SNIA Global Education

SNIA Tutorial 3
EVERYTHING YOU WANTED TO KNOW ABOUT STORAGE:
Part Teal —
Queues, Caches and Buffers

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2018 Flash Memory Summit

Welcome to
SNIA Education Afternoon
at Flash Memory Summit 2018

Agenda

1:00 pm – 1:50 pm	SNIA Tutorial 1 *A Case for Flash Storage* Dejan Kocic, NetApp
1:50 pm – 2:45 pm	SNIA Tutorial 2 *What if Programming and Networking Had a Storage Baby Pod?* John Kim, Mellanox Technologies and J Metz, Cisco Systems
2:45 pm – 3:00 pm	Break
3:00 pm – 3:50 pm	SNIA Tutorial 3 *Buffers, Queues, and Caches* John Kim, Mellanox Technologies and J Metz, Cisco Systems
4:00 pm – 5:00 pm	SNIA Tutorial 4 *Birds-of-a-Feather – Persistent Memory Futures* Jeff Chang, SNIA Persistent Memory and NVDIMM SIG Co-Chair

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2,500
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SNIA Global Education

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9/24-9/27 Santa Clara, CA

SDC discount registration cards in FMS bags & at **SNIA booth 820**

SNIA PERSISTENT MEMORY PM SUMMIT

JANUARY 24, 2019 | SANTA CLARA, CA

Complimentary registration now open at **snia.org/pm-summit**

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Special Thanks

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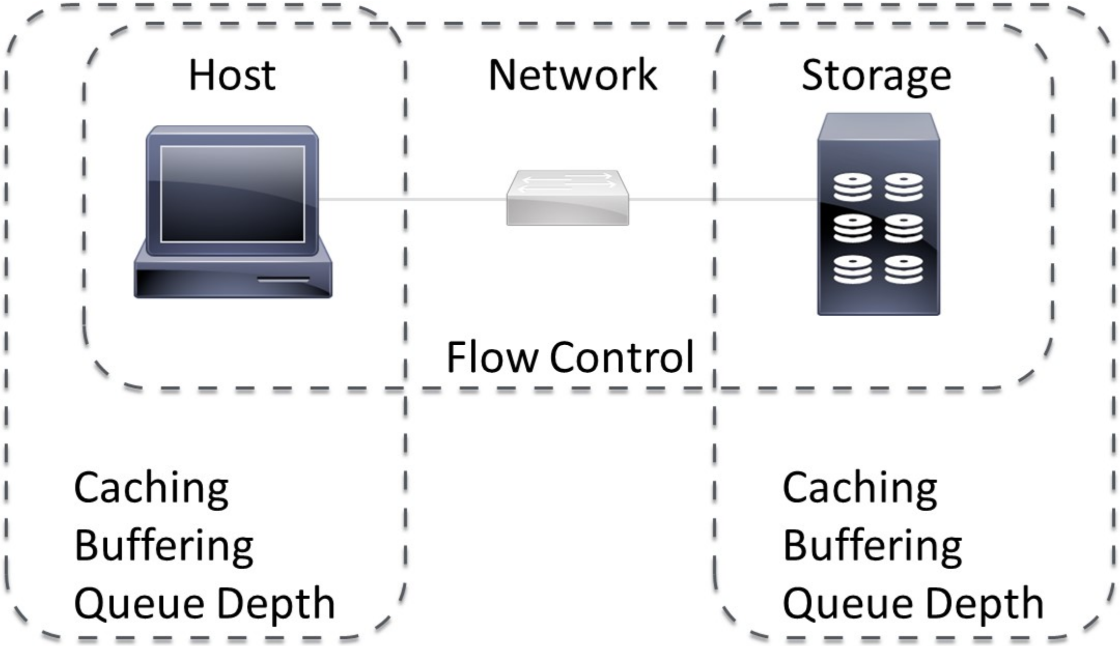
Dell EMC

David Minturn
Intel

Rob Davis
Mellanox

Today's Agenda

- Queuing
- Buffering
- Caching
- Flow Control



QUEUING

Definitions- Queue Depth

IO Operation (aka “IOP”)

Storage operation issued by a host (initiator) to a storage device/system (target)

Example: Host issues a READ Operation of 100 blocks from a storage device

IO Queue

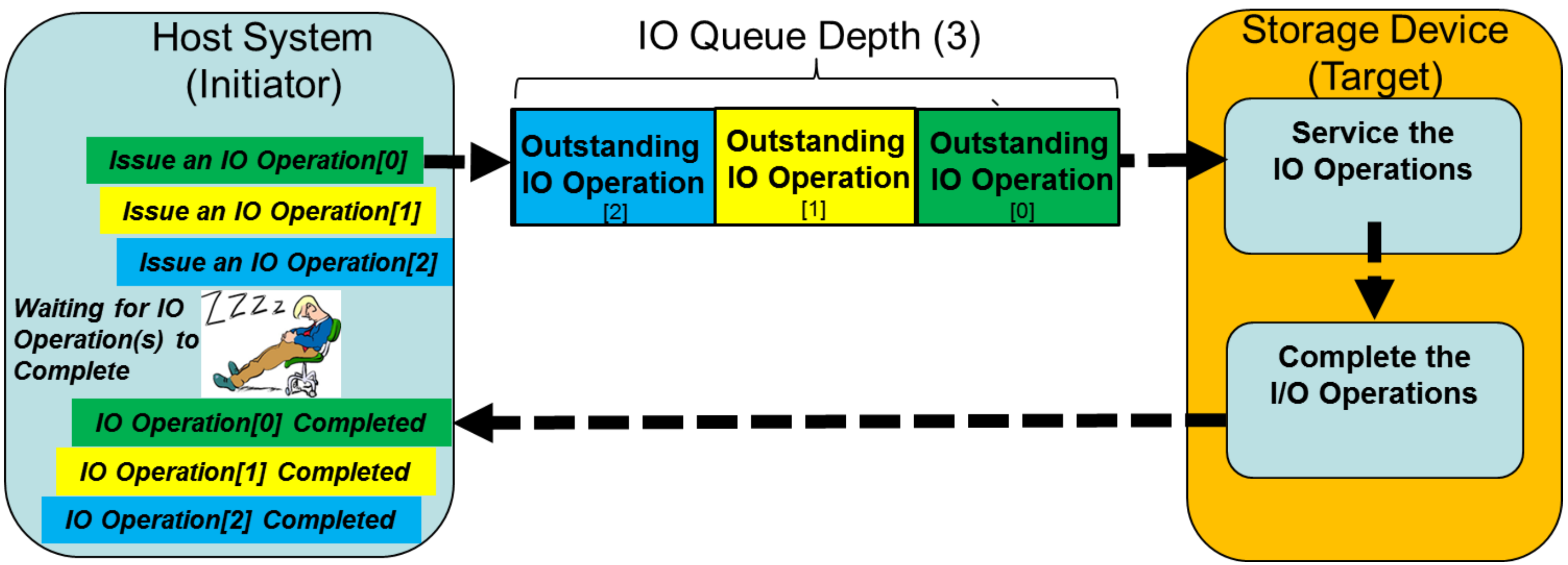
A queue which holds one or more outstanding **IO Operations**

