INTRODUCTION BLOCK MQ IO SCHEDULER

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Overview

- BLOCK MQ Background

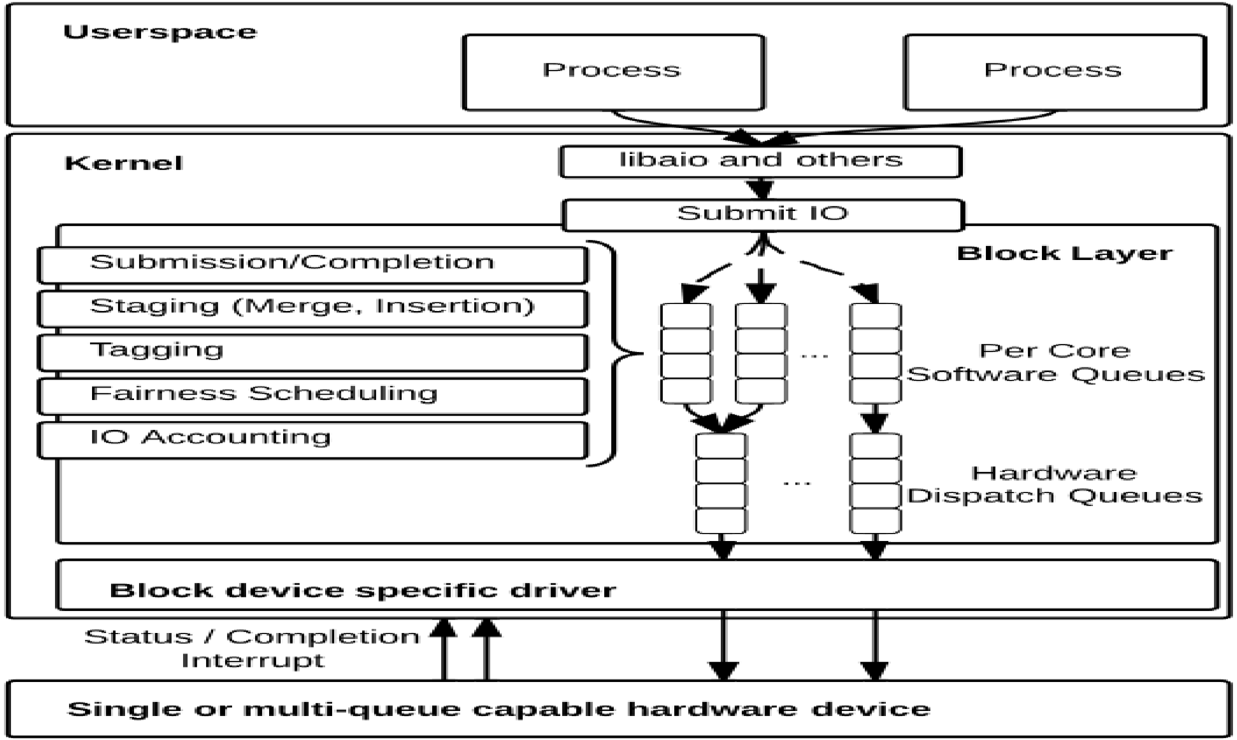
  - Introduced in V3.13

  - for better supporting new storage of NVMe

  - address scalability issue of q→queue_lock

  - initially without any IO scheduler

BLK MQ Framework

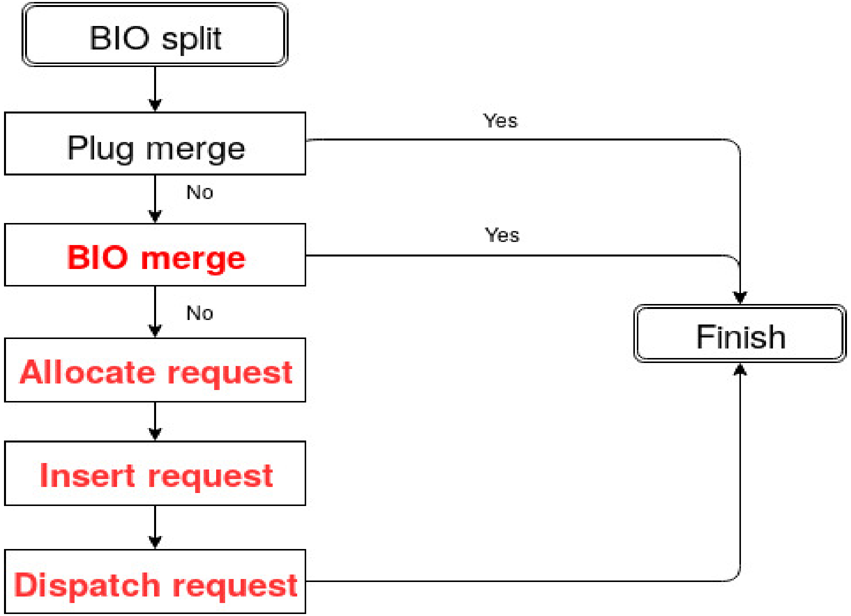


BLOCK MQ IO SCHEDULER

- BLOCK MQ IO Scheduler background
- Better support traditional Storage device
- Replace blk_queue_bio() path totally in future
- Available in V4.11, initially with mq-deadline only
- BFQ and Kyber is merged in V4.12

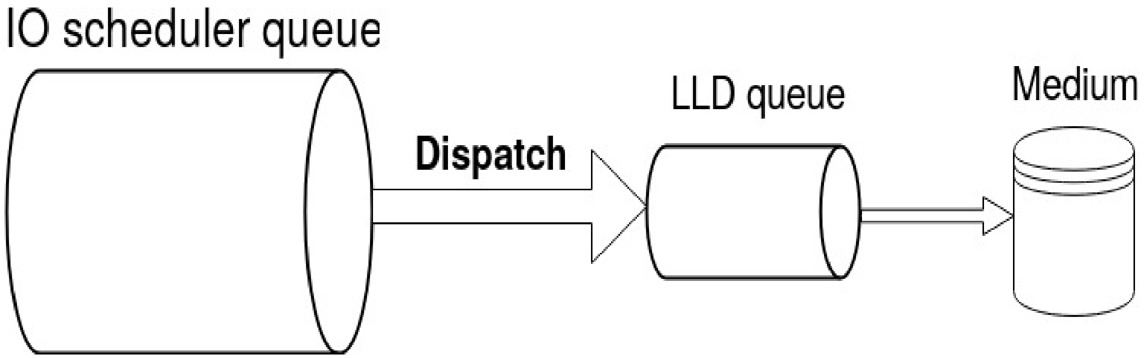
MQ IO Scheduler Framework

- BLOCK MQ IO Path(blk_mq_make_request)



MQ IO Merge Model

- IO scheduler queue Vs. LLD queue



IO Merge is possible IFF IO scheduler queue depth > LLD queue’s

MQ IO Merge Model

- IO scheduler queue depth

  - controlled via /sys/block/XXX/queue/nr_requests

  - respected via allocating request
- LLD queue depth

  - driver/device specific way to control, or not controllable

  - .queue_rq() returns BLK_STS_RESOURCE when LLD queue is full

  - LLD queue depth is highly related with storage device performance

MQ IO Merge Model

- None Scheduler

  - introduced for NVMe at the beginning

  - no scheduler queue, so IO merge is possible IFF driver has specific queue depth, such as q->queue_depth on SCSI, not possible on NVMe actually

  - IO merge is on percpu SW queue, and use simple policy, merge isn’t efficient

MQ IO Merge Model

- MQ-DEADLINE / BFQ

  - basically similar with old block

  - introduced for making MQ working well on traditional disks (such as, SCSI)

  - IO merge is good because of per-request-queue scheduler queue

  - may not scale well for high performance MQ devices, such as NVMe, SCSI FC/SRP, because of per-request-queue lock

