QContext, and Supporting Multiple Event Loop Threads in QEMU

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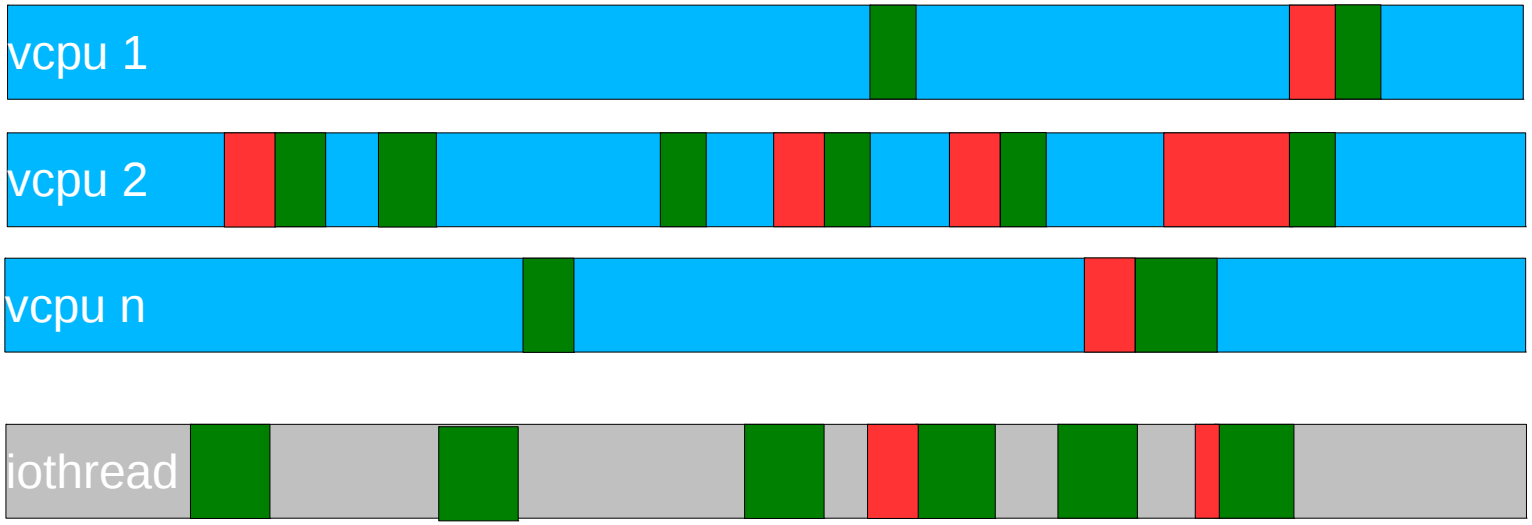
QEMU Threading Model Overview

- Historically (earlier this year), there were 2 main types of threads in QEMU:
- **vcpu threads** – handle execution of guest code, and emulation of hardware access (pio/mmio) and other trapped instructions
- **QEMU main loop (iothread)** – everything else (mostly)
  - GTK/SDL/VNC UIs
  - QMP/HMP management interfaces
  - Clock updates/timer callbacks for devices
  - device I/O on behalf of vcpus

QEMU Threading Model Overview

- All core qemu code protected by global mutex
- vcpu threads in KVM_RUN can run concurrently thanks to address space isolation, but attempt to acquire global mutex immediately after an exit
- Iothread requires global mutex whenever it's active

High contention as threads or I/O scale



QEMU Thread Types

- vcpu threads
- iothread
- **virtio-blk-dataplane thread**
  - Drives a per-device AioContext via aio_poll
  - Handles event fd callbacks for virtio-blk virtqueue notifications and linux_aio completions
  - Uses port of vhost's vring code, doesn't (currently) use core QEMU code, doesn't require global mutex
  - Will eventually re-use QEMU block layer code

QEMU Block Layer Features

- Multiple image format support
- Snapshots
- Live Block Copy
- Live Block migration
- Drive-mirroring
- Disk I/O limits
- Etc...

More dataplane in the future

- Scalable, high performance I/O with full feature support is a big win for users
- Likely to see more dataplane implementations in the future (virtio-scsi, virtio-net, NetClients?)

How do we manage these event loops?

- Ad-hoc event loop implementations?
- How to handle event assignment? 1 thread per device? What about multiqueue?
- Multiple devices per thread?
- Standard command-line syntax?
- Re-configurable at runtime?