IO Queue Depth

Maximum number of outstanding **IO Operations** that the **IO Queue** can hold

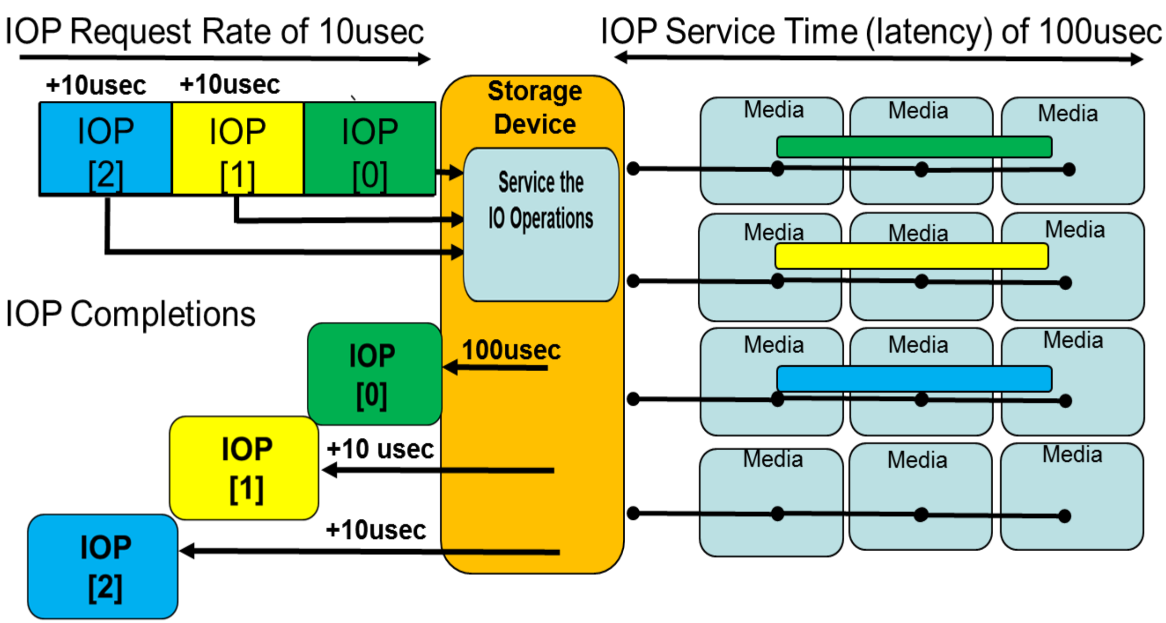
IO Queue Depth Example

- Example: IO Queue with a IO Queue Depth of three



IO Queue Depth Considerations (Storage Device Performance)

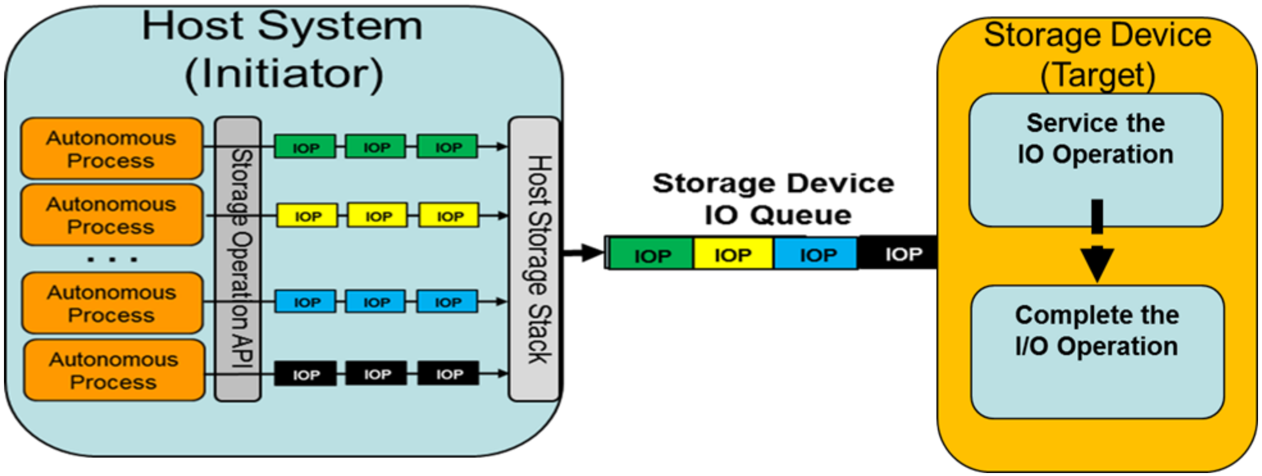
- Larger Queue Depth allows IO Operations to be serviced in parallel or batched resulting in higher total IOPS and bandwidth



Example Results:
@Queue Depth =1;
IOPS are 10K (1/100usec)
@Queue Depth =3;
IOPS are 25K (3/120usec)

IO Queue Depth Considerations (End to End Queue Depth)

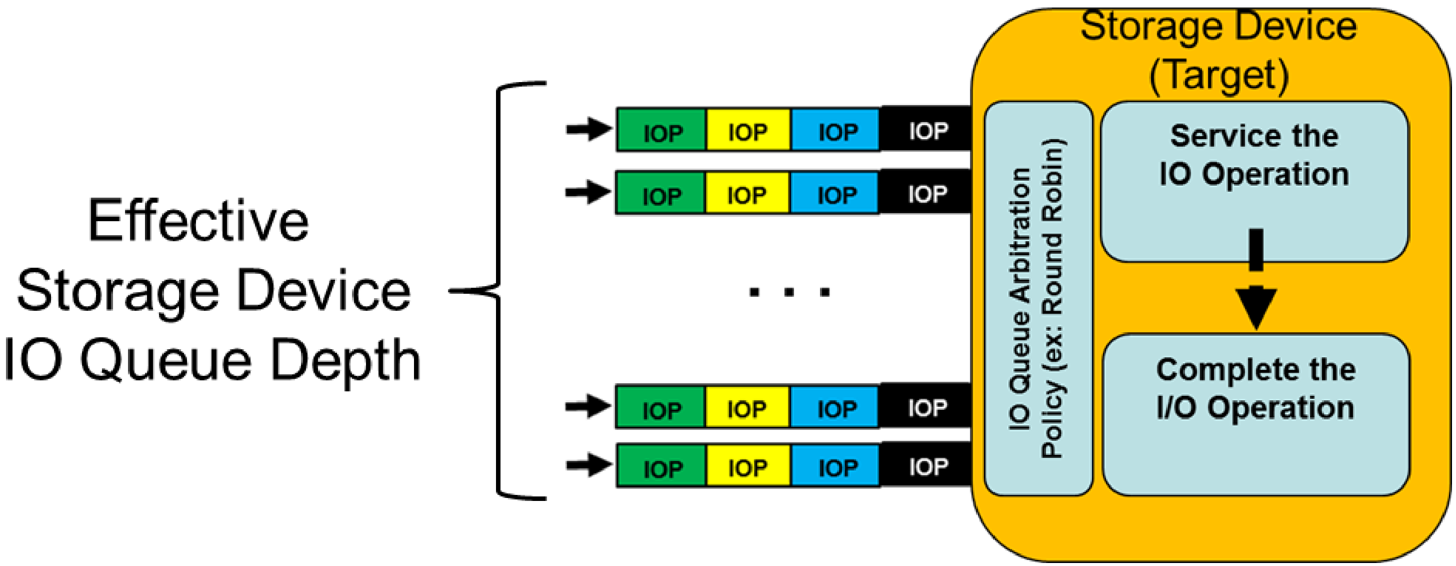
- Host systems typically have multiple Autonomous Processes simultaneously issuing IO Operations (Application Queue Depth)
- Host O/S storage stacks have internal queues to accommodate oversubscribed Storage Device IO Queues (O/S Stack Queue Depth)



Queue Depth must be looked at End to End; App->O/S->Storage Device->Media

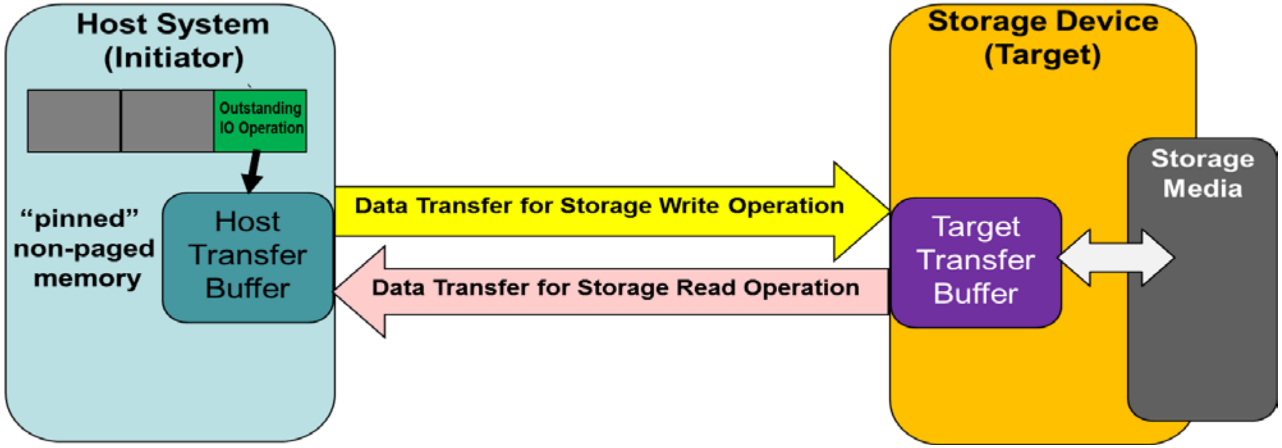
IO Queue Depth Considerations (Multiple IO Queues)

