QOM Vadis?

Taking Objects To The CPU And Beyond

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About Me

Introducing The Presenter

- QEMU contributor and maintainer for Cocoa, PReP, stable-0.15, QOM-CPU
- Working on KVM at SUSE
  - Level 3 support & feature development for SLE customers
  - Maintenance of SLE and openSUSE qemu package
- Studying Software Eng. for Embedded Systems
  - Aiming for a thesis on virtual development environments

Quo Vadis?

Outline Of This Presentation

- Introduction to QOM
- Remodeling the CPU with QOM
- Next steps

Introduction To QOM

QEMU

Conceptual Overview Of Device Emulation

- CPU-centric emulation!
- How: instructions (TCG only), PIO, MMIO
- Relevant: software-visible (black-box) behavior
- Irrelevant: simulation of inner workings / firmware
- QOM (formerly qdev) used for device encapsulation, reuse and parameterization

QEMU Object Model

QOM Terminology

- Type
  - Defines class
- Class
  - Stores static data & virtual method pointers
  - Lazily initialized from type and, optionally, static data
- Object
  - Stores dynamic data (“chunk of allocated memory”)
- Property
  - Accessor to dynamic object data
  - Inspectable via monitor interface

A Simple Object Example

Declaration

```
static const TypeInfo example_type_info = {
    .name = "example",
    .parent = TYPE_OBJECT,
};

static void example_register_types(void) {
    type_register_static(&example_type_info);
}

type_init(example_register_types)
```

A Simple Object Example

Usage

- Add entry to Makefile.objs
- Instantiation
  - Object *obj = object_new("example");
- Finalization:
  - object_delete(obj);
- Note: More fine-grained control over lifetime and memory is available.

QOM Hooks

When What is Run

- type_init(): early during startup
- TypeInfo::class_init: when class is first created
  - object_new() / object_initialize()
  - object_class_foreach()
- TypeInfo::instance_init: for each instance created
  - object_new() / object_initialize()
- TypeInfo::instance_finalize: cleanup per instance
  - object_delete() / object_finalize()

qdev

Device Modeling Before And After QOM

- Forest of busses: PCI, ISA, … fallback: “SysBus”
- Two-stage construction via properties
- Hasn't changed … much
  - device_init() → type_init()
  - TypeInfo, .class_init
  - new type handling macros
- Possible to write a dummy device in < 10 minutes!
- Unit tests via qtest framework (some constraints!)

A Simple SysBusDevice Example

Declaration

```
#define TYPE_EXAMPLE = "example"

typedef struct ExampleState {
    SysBusDevice parent;
    MemoryRegion iomem;
} ExampleState;

static const TypeInfo example_type_info = {
    .name = TYPE_EXAMPLE,
    .parent = TYPE_SYS_BUS_DEVICE,
    .instance_size = sizeof(ExampleState),
    .class_init = example_class_init,
};

static void example_register_types(void) {
    type_register_static(&example_type_info);
}

type_init(example_register_types)
```

A Simple SysBusDevice Example

Implementation

```
#define EXAMPLE_STATE(obj) \
    OBJECT_CHECK(ExampleState, (obj), TYPE_EXAMPLE)

static void example_device_init(SysBusDevice *dev) {
    ExampleState *s = EXAMPLE_STATE(dev);
    memory_region_init_io(&s->iomem, …);
    sysbus_init_mmio(dev, &s->iomem);
}

static void example_class_init(ObjectClass *oc, void *data) {
    SysBusDeviceClass *sdc = SYS_BUS_DEVICE_CLASS(oc);
    sdc->init = example_class_initfn,
}
```

A Simple SysBusDevice Example

Usage

- Add entry to Makefile.objs
- Instantiation
  - DeviceState *dev = qdev_create("example");
- Realization:
  - qdev_init_nofail(dev);
- Note: Today these are mostly wrapping QOM functions and can be inlined for QOM migration.

QOM Conventions

Which Examples To Follow (1/3)

- DO use TYPE_FOO constants defined in a header
- DO use verbose macro names
- DO use names-separated-by-dashes
- DON'T duplicate literal string type names

- #define TYPE_EXAMPLE "example"
- .name = TYPE_EXAMPLE,
- object_new(TYPE_EXAMPLE)
- qdev_create(TYPE_EXAMPLE)

QOM Conventions

Which Examples To Follow (2/3)

- DO place parent field first
- DON'T use “busdev” or similar qdev conventions

- typedef struct MyState {
    Object parent; /* or PCIDevice parent etc. */
    uint32_t some_register_value;
  } MyState;

QOM Conventions

Which Examples To Follow (3/3)