QContext Overview

- **Object that represents an event loop**
  - **QOM-based object, can be instantiated via -object**
  - **creates it's own event loop thread**
  - **unique id that can be passed to any devices that want to offload a set of events**
- Each QContext can drive a set of event sources (AioContexts, GSources, etc)
- Can be managed/introspected via QOM properties

QContext basic usage

```
qemu -object qcontext,id=ctx1,threaded=yes \
        -device virtio-blk,x-data-plane=on,context=ctx1,...
```

```
qemu -object qcontext,id=ctx1,threaded=yes \
        -device virtio-blk,x-data-plane=on,context=ctx1,... \
        -object qcontext,id=ctx2,threaded=yes \
        -device virtio-blk,x-data-plane=on,context=ctx2,... \
        ...
```

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Consolidating dataplane threads

```
qemu -object qcontext,id=ctx1,threaded=yes \
        -device virtio-blk,x-data-plane=on,context=ctx1,... \
        -device virtio-blk,x-data-plane=on,context=ctx1,... \
        ...
```

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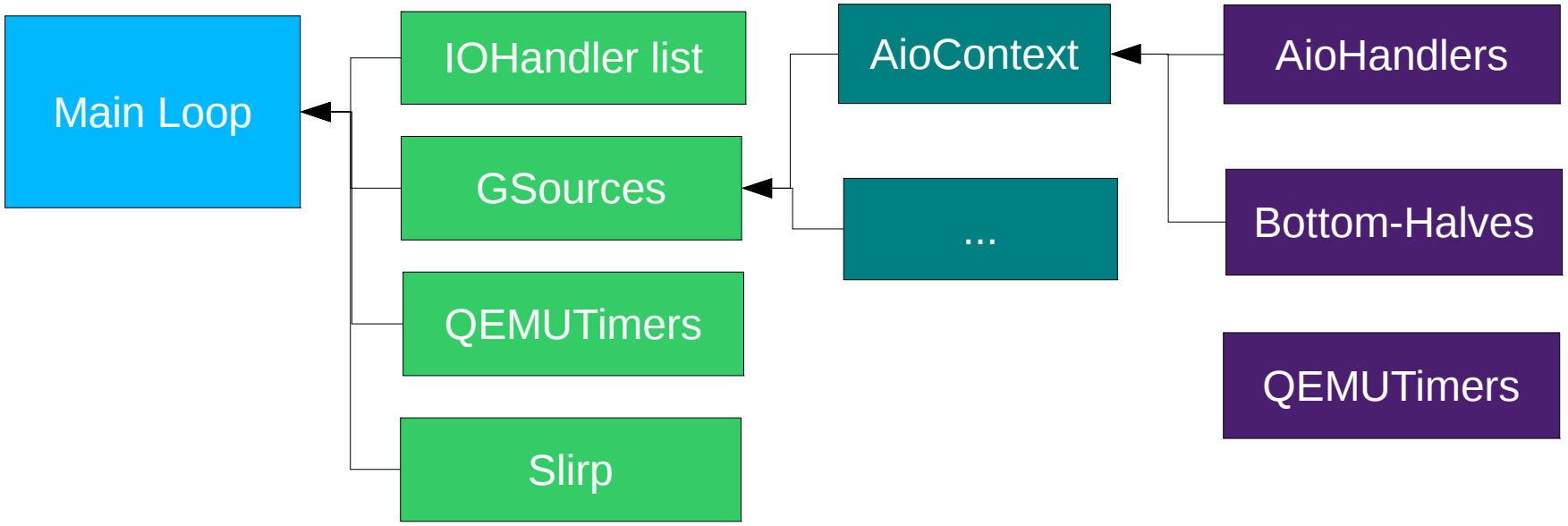
- **Can be managed/introspected via QOM properties**

