XRootD Real-time Streaming Checksums

Atlas S&C Week #84

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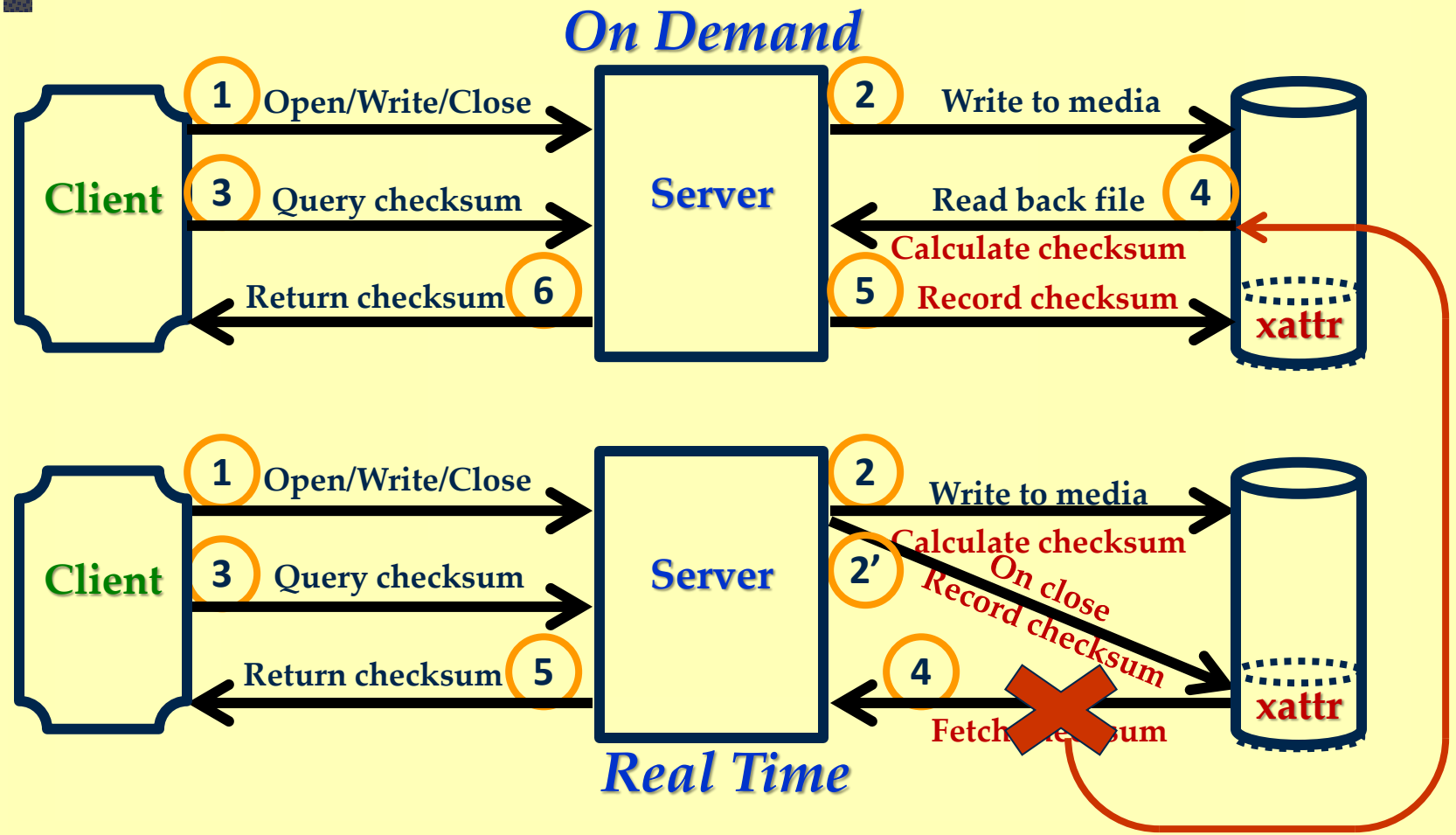
On Demand vs. Real Time



Out of order writes

- Multi-streaming undermines write order
  - Stream I/O is asynchronous
    - This is true for the client as well as the server
  - Not an issue for on demand checksums
- Real time checksums handle write order
  - This is occurs for any kind of checksum
    - However, efficiency is checksum dependent
    - High efficiency for combinable checksums
      - I.E. cs_1[data1] *combine* cs_2[data2] = cs_3[data1||data2]
      - Polynomial CRC's and adler32