- Modern Storage Devices use a multi IO queue model for efficiency, typically one IO Queue per host CPU
- Effective Storage Device IO Queue Depth equals:
  # of IO Queues * individual IOQ Depth



IO Queue Depth Considerations (Memory Usage)

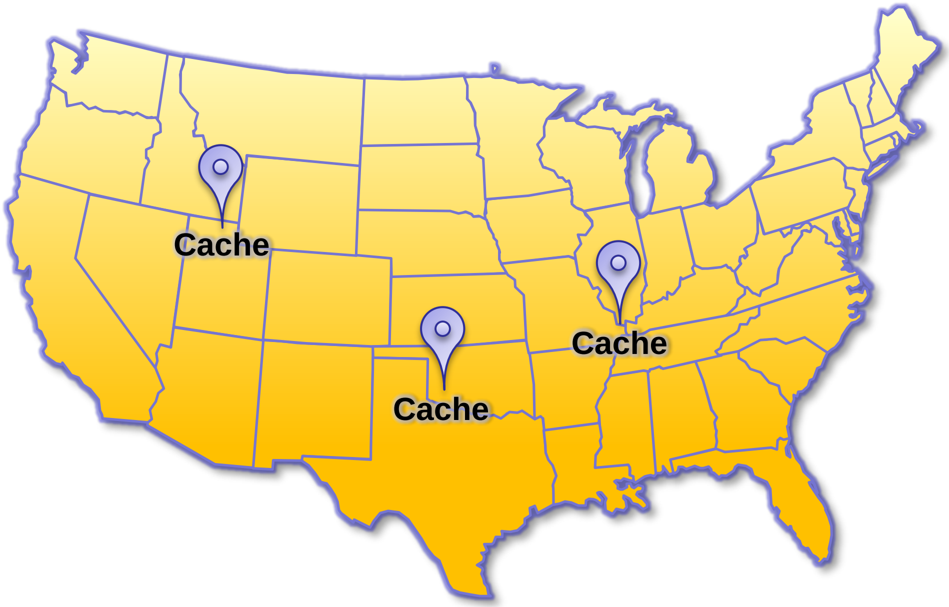
- Memory buffers (termed Transfer Buffers) are used to exchange IO Operation data between the Host System and Storage Device
- Transfer buffer resources are committed until the IO Operation completes
  - Resources may be large; example 64K IO requires 64K of memory



IO Queue Memory = IO Queue Depth * size of (IOP Descriptor + Transfer Buffer)

CACHE

Cache in the US



Definition

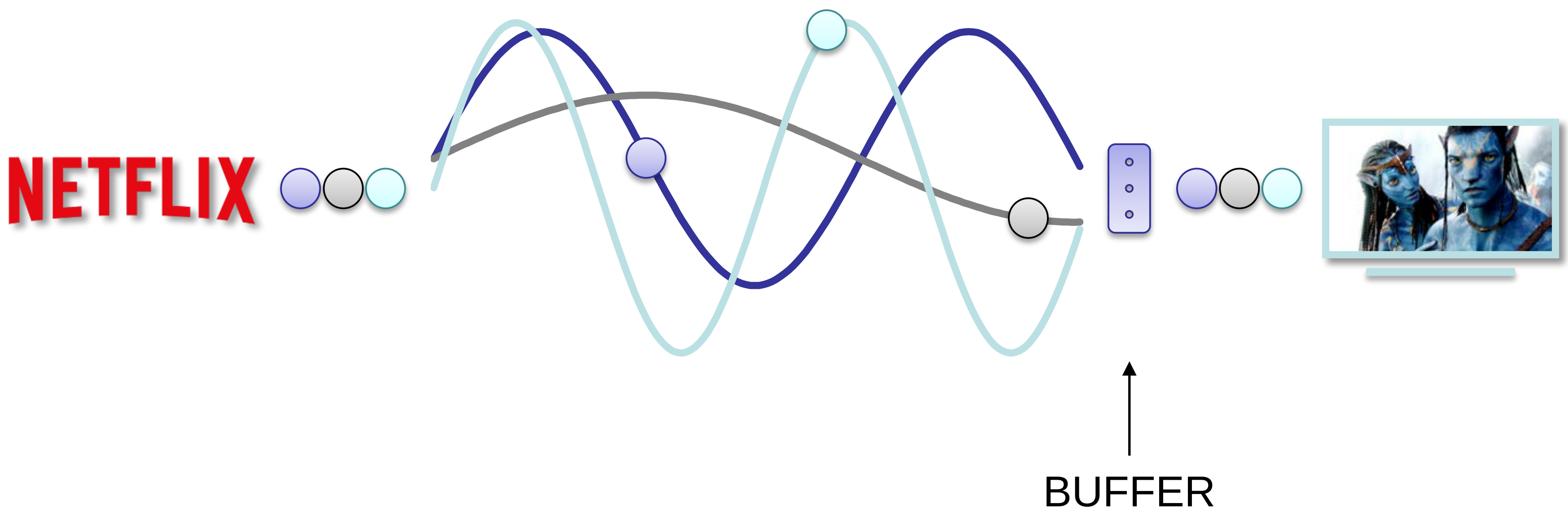
Cache (aka Cache Memory)

