Is QEMU too complex
and what can we do about it?

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Betteridge's law of headlines

"Any headline that stion mark can be an word no."

Red Hat

Is QEMU complex?

Yes

Is QEMU **too** complex?

Yes (but everything is)

Why is complexity a problem?

- More bugs (even if not security-sensitive)
- Code is harder to review
- Contributing is more difficult

Essential complexity

- What makes QEMU complex
- A property of the **problem** you are trying to solve

Essential complexity

- Guest devices (emulation, live migration)
- Management interface (monitor)
- Storage management
- Network servers (VNC, NBD)
- Portability
- Configurability

Essential complexity

- Concurrent I/O
- TLS
- Hotplug
- Stable CPU models after hardware upgrade
- Stable hardware models after VMM upgrade
- Live migration
- Boot a distribution kernel

Also essential complexity

- “Human” monitor
- “Easy” options for command line use
- Disassembler
- Multiple accelerators
- Object model + marshaling/unmarshaling
- GUI

Complexity of tools

- Both internal and external!
- Make common tasks easier vs. making debugging harder
- Examples:
  - Build system (configure+Meson vs. configure+rules.mak)
  - Configuration management (kconfig)
  - Code generation (QAPI)

Accidental complexity

- Makes QEMU too complex
- A property of the **program** that solves the problem

Fighting accidental complexity?

- Understand complexity
  - Know essential complexity
  - Know **the sources** of accidental complexity
- Keep complexity in mind when making changes
  - Use essential complexity to your advantage
  - Watch out for accidental complexity, don’t let it take over
- This is the reviewer’s job!

Signs of accidental complexity

- Incomplete transitions
  - A new way to do the same thing
  - Features supported only by a few targets/devices
- Duplicated logic
  - Missing abstractions
  - Excessive ad hoc code

A new way to do the same thing

- Error reporting (Error* vs. error_report)
- Board modeling (e.g. QOM child objects)
- Live migration (VMStateDescription vs. vmstate_register)
- QEMUTimer vs. QEMUTimer*
- Configure vs. meson

Automated conversions with Coccinelle

timer_del(mytimer); timer_free(mytimer);	timer_free(mytimer);

if (!foo(..., &err)) {
  error_propagate(errp, err);
  return;
	if (!foo(..., errp)) {
	  return;

sysbus_init_child_obj(parent, propname, \
  child, sizeof(T), type)
	sysbus_init_child_obj(parent, propname, \
	  child, sizeof(*child), type)

object_new/isa_create/pci_create qdev_init_no_fail	qdev_new/isa_new/pci_new qdev_realize/qdev_realize_and_unref/...

Incomplete support for features

- I/O error reporting (rerror/werror)
- I/O accounting (query-blockstats)
- Asynchronous I/O (block or character devices)
- No real solution, you just have to put in the work

Fear of incomplete transitions?

- Incomplete transitions are not always bad
  - ... if the new feature requires a transition period anyway
  - ... if the old API affects the command line
- Work in phases
  - Identify the smallest amount of work that is an improvement
  - Plan for what comes later
  - Incomplete transitions should not deter from improving QEMU!

Summary

- Do not be afraid of transitions—but make a plan
- Ensure good test coverage
- Learn Coccinelle