MQ IO Merge Model

- Kyber

  - introduced for high performance devices, such as NVMe, NVMe OF

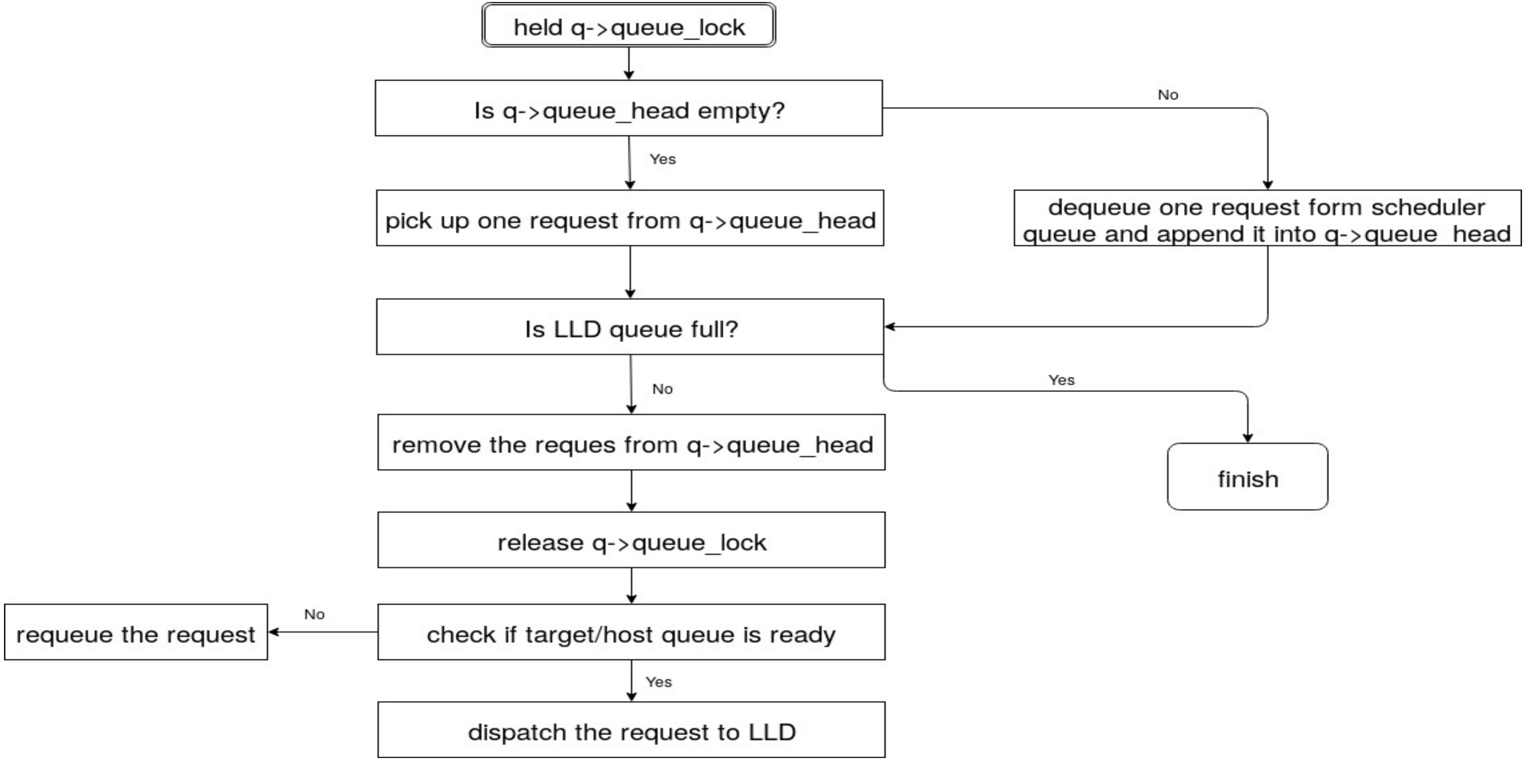
  - introduce READ, SYNC_WRITE, OTHER domains, and each

  domain has its queue depth for simulating LLD queue depth,

  - IO merge is possible because of domain queue

  - IO merge is on percpu SW queue

Block legacy IO Dispatch Model



held q->queue_lock

Is q->queue_head empty?

Yes

No

pick up one request from q->queue_head

dequeue one request form scheduler queue and append it into q->queue_head

Is LLD queue full?