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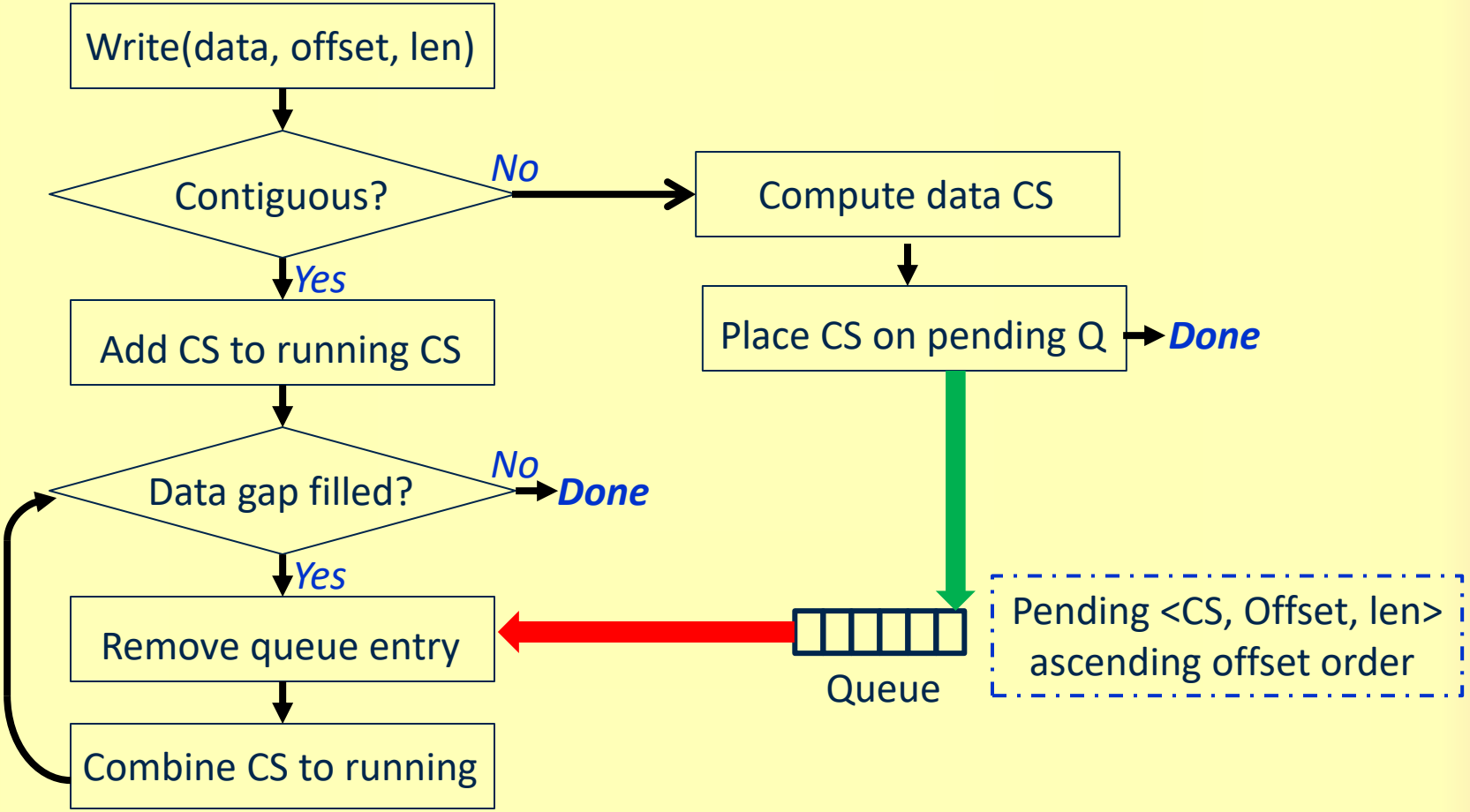
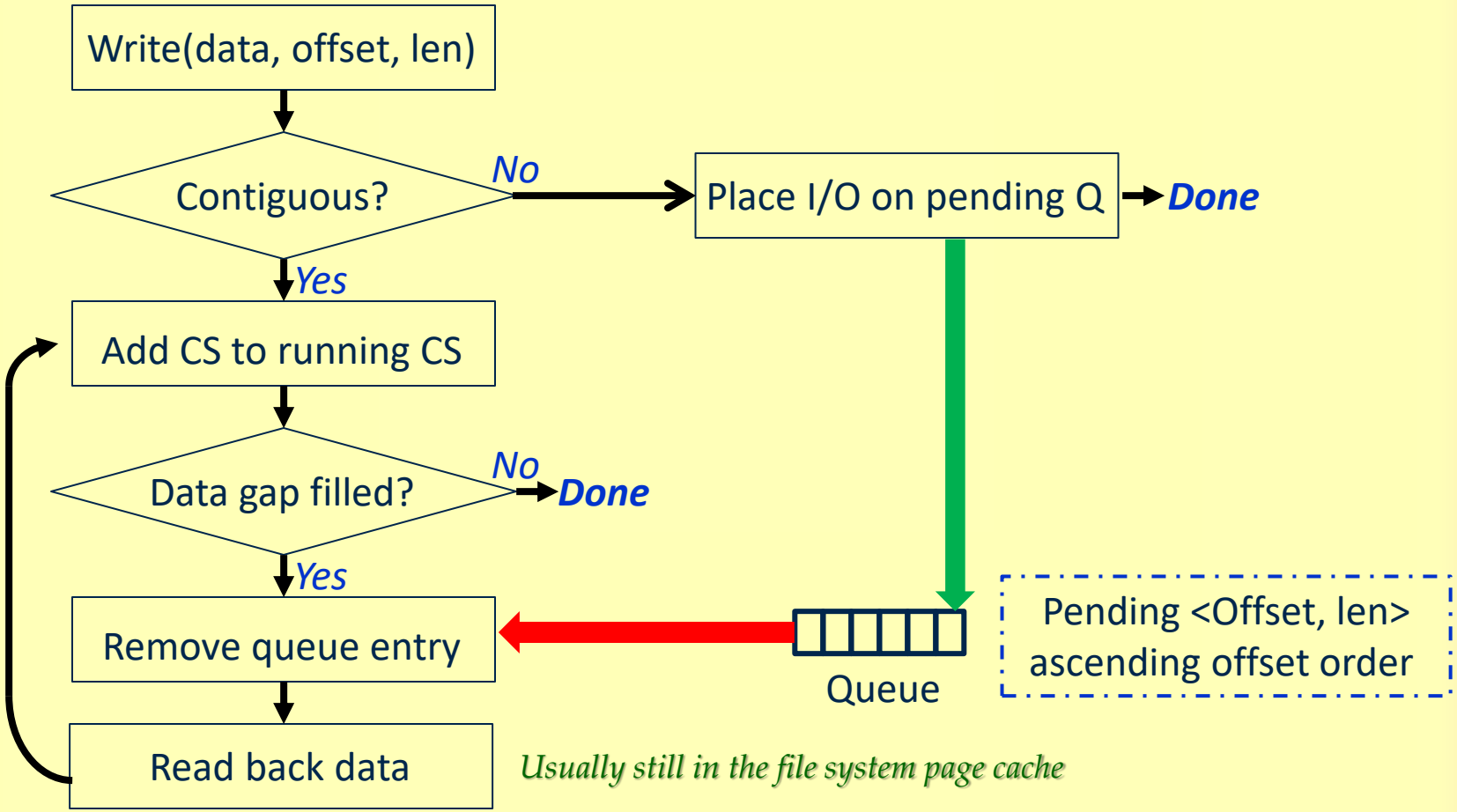
Combinable ordering (simplified)