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Duplicated logic

- Missing abstractions
  - Example: dirty page handling in display emulation

```
$ git grep -w memory.*dirty hw/display

hw/display/bochs-display.c:        snap = memory_region_snapshot_and_clear_dirty(&s->vram,
hw/display/bochs-display.c:            dirty = memory_region_snapshot_get_dirty(&s->vram, snap,

hw/display/cg3.c:        snap = memory_region_snapshot_and_clear_dirty(&s->vram_mem, 0x0,
hw/display/cg3.c:            update = memory_region_snapshot_get_dirty(&s->vram_mem, snap, page,

hw/display/exynos4210_fimd.c:            snap = memory_region_snapshot_and_clear_dirty(w→mem_section.mr,
hw/display/exynos4210_fimd.c:                is_dirty = memory_region_snapshot_get_dirty(w->mem_section.mr,

hw/display/framebuffer.c:    snap = memory_region_snapshot_and_clear_dirty(mem, addr, src_width * rows,
hw/display/framebuffer.c:        dirty = memory_region_snapshot_get_dirty(mem, snap, addr, src_width);

hw/display/g364fb.c:    return memory_region_snapshot_get_dirty(&s->mem_vram, snap, page, G364_PAGE_SIZE);
hw/display/g364fb.c:    snap = memory_region_snapshot_and_clear_dirty(&s->mem_vram, 0, s->vram_size,

hw/display/macfb.c:    return memory_region_snapshot_get_dirty(&s->mem_vram, snap, addr, len);
hw/display/macfb.c:    snap = memory_region_snapshot_and_clear_dirty(&s->mem_vram, 0x0,

hw/display/sm501.c:    snap = memory_region_snapshot_and_clear_dirty(&s->local_mem_region,
hw/display/sm501.c:        update |= memory_region_snapshot_get_dirty(&s->local_mem_region, snap,

hw/display/tcx.c:    ret = memory_region_snapshot_get_dirty(&s->vram_mem, snap, addr, len);
hw/display/tcx.c:        ret |= memory_region_snapshot_get_dirty(&s->vram_mem, snap,
hw/display/tcx.c:        ret |= memory_region_snapshot_get_dirty(&s->vram_mem, snap,
hw/display/tcx.c:    snap = memory_region_snapshot_and_clear_dirty(&ts->vram_mem, 0x0,
hw/display/tcx.c:    snap = memory_region_snapshot_and_clear_dirty(&ts->vram_mem, 0x0,

hw/display/vga.c:        snap = memory_region_snapshot_and_clear_dirty(&s->vram, region_start,
hw/display/vga.c:            update = memory_region_snapshot_get_dirty(&s->vram, snap,
hw/display/vga.c:            update |= memory_region_snapshot_get_dirty(&s->vram, snap,
hw/display/vga.c:            update = memory_region_snapshot_get_dirty(&s->vram, snap,
```