/ˈkaSH/

- An auxiliary memory from which high-speed retrieval is possible

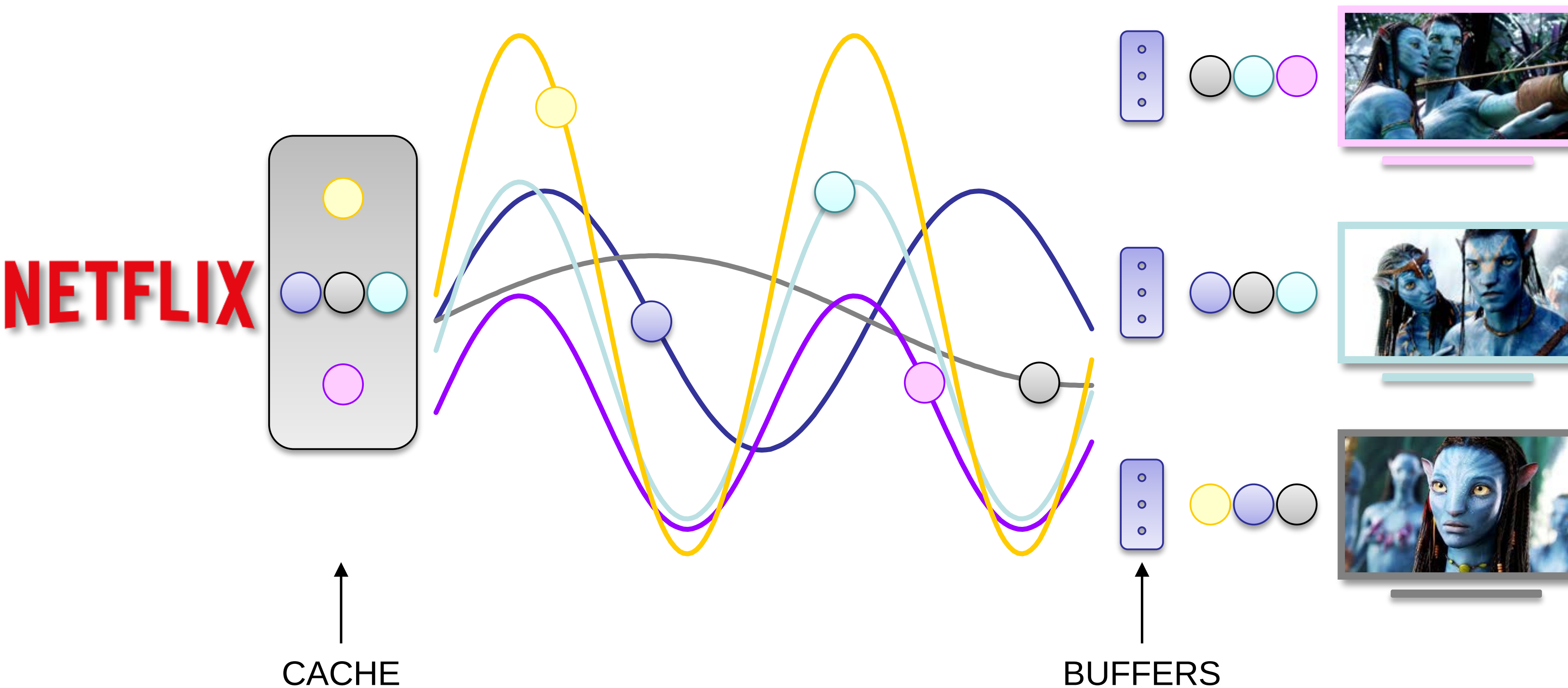
Buffer

Use once and throw it away + allows blocks re-arranging



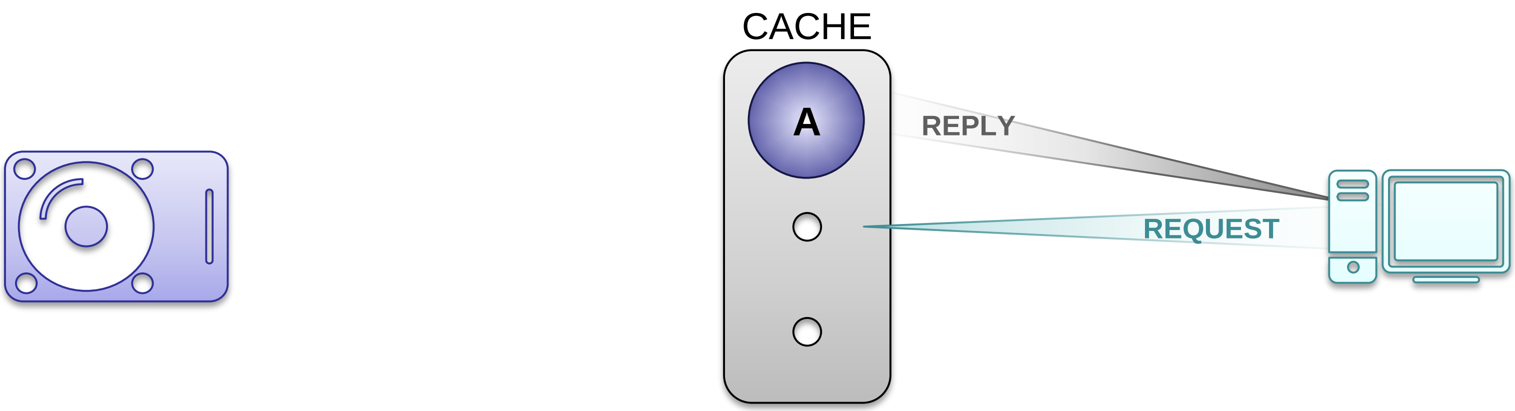
Cache

Cache implies multiple use of blocks



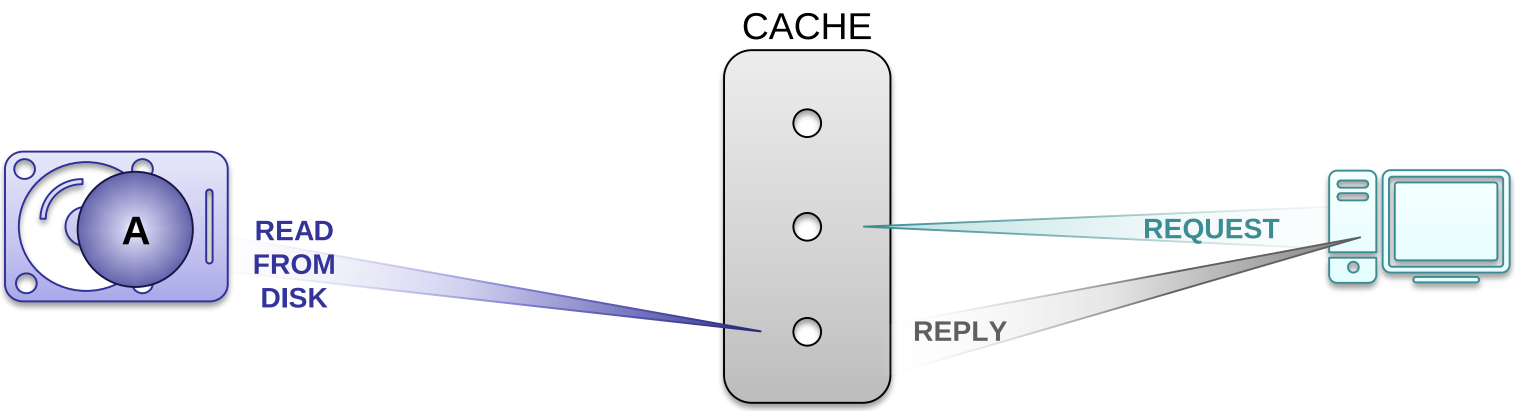
Reads with Cache

Read Hit: First reason for Caches to exist



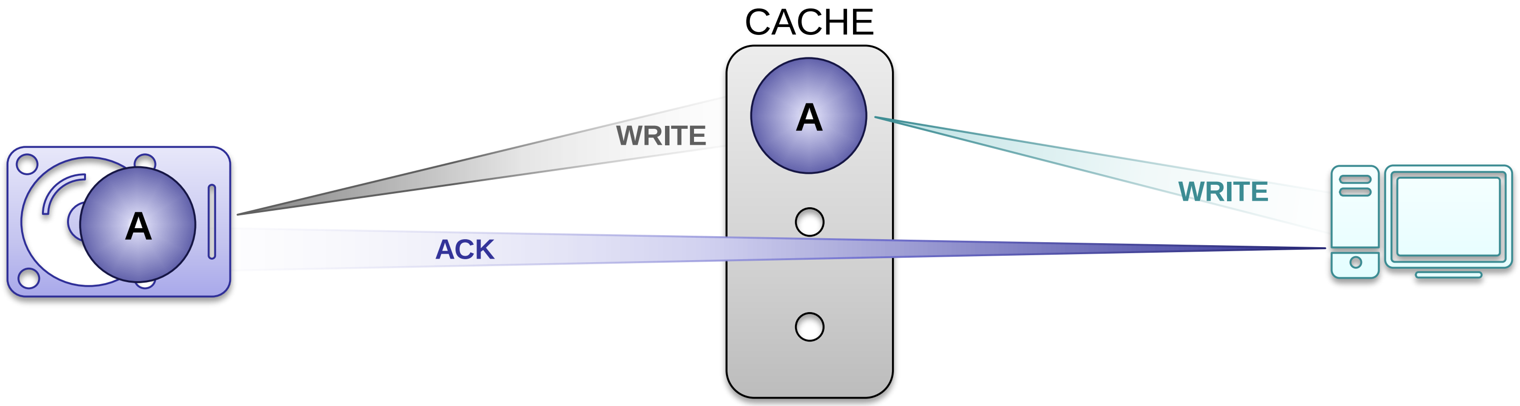
Reads with Cache

