CLOUD COMPUTING APPLICATIONS

Cloud Storage: Block Storage

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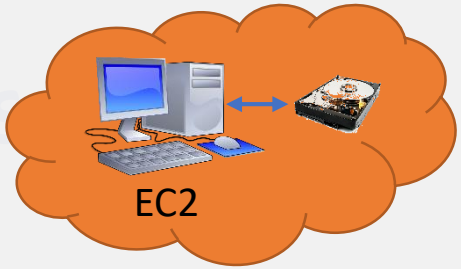
Cloud Storage Category 1: Block Storage – Instance Stores

- The physical machine running the virtual machine is physically connected to the storage device
  - virtual devices whose underlying hardware is physically attached to the host computer for the instance
  - Data transfer is limited by SATA / NVMe bandwidth
  - I3en.metal: 8 x 7,500 GB (60 TB)



- Since the machine may be rented to someone else in the next minute, the data stored on the drive does not persist, it's **ephemeral**.

- Example:
  - Amazon AWS: Instance Store
  - Google: Local SSD

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Instance Size	Local Storage (GB)	Read MBps	Write GBps
i3.large *	1 x 475 NVMe SSD	391	137
i3.xlarge *	1 x 950 NVMe SSD	806	273
i3.2xlarge	1 x 1,900 NVMe SSD	1,611	703
i3.4xlarge	2 x 1,900 NVMe SSD	3,223	1,406
i3.8xlarge	4 x 1,900 NVMe SSD	6,445	2,813
i3.16xlarge	8 x 1,900 NVMe SSD	12,891	5,469
i3.metal	8 x 1,900 NVMe SSD	12,891	5,469

** Throughputs are a snapshot in time, might be different now*

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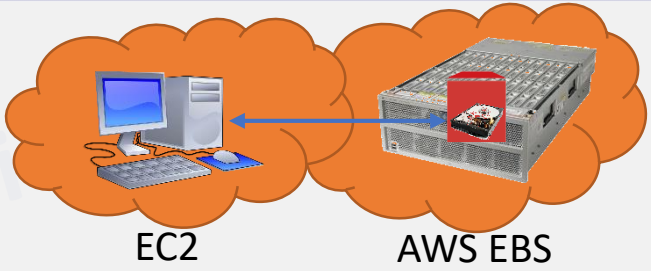
Storage Virtualization

- The process of presenting a logical view of the physical storage resources to a host computer system
  - Block Virtualization
  - File Virtualization

Cloud Block Storage – Virtual Block Stores

- Simulate a hard drive or SSD
- The physical machine running the virtual machine is separate from the physical machine hosting the data
  - NVMe over Fabric
    - NVMf or NVMe-oF
  - Data transfer is limited by network bandwidth

- The Hypervisor on the host machine has middleware that intercepts the network comm. and presents the network stream of bytes to the virtual machine as a “Block Storage Device”
  - E.g. in AWS, EBS as an NVMe device
  - E.g.in Google Cloud: Persistent Disk



Cloud Block Storage – Virtual Block Stores

- Typically less storage bandwidth than the previous option (EBS)
- You can also select how much bandwidth you are willing to pay for
  - Selecting IOPS for io1 type
- gp2 types are preselected and fixed
  - 3 IOPS/ gigabyte, 16KBps / IOPS, min 100, max 16,000
  - Bursting support
- Note: A single EC2 instance can be attached to more than 1 EBS volume
- Some instance types are EBS optimized
  - Bandwidth for EBS access is separate from network bandwidth
  - Other (micro, small, older generations) share network bandwidth

Instance Size	Instance Storage	EBS Bandwidth (MBps)
m5.large	EBS-Only	Up to 594
m5.xlarge	EBS-Only	Up to 594
m5.2xlarge	EBS-Only	Up to 594
m5.4xlarge	EBS-Only	594
m5.8xlarge	EBS Only	850
m5.12xlarge	EBS-Only	1,188
m5.16xlarge	EBS Only	1,700
m5.24xlarge	EBS-Only	2,375
m5.metal	EBS-Only	2,375

** Throughputs are a snapshot in time, might be different now*

AWS Elastic Block Storage

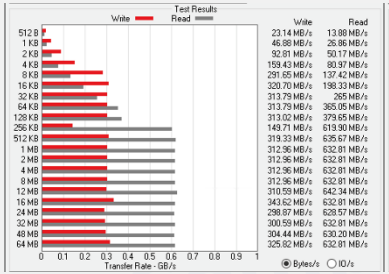
- Depending on IO requirements, different offerings and prices
  - gp2 up to 250 MB/s @ $0.10 per GB-month
  - io1 up to 1,000 MB/s @ $0.125 per GB-month AND $0.065 per IOPS-month
  - …
- Note: A single EC2 instance can be attached to more than 1 EBS volume
  - Max Throughput/Instance for T3 class: 2,375 MB/s

** Prices and bandwidths are a snapshot in time, might be different now*

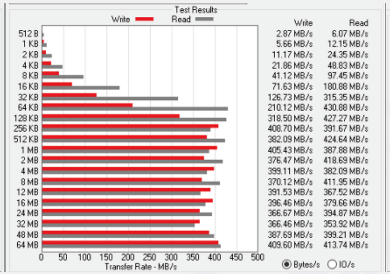
Instance Store vs. EBS Throughput

Experiment on an AWS m5ad.2xlarge instance (General Purpose, 8 vCPU, 32 GB RAM, 10GB network, EBS optimized)

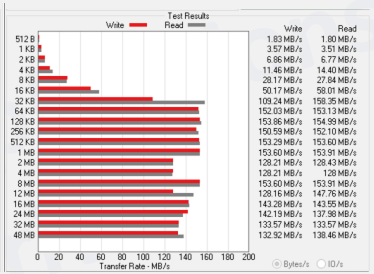
Instance Store 300GB



Io1 @ 200GB with 10000 IOPS



gp2 @ 30GB with 100/3000 IOPS

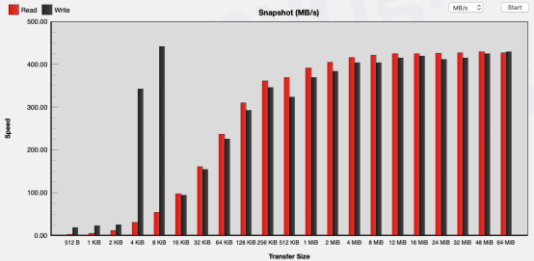


100*16KB = 1.56 MBps
3000*16KB = 45 MBps

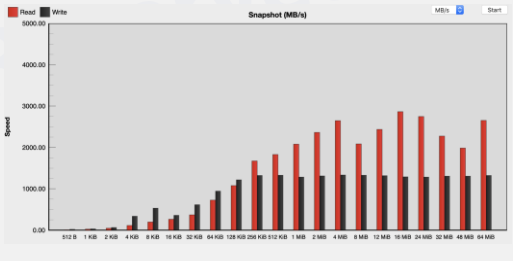
- Bursting
- IO Consolidation at EBS Backend

Experiment on laptop (Macbook Pro)

SSD via USB 3.0 (5 Gbit/s)



NVMe SSD (PCIe 3.0 × 4 8.0 GT/s (31.5 Gbit/s))



Summary

- Block Storage
- Instance Store
- Virtual Block Store
- Performance Comparison