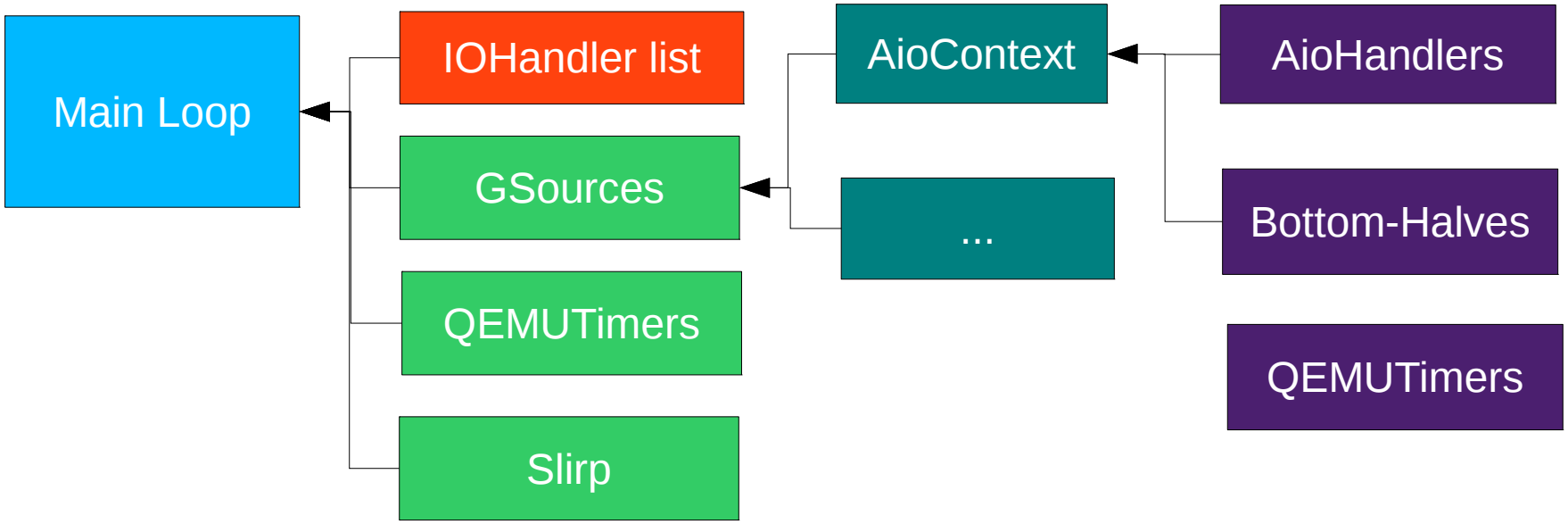
Consolidating dataplane threads

```
mdroth@loki:~$ qom-list /objects/
ctx1/
qcontext-main/
type

mdroth@loki:~$ qom-list /objects/ctx1
thread_id
threaded
id
type

mdroth@loki:~$ qom-get /objects/ctx1.thread_id
6787
```

Main Loop Event Sources



Event Registration – IOHandlers



- qemu_set_fd_handler(fd, fd_read_fn, fd_write_fn, user_data)
- qemu_set_fd_handler2(fd, read_poll_cb, read_cb, write_cb, user_data)
- **set_fd_handler2(ctx, fd, read_poll_cb, read_cb, write_cb, user_data)**
-
- **Needs to be thread-safe now (or does it?)**

Thread-safe Event Registration/Modification

```
set_fd_handler(fd, …):
  lock(iohandler_list)
  iohandler_list.modify(fd1, …)
  unlock(iohandler_list)
```

```
iohandler_dispatch:
  lock(iohandler)
  For iohandler in iohandler_list:
  dispatch(iohandler)
  → set_fd_handler(fd, ...)
  unlock(iohandler)
```

- **Just use a simple mutex!**
- Recursive mutex? No.
- g_main_context_acquire – still susceptible to ABBA deadlock
- Defer registration via bottom-halfs

Thread-safe Event Registration/Modification

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Thread-safe Event Registration/Modification

```
lock(tap_mutex)
set_fd_handler(ctx, fd, …):
  gmc_acquire(ctx)
  iohandler_list.modify(fd1, …)
  unlock(iohandler_list)
  gmc_release(ctx)
unlock(tap_mutex)
```

```
iohandler_dispatch:
  gmc_acquire(ctx)
  For iohandler in iohandler_list:
  dispatch(iohandler)
  → lock(tap_mutex)
  unlock(iohandler)
  gmc_release(ctx)
```

- Just use a simple mutex!
- Recursive mutex? No.
- **g_main_context_acquire** – still susceptible to ABBA deadlock, but can drop all locks prior to avoid lock-order reversal. Ugly.
- Defer registration via bottom-halfs

Thread-safe Event Registration/Modification

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- Recursive mutex? No.
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- **Defer registration via bottom-halfs**

Questions