No

Yes

remove the reques from q->queue_head

finish

release q->queue_lock

check if target/host queue is ready

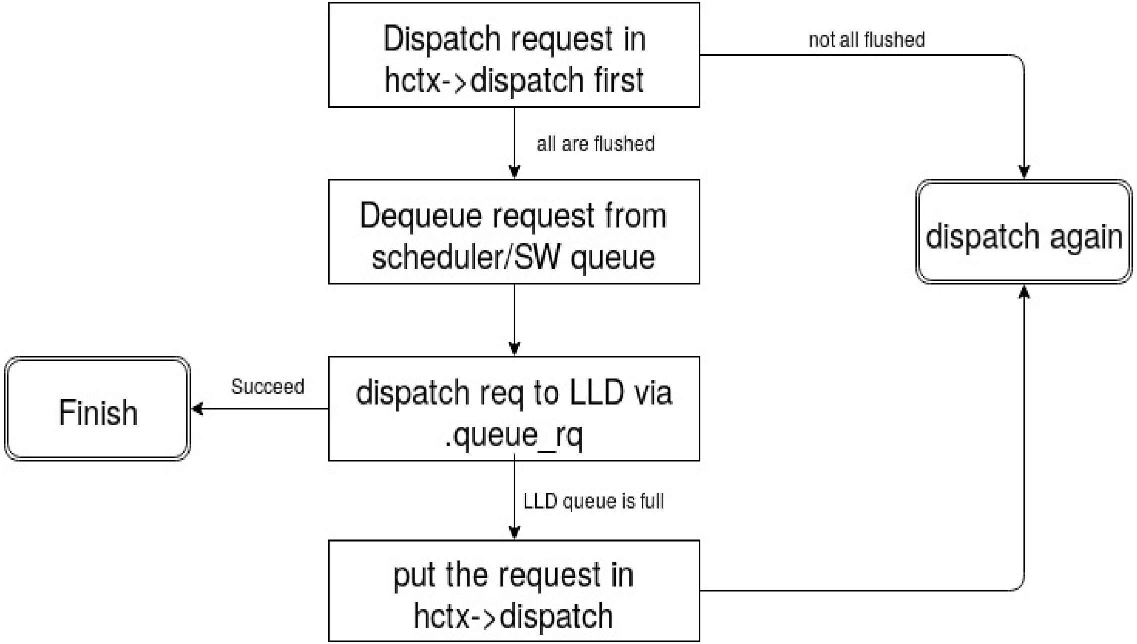
No

requeue the request

Yes

dispatch the request to LLD

MQ IO Dispatch Model


Dispatch request in hctx->dispatch first
not all flushed
all are flushed
Dequeue request from scheduler/SW queue
dispatch again
Finish
Succeed
dispatch req to LLD via .queue_rq
LLD queue is full
put the request in hctx->dispatch

MQ IO Dispatch Model

- Issues

  - hctx->dispatch can’t be dispatched one by one without holding hctx→lock; between moving hctx→disptach moved to one temp list and being flushed out, scheduler can’t be dequeued

  - q->queue_depth is often among the whole request queue, all hctx should respect this limit

MQ IO Dispatch Model

- Solutions for these issues

  - bypass hctx->dispatch totally

  - reserving budget before before dequeuing from IO scheduler queue by introducing .get_budget and .put_budget in blk_mq_ops

  - will be merged to V4.15 if everything is fine

  - better than legacy path in theory without holding per-queue lock

Performance data

- mq-deadline(fio, libaio, direct, bs=4k, queue_depth=64, jobs=64, disk=SRP/IB, V4.14-rc4)

```
---------------------------------------------------------------------------------
             |  V4.14-rc4     | V4.14-rc4          | patched V4.14-rc4
IOPS(K)  |  DEADLINE   |MQ-DEADLINE  |MQ-DEADLINE
---------------------------------------------------------------------------------
read         |      450.0       |      154.12          |      474.0
---------------------------------------------------------------------------------
write        |     419.65     |      135.88          |      481.89
----------------------------------------------------------------------------------
```

Next Step of MQ IO scheduler

- Improving on Kyber

  - pre-defined/hard coded domain depth

  - hard coded latency

  - domain queue depth adjust approach

  - very young

- SSD friendly IO schedule

Next Step of MQ IO scheduler

- One big challenge

  - need to provide excellent support on modern high performance storage, such as NVMe, NVMe OF

  - meantime not cause performance regression on traditional storage, such as SCSI redhat.

THANK YOU