Read Miss



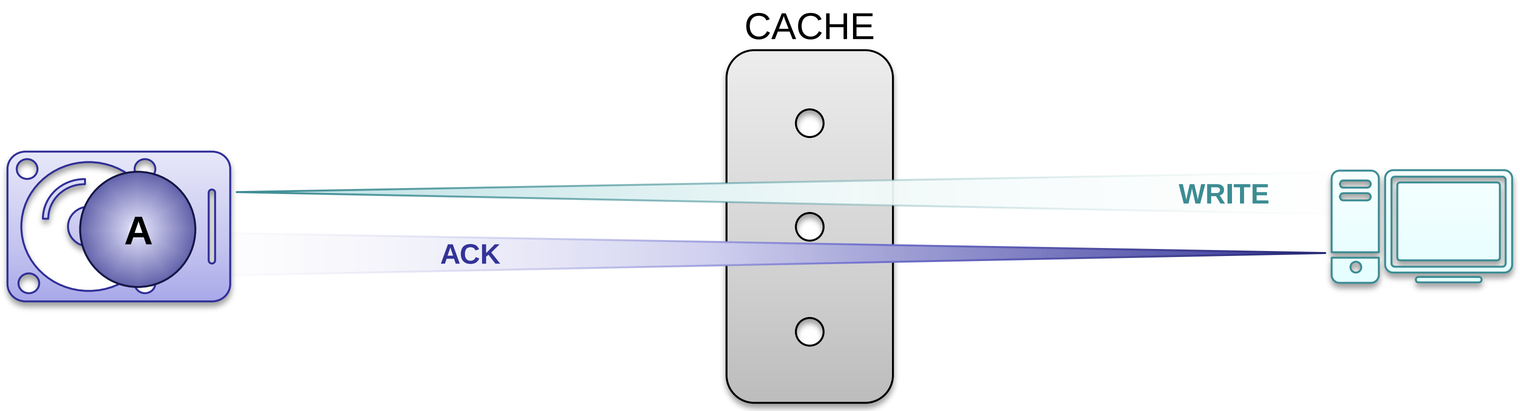
Writes with Cache

Write-through: Write data to Cache and Disk, then confirm completion



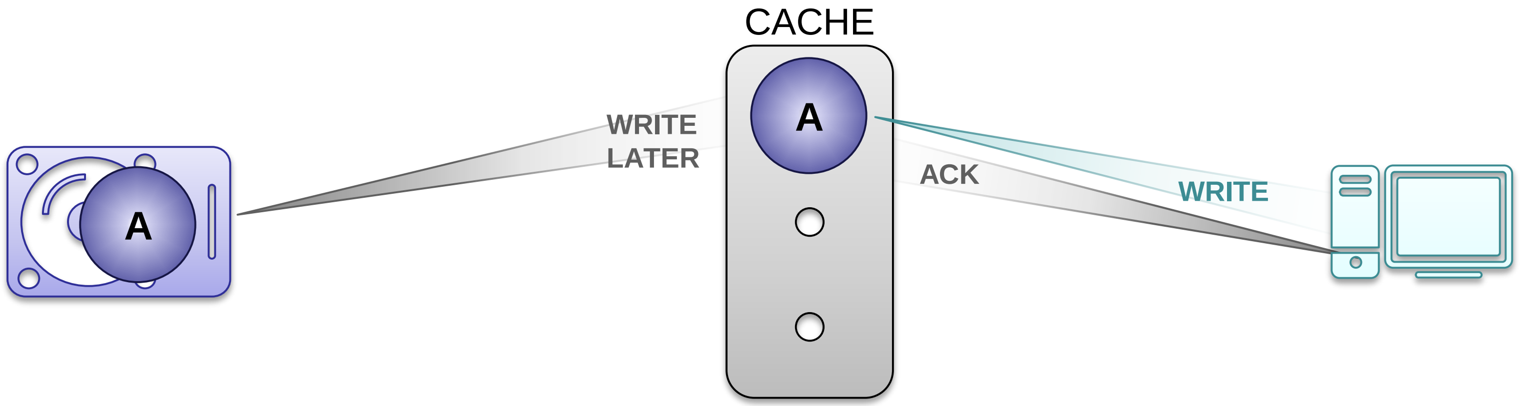
Writes with Cache

Write-around: Bypass cache

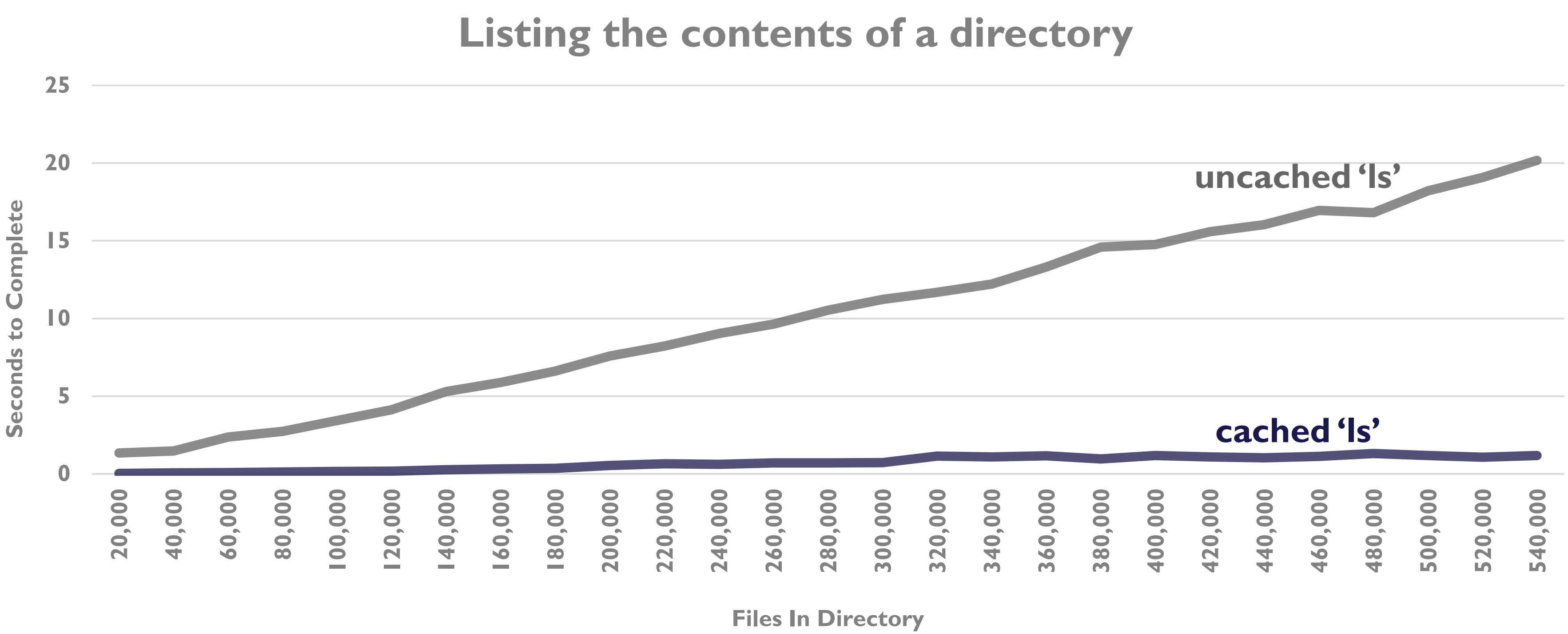


Writes with Cache

Write-back: Write data to Cache and confirm completion; write to disk later

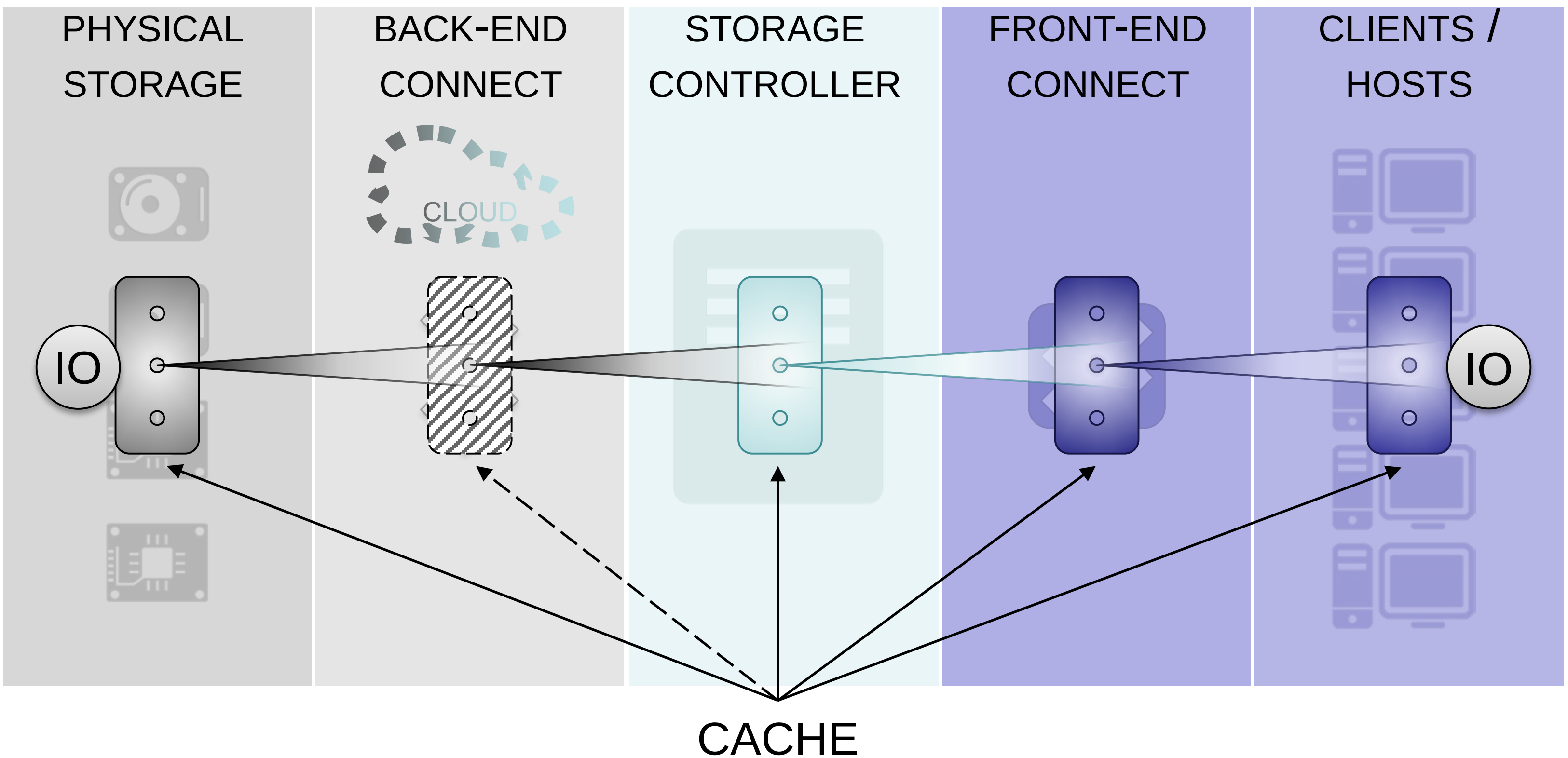