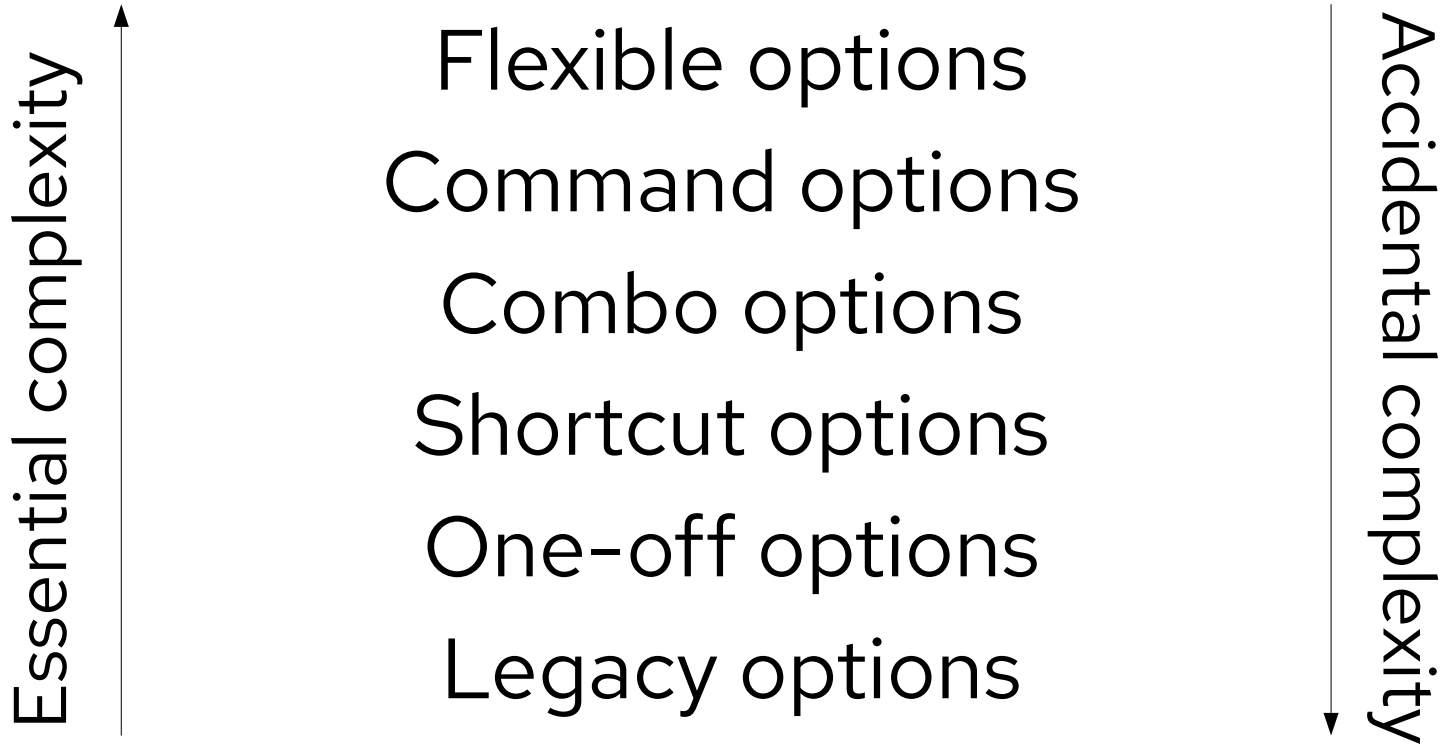
Duplicated logic

- Missing abstractions
  - Example: dirty page handling in display emulation
  - New abstractions may become incomplete transitions
- Tradeoffs: ad hoc code vs. data structures
  - Manual parsing with sscanf vs. QemuOpts/keyval
  - Scattered tables and functions vs. modinfo
- Excessive duplication requires a transition plan

Case study: command line

- 117 command line options, ~3000 lines of code
  - Essential complexity: some
  - Accidental complexity: too much
- How to not make things worse?
- How to simplify things?

Case study: command line



Flexible options

- Back-end: -accel, -blockdev, -chardev, -display, -netdev, -object
- Front-end: -cpu, -device, -machine, -mon
- Delegated via function pointers, QOM classes, etc.
  - Often no need to touch command line parsing code!
  - Main mechanism for new features
- Too many parsers: QemuOpts, keyval, JSON, bespoke

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Command options

- -S, -add-fd, -action, -loadvm, -plugin, -trace
- Small burden if 1:1 mapping to QMP
- High bar for adding new ones

Combo options

- Block device: -drive
- Character device: -serial, -monitor, -qtest, ...
- Other: -nic, -net, -virtfs
- Useful, but very high burden
- Worst modularity

Shortcut options

- -accel: -enable-kvm
- -action: -no-reboot, -no-shutdown
- -display: -sdl, -full-screen, -curses, -nographic
- -drive: -cdrom, -hdX, -pflash, -sd, ...
- -machine: -kernel, -nographic, -no-acpi, -smp, -usb,...
- Good modularity
- Smallest burden, but do not add more

One-off options

- Machine: -acpitable, -boot, -m, -option-rom, -rtc,...
- Developer: -d/-D, -L
- Environment: -msg, -name, -compat
- Backend: -spice
- Mix: -overcommit
- **Transform** if possible **into property shortcut options**
- Avoid creating new ones, prefer QMP+command options

Legacy options

- Configuration: -alt-grab, -ctrl-grab, -echr, -portrait, -rotate...
- Wannabe management: -daemonize, -pidfile, -runas, -chroot
- Failed experiments: -readconfig, -writeconfig, -no-user-config
- Deprecate/remove, or transition to shortcut options

Do not design in a void!

- Do you really need a new flag? Command-line parsing is already integrated with:
  - QOM object and properties
  - QAPI structs
  - QMP commands
- Advantage: improved modularity, all code in one place
- Exploit existing interactions between subsystems

~~There should be one obvious way to do it~~

There should be one documented way to do it

Summary

- Do not be afraid of transitions—but make a plan
- Ensure good test coverage
- Learn Coccinelle
- Evaluate tradeoffs, but don’t make things worse!
- Know essential complexity, exploit it to your advantage
- Document best practices

Thank you

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