("Read IP %c CONTROL: 0x%x\n", 'A' + ip_n, (unsigned) ret);
        }
        break;

    case REG_RESET:
        DPRINTF("Read RESET\n"); /* Not implemented */
        break;

    case REG_STATUS:
        ret = s->status;
        DPRINTF("Read STATUS: 0x%x\n", (unsigned) ret);
--:---  tpci200.c      27% (179,0)   Git-ipoctal-new   (C/l Smrt Abbrev)--[tpci200_re
```

## Testing our drivers

## Tests

- Create a set of tests for the device
- Tests can “talk” to QEMU and inject errors or force other conditions
- Detect problems before the changes are put into production

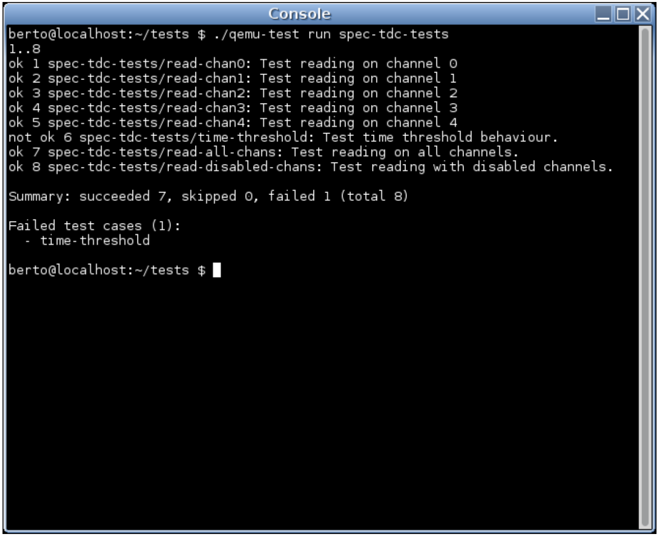
## Test environment

- Framework written in python
- Simple process:
  - The virtual machine is started
  - The test environment is set up
  - Tests are run
  - The results are compared with the expected values

## Unattended testing

- Run QEMU without user interaction
- No display necessary
- Select the kernel that you want to boot
- Log all messages, compare them against expected values
- Easily share files between both sides
- Detect when the system crashes

## Running the tests



```
berto@localhost:~/tests $ ./qemu-test run spec-tdc-tests
1..8
ok 1 spec-tdc-tests/read-chan0: Test reading on channel 0
ok 2 spec-tdc-tests/read-chan1: Test reading on channel 1
ok 3 spec-tdc-tests/read-chan2: Test reading on channel 2
ok 4 spec-tdc-tests/read-chan3: Test reading on channel 3
ok 5 spec-tdc-tests/read-chan4: Test reading on channel 4
not ok 6 spec-tdc-tests/time-threshold: Test time threshold behaviour.
ok 7 spec-tdc-tests/read-all-chans: Test reading on all channels.
ok 8 spec-tdc-tests/read-disabled-chans: Test reading with disabled channels.

Summary: succeeded 7, skipped 0, failed 1 (total 8)

Failed test cases (1):
  - time-threshold

berto@localhost:~/tests $
```

igalia

## Continuous integration

- We can run tests automatically when the driver is updated
- Also if the hardware specs change
- Detect regressions more easily

## Conclusions

## Overall benefits

- No need to have the actual hardware
- You can also help the development of the hardware
  - Hardware and software can be developed in parallel
- Distributed teams
- More stable drivers
- Test changes before they are deployed
  - Faster development
- Continuous integration
- Contribute to QEMU

## Questions & Answers

## Thank you!

## Images used in this presentation

- http://www.flickr.com/photos/9197427@N06/2885827751
- http://www.flickr.com/photos/twosevenoneoneninneeightthreesevenatenzerosix/7848902444/
- http://www.flickr.com/photos/altemark/273968506/
- http://www.flickr.com/photos/11304375@N07/2046228644/
- http://www.ohwr.org/projects/spec/wiki
- http://www.ohwr.org/projects/fmc-tdc/wiki