Noncombinable ordering (simplified)



On Demand vs. Real Time

Feature	On Demand	Real Time
CPU efficiency	Good	Good (Great for EC Ceph)
I/O Efficiency	Low (Reread is needed)	High (Reread not needed)
Complexity	Low	Intermediate (Must track writes)
Predictability (Multi-stream copy)	High	Low (Order dependent)
Integrity (Trust in checksum)	High	Low (Ignores disk errors)

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So, why is real time better?

- Unsurpassed in efficiency
  - 50% less resource use in many dimensions
    - Media contention
    - I/O buss utilization
    - CPU use for erasure encoded file systems
- However …
  - Disk errors are caught indirectly downstream
    - This can have real impacts on applications
      - Random failures due to uncaught media errors

Enabling real-time checksums

- Use the **ofs.cksrt** directive
  - **ofs.cksrt** [**auto** {**default** | **off** | *cipher*}] [**chkcgi**]
    - **auto** automatically performs real-time checksum if
      - Creating or replacing a file with open in write mode
    - **default** uses checksum specified via **xrootd.chksum**
      - *cipher* uses the specified native checksum
        - Native checksums: **adler32**, **crc32**, **crc32c**, and **md5**
    - **off** disables feature which is the default
    - **chkcgi** allows applications to control r/t checksum
      - Open **URL** must contain the **CGI** "**cks.type**=*cipher*"

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Things that can go wrong

- A real-time checksum fails and abandoned when:
  - Any part of the file is overwritten
  - Any part of the file remains unwritten on close
  - File is truncated with a non-zero length
  - File is subject to a vector write
  - An I/O or other error occurs
  - The file is not closed before client disconnects

Do bad things really happen?

- Not too often but when it happens …
  - Checksum recovery is inapplicable
    - Resume where you left off w/o real-time checksum
      - Checksum recovery tremendously increases complexity
  - Warning message printed to log with filename
    - Includes reason why real-time checksum failed
  - Real-time checksum not recorded
  - File transitions to an on-demand checksum

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Availability

- XRootD 6.1.0
  - Protocols
    - xroot
    - http/davs
    - TPC all protocols, pull and push
  - Multi-stream supported in all protocols
    - Out-of-order writes are transparently handled
- Additional improvements expected in 6.2
  - Faster computation for crc32*x* checksums