- DO use cast macros (based on struct layout)
- DON'T rely on DO_UPCAST() (field names)
- DO use per-type variable declarations
- Avoid using cast macros other than OBJECT() inline

- ```
  void do_something_with(MyDeviceState *s) {
      PCIDevice *pci = PCI_DEVICE(s);
      pci->field = foo;
      /* not s->pci.field or PCI(s)->field */
  ```
  ```

QOM ABI
Stability Rules

- Properties are externally visible (like command line)!
- A property MAY be
  - dropped
  - renamed
- But: A property MAY NOT change its type.

Remodeling The CPU With QOM

vCPU Use Cases

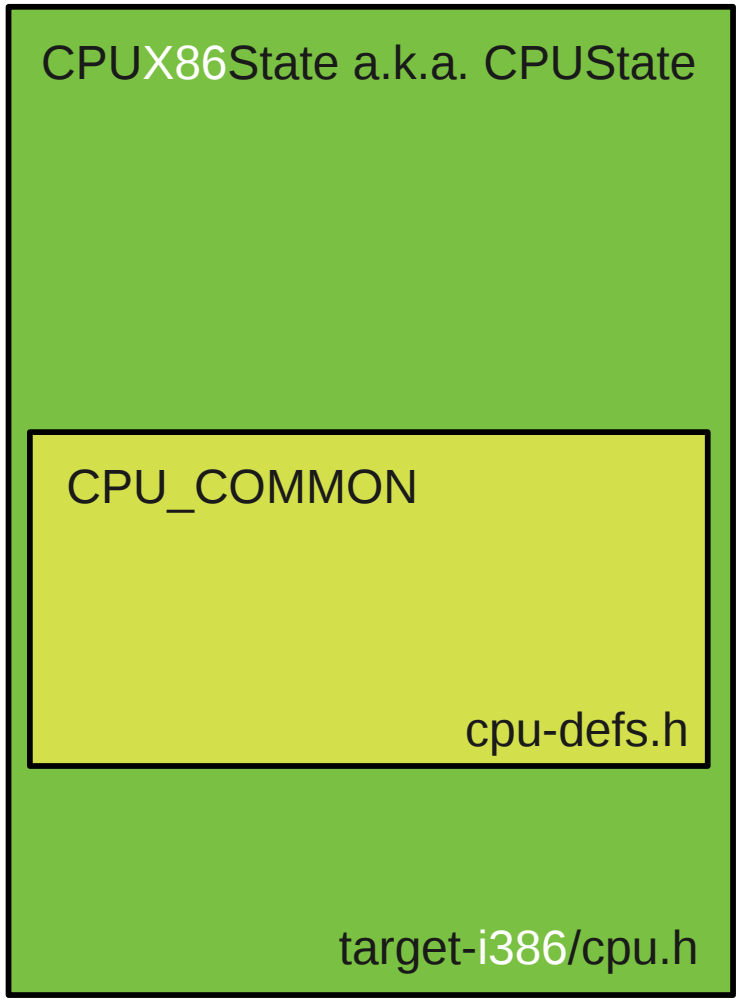
Data Center Meets System-on-a-Chip

- Homogeneous environment (largely)
- Standardized machine
- Long-running guests
  - Live migration
  - Hot-plug of resources
- Users: Sysadmins

- Highly fragmented hardware/software landscape
- “Weird” hardware is out there in the wild!
  - Heterogeneous cores
  - Kernel bring-up, drivers…
- Users: Developers

CPU State

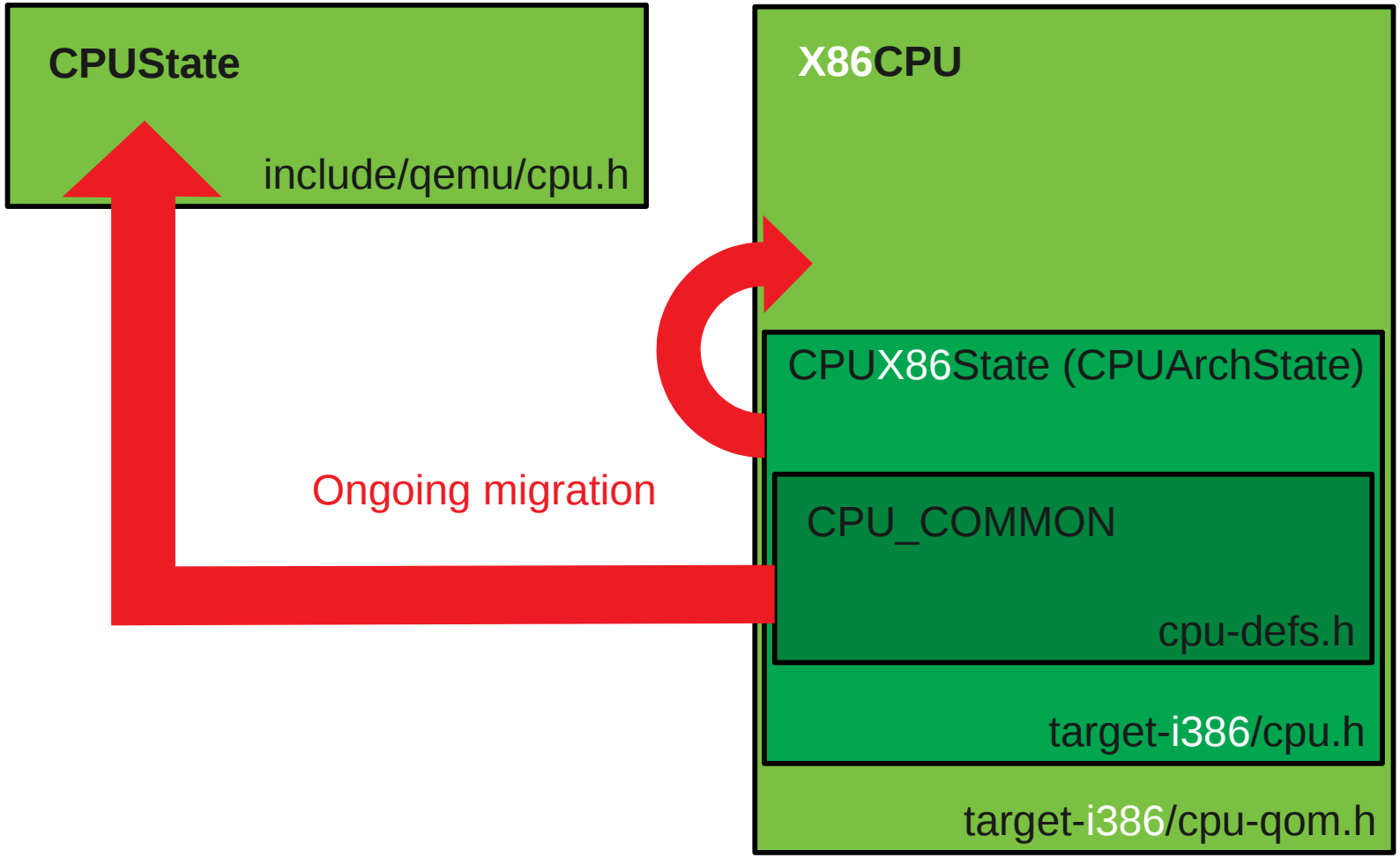
Data Layout Before QOM



Common fields at varying offset make it impossible to use different CPUxxxStates at once!

CPU State

New Data Layout With QOM



CPU State

Understanding The Migration

- CPUState can now be used in every file!
- CPUArchState is still dependent on cpu.h
- CPUArchState → CPUState: ENV_GET_CPU()
- CPUState → CPUArchState requires knowledge of CPU type (no symmetry guarantees across targets)
- First set of fields was moved to CPUState for v1.3

CPU State

API Guidelines

- New target-independent code should use CPUState
  - Series adapting kvm_arch_*() under way
- Target-specific code should use FooCPU
  - Provides easy access to both CPUFooState and new fields
- CPUArchState is usually reset by zeroing the front part
  - Pointers or persistent data needs to be in CPUFooState behind CPU_COMMON,
  - or in FooCPU – before CPUArchState if accessed by TCG

CPU subclasses

How We Create vCPUs