Performance in a File Oriented World



"Uncached 'ls'" had a USB unmount just prior to the 'ls' command execution

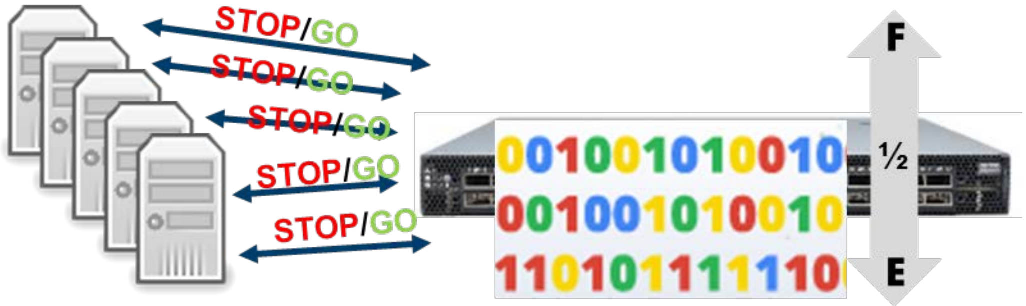
Where Do Caches Exist?



FLOW CONTROL

What is Flow Control?

- Flow control is a mechanism for temporarily stopping the transmission of data on computer network to avoid buffer overflows



What is Flow Control?

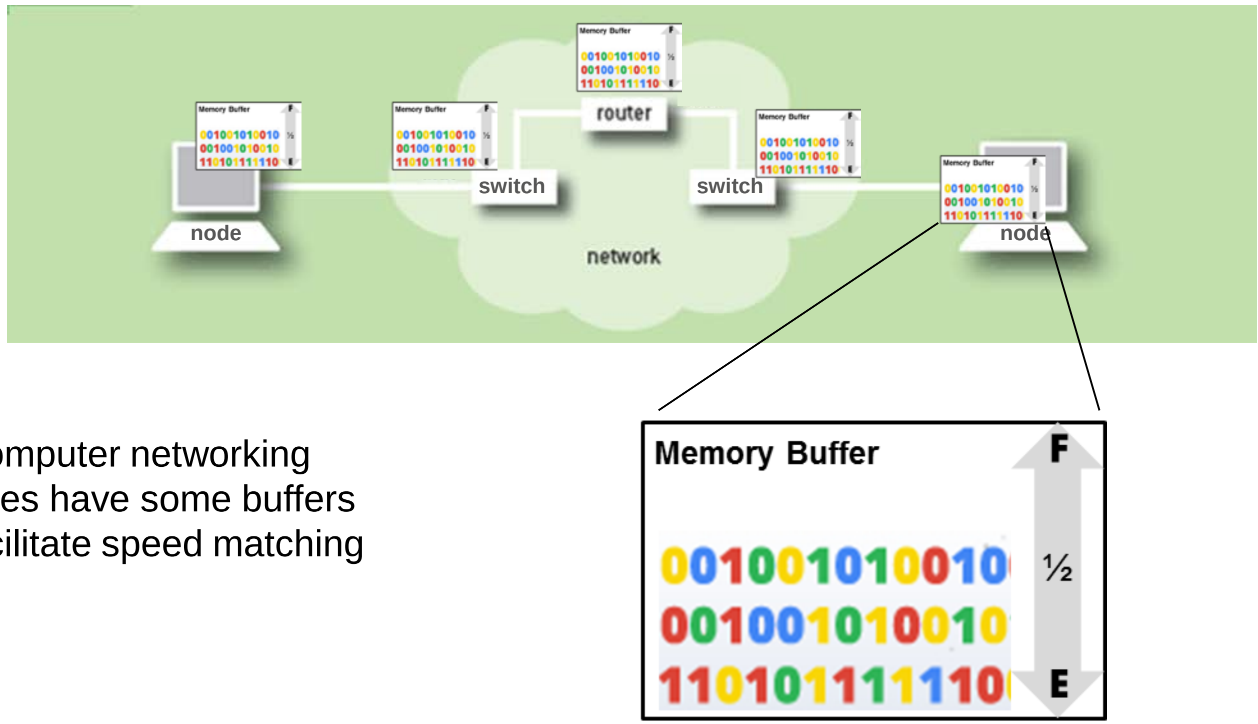
No Flow Control

What is Flow Control?