- Subclasses prepared per -cpu name (~90% there)
- Currently flat hierarchy of, e.g., TYPE_OBJECT → TYPE_CPU → TYPE_ARM_CPU → “cortex-a9”
- More advanced hierarchies of CPU families possible (requested for sparc)
- Goal: Get rid of cpu_init() in favor of QOM/qdev

Next Steps

Reference Counting

Solving Object Finalization Issues

- Device is unplugged – but object still referenced
  - Current solution: object_unparent()
- Drop object_delete() in favor of object_unref()?
  - Less predictable whether or when memory is freed

Realization

Two-stage Initialization For All Objects

- Idea: Generalize DeviceClass::init()
  - void realizefn(Object *obj, **Error **err**)
  - void unrealizefn(Object *obj) ?
- Provide “realized” property to inspect / set

Monitor Improvements

Extending QMP Plumbing For Handling Objects

- Today: qom-list, qom-get, qom-set
- qom-create?
  - Currently device_add requires DeviceState

Static Properties For QOM?

Generalizing qdev Properties

- Facilitate read-only-when-realized
- Facilitate getters / setters for simple value types?
- How to handle global default values?
- Suggestions and patches welcome!

Preparing For CPU Hotplug

Standardizing CPU Creation and Initialization

- Make the CPU a device
  - Add qdev support to linux-user / bsd-user for v1.3
- Properties for x86 CPU manipulation / inspection
  - Versioning of CPU models via global qdev properties?

QOM'ifying SoCs

Using QOM For Grouping Of Devices

- Early prototype: SuperH 7750
- Drafts: Tegra2
- Common pattern: one SoC on multiple boards
  - Helper function for CPU and device creation
  - Idea: Group in inspectable way using QOM Container
- Open issues:
  - How to deal with -cpu?
  - Static properties for parameterization?

Spreading QOM

Standardizing Object Creation and Initialization Elsewhere

- blockdev?
- chardev?
- netdev?

Submit your models upstream to not get left behind!

www.qemu.org

Thank you.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