No Flow Control

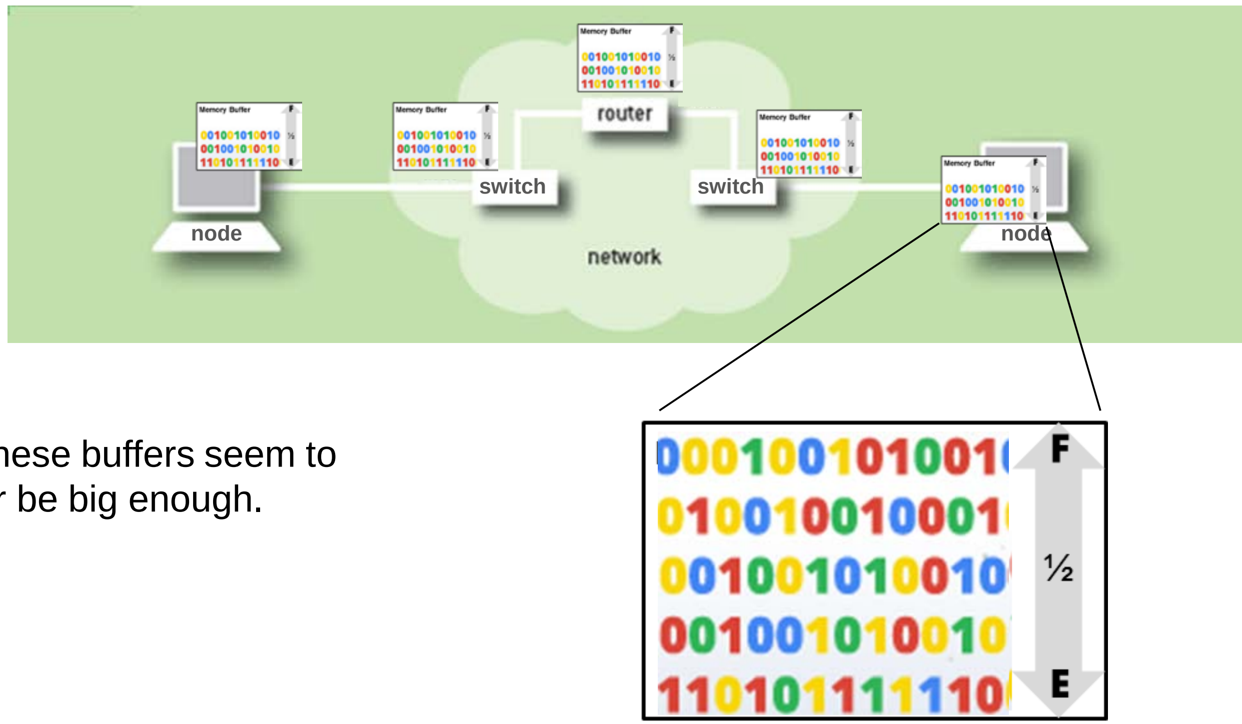
Flow Control

Buffers are Everywhere



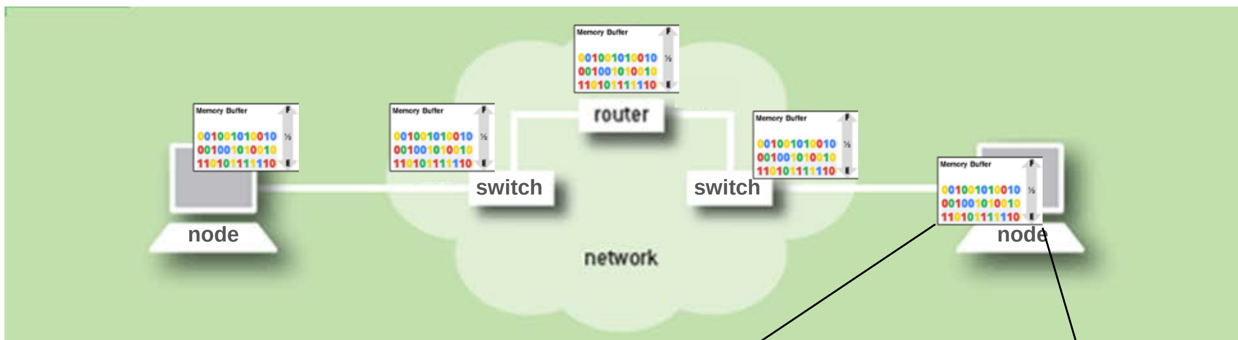
All computer networking devices have some buffers to facilitate speed matching

Buffers are Everywhere

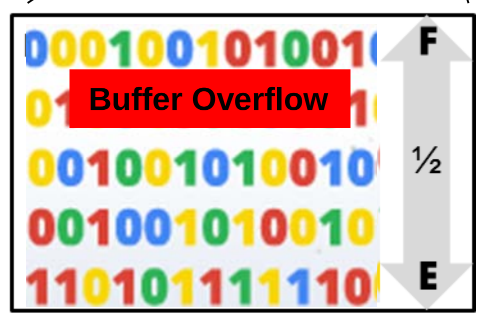


But these buffers seem to never be big enough.

Buffers are Everywhere

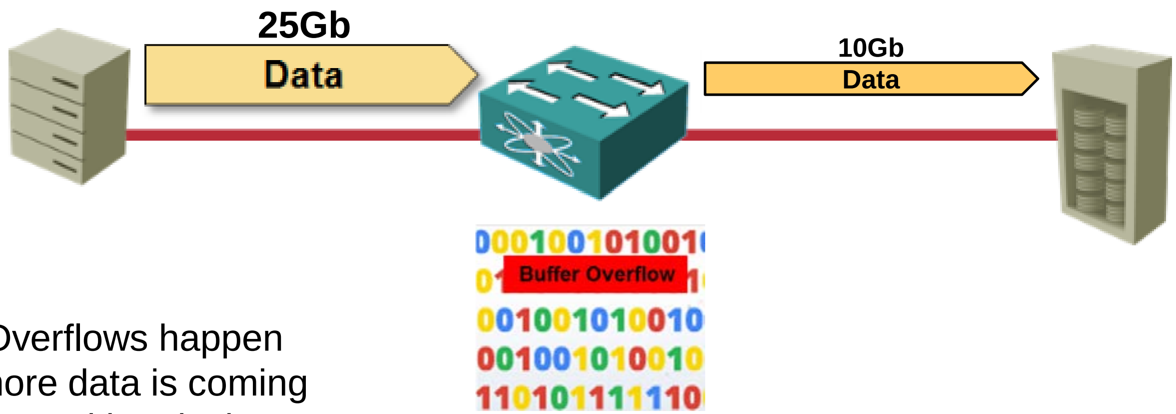


This can lead to a Buffer Overflow resulting in Data Packet Drops forcing error recovery delays.



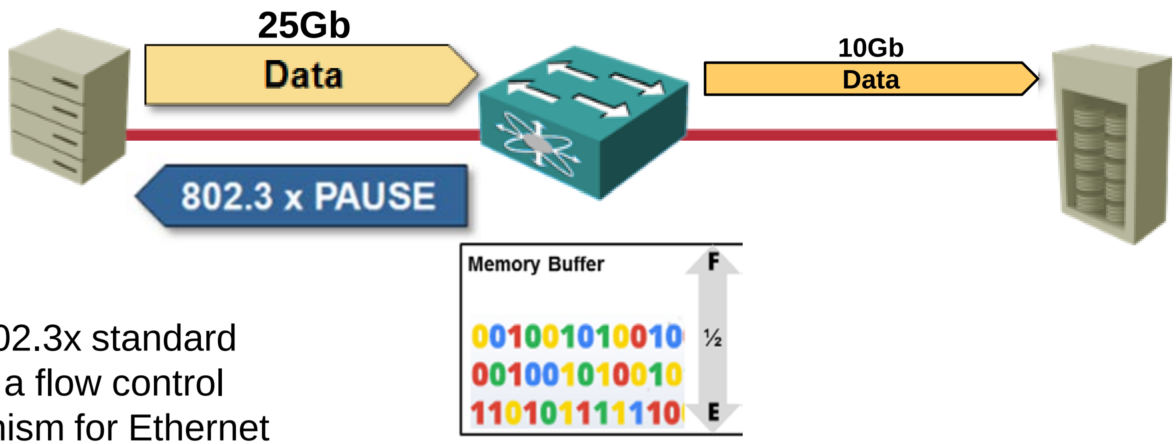
Buffer Overflows are Bad…

Why Do Overflows Happen



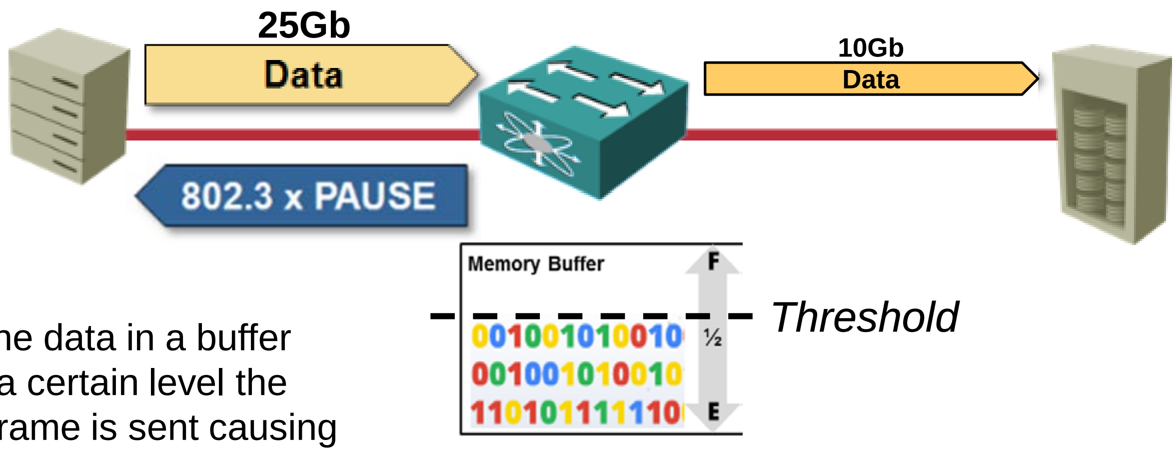
Buffer Overflows happen when more data is coming into a networking device then is going out.

Flow Control Prevents Overflows



IEEE 802.3x standard defines a flow control mechanism for Ethernet called the pause frame.

Flow Control Prevents Overflows



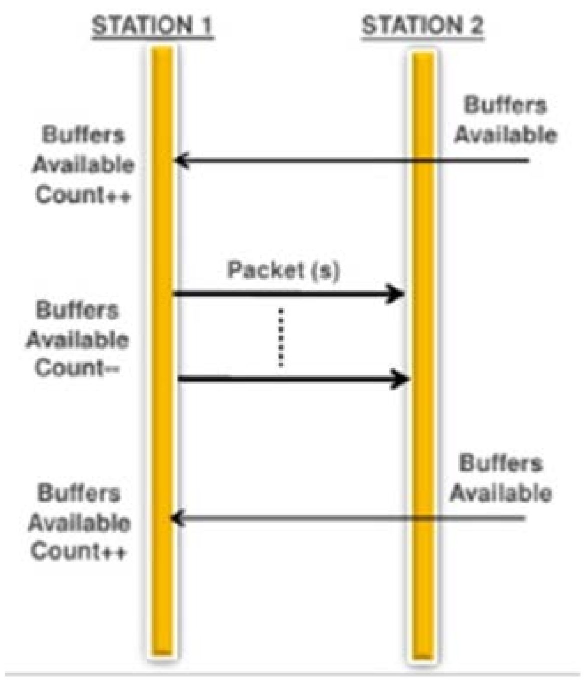
When the data in a buffer gets to a certain level the pause frame is sent causing the upstream device to stop sending data for a specified amount of time.

Fibre Channel and InfiniBand

ANSI INCITS T11

IBTA

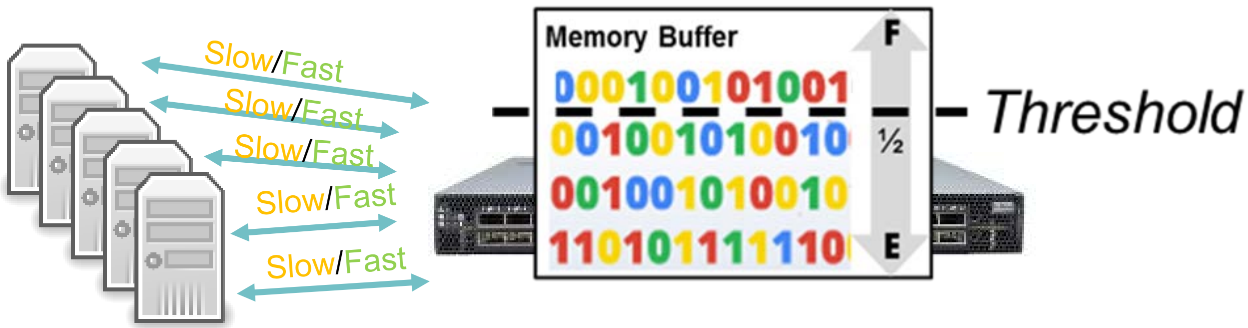
credit-based flow control



With credit based flow control the sending device knows how much buffer space the receiving device has eliminating buffer overflows.

Explicit Congestion Notification

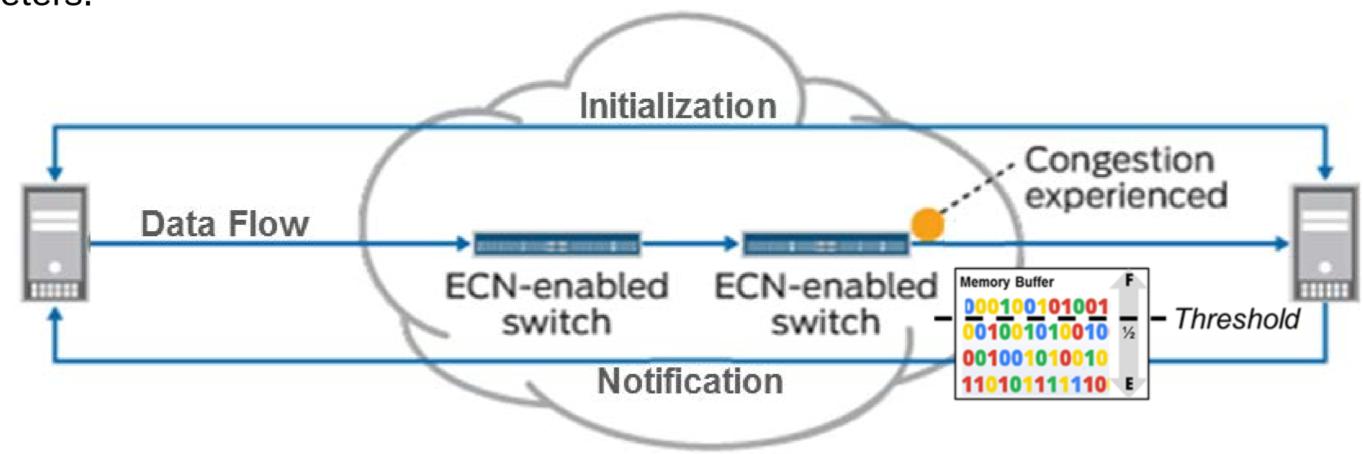
Explicit Congestion Notification (ECN) slows down a explicit device's data rate that is believed to be overflowing another devices buffer.



Explicit Congestion Notification

The data rate of the device slowed down then increases in increments over time based on preset parameters.

RFC 3168 - Explicit Congestion Notification (ECN)



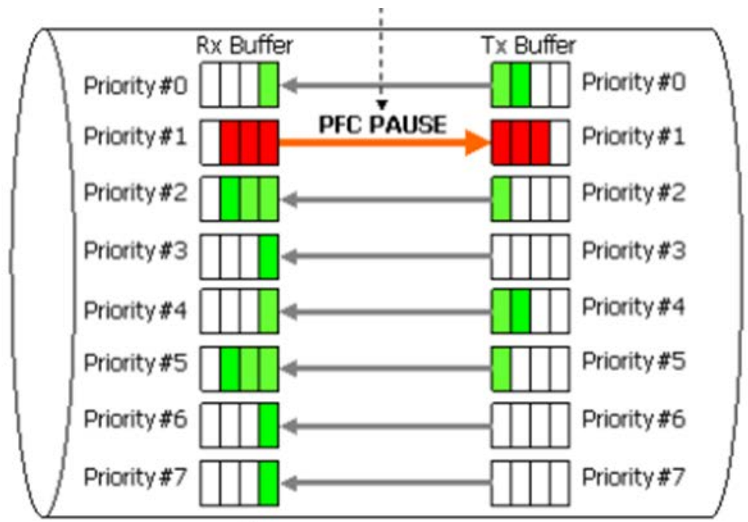
Priority Flow Control

Priority Flow Control

Priority Flow Control

Priority Flow Control (PFC) is similar to 802.3x Pause, except eight priority levels are added. When the data in any of the eight buffers gets to a certain level a pause is sent causing the upstream device to stop sending data only for that priority level for a specified amount of time.

802.1Qbb - Priority-based Flow Control



Overall Summary

- Queues Line Up Work Processes or Requests
- Buffers absorb traffic bursts and smooth out data flow
- Caches store data closer to the user to accelerate access
- Flow Control Modules the Rate of Data or Requests to prevent buffer overflow

Other Storage Terms Got Your Pride? This is a Series!

- Check out previously recorded webcasts:
  - **http://sniaesfblog.org/everything-you-wanted-to-know-about-storage-but-were-too-proud-to-ask/**
- **Teal** – Buffers, Queues and Caches
- **Rosé** - All things iSCSI
- **Chartreuse** – The Basics: Initiator, Target, Storage Controller, RAID, Volume Manager and more
- **Mauve** – Architecture: Channel vs. Bus, Control Plane vs. Data Plane, Fabric vs. Network
- **Sepia** – Getting from Here to There
- **Turquoise** – Where Does My Data Go?
- **Cyan** – Storage Management
- **Aqua** – Storage Controllers

Speaking of Series…Check out Storage Performance Benchmarking

- Storage Performance Benchmarking:
  1. Introduction and Fundamentals
  2. Solution under Test
  3. Block Components
  4. File Components

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