Faculty of Engineering & Applied Science

SOFE4790U – Distributed Systems

Homework: Networking and Virtualization

Due Date: 10/02/2022

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Part 1: Networking:
Review your course on computer networks. Can you try to summarize what you learned in that course? Focus on the 7 layers of the OSI interconnectivity model? What different detailed functionality does each layer provide? how does this help two applications to communicate?

The OSI layer helps two different applications communicate through the 7 layers. Each layer contains a protocol data unit which is used to communicate among two different nodes at each layer. When computer A is trying to communicate with computer B, where the data or message being sent is managed by the first three-layer (Application, Presentation, Session) and then will be segmented at the transport layer. The network layer will produce a packet which will then proceed to the data link layer which creates a frame for the packets that were received. The physical layer will send the information from computer A to computer B by converting it to bits and sending over the medium, and at computer B it will unframe the packets at each layer following the same protocol used by computer A until the message is received. The seven OSI layers are shown below with examples of devices being used at certain levels and protocols.

OSI Layer Level	Description	Example
Physical Layer (Layer 1)	Transmits bits over a medium and determines throughput, latency, error rate of a network link.	Ethernet Cables, Coax Cable, fiber cable, HUB
Datalink Layer (Layer 2)	It provides communication between two nodes while sending **frames** over a network link; within the frame is the data that is transmitted from one end to another end (Wire) which is encapsulated. The data link layer is divided into two subsections: MAC (Media access control) and LLC (Logical Link Layer). MAC allows for control of the frame and provides any detection of a collision of the frames while the LLC provides error checking such as checksum, parity bit, and CRC (cyclic redundancy codes).	MAC Address, Switch

Network Layer (Layer 3)	It provides the ability to move **packets** between the networks using routing protocols. The network layer allows other devices or networks to communicate with each other over multiple links (end-to-end) through packets and allows for network addressing (IP Address)	IP, Routing Protocols
Transport Layer (Layer 4)	The transport layer (4^{th} layer) provides with reliable data transfer while segmenting them into packets. It provides error checking and flow control in an **end-to-end** network whereas in the link layer it provides error checking at the physical layer. The main protocol being used at the transportation layer is TCP/UDP. TCP is a connection-oriented protocol and reliable which requires an acknowledgement packet (HTTP) while UDP is a connection-less oriented protocol and unreliable which does not require any form of acknowledgement packet (VOIP).	TCP/UDP
Session Layer (Layer 5)	The session layer maintains the ongoing session (**ports**) while keeping it active and provides synchronization which allows the user to reconnect to the same checkpoint in case of a failure.	OS, Remote Procedure call (RPC), Gateway
Presentation Layer (Layer 6)	The encryption and data compression are done at the presentation layer such as ASCII coding.	ASCII, signed integer, unsigned integer
Application Layer (Layer 7)	Provides the user access to network resources/applications and allows protocols to communicate with each other.	HTTP, FTP. SMTP, DNS

Part 2: Virtualization

SnowFlock

Cloud computing allows an end user to rent servers in the cloud and does not need a physical device such as a server which will lead to lower costs. The main component of a cloud is providing a virtual machine (VM), which imitates a physical machine, but the end users are not observant of the fact that the machines are being shared by many other users or the location of the resources. The cloud provides user access and location transparency.

The purpose of cloud computing is to help user set up their servers within seconds compared to purchasing, installing, and configuring the servers which may take weeks or months. Although the cloud systems are not stand-alone systems and require a pool of resources to be added. For a user to configure the servers, they still need to manage the cluster and add new servers. Snowflock solution to this issue is virtual machine cloning which uses API calls. It can solve the issues with a single logical operation with cloning, resource allocation, and cluster management. The VM makes copies of the cloud servers which store the parent's operating system and application cache while adding them to a private cluster. These resources can be used at any time depending on the number of resources required from the user. Snowflock has allowed the creation of VM in under 5 seconds and can process the load across many physical hosts. It has also integrated into the cloud-based-elastic servers which allow the new worker node to come online and be loaded up 20 times faster. SnowFlock implements a similar process used in UNIX called fork which creates a new process of the parent (duplicate) within the system. In Snowflock it creates a copy of the memory, processes, filesystem, and virtual devices which can be used to create multiple copies and executed in a parallel sequence.

Compute Resource Consolidation Pattern

Grouping multiple tasks and operations into one unit to maximize resource utilization will allow the user to cut the cost and expenses of their business. Running multiple tasks on a different system with limited usage and charges per resource is not optimal. Grouping similar tasks with a similar profile of scalability and processing requirement will help them scale together as one unit. The idlest situation is to run systems which are not cost-effective and are frequently idle. When combining multiple tasks together, tasks that require scalability or the computational level fluctuates depending on the traffic should not be grouped with tasks that do not require as many resources which may overall lead to more tasks being done. When implementing the compute resource consolidation pattern, it is recommended to think about the topics below before implementing the pattern,

Topics	Description
Scalability and Elasticity	Do not group tasks that require the same level of scalability for a resource.
Lifetime	Design the tasks to have checkpoints and restart the tasks when interrupted or resource is resumed.
Release cadence	If one code requires to be updated or the system to be restarted, all other tasks will have to stop and be restarted as well!
Security	Each task running should have trust between each other without causing an issue or corrupting each other.
Fault Tolerance	If one system fails, all the tasks within the system are at a halt as well.
Contention	Do not use tasks that require the same resources such as two tasks using a lot of memory.
Complexity	Adding multiple tasks within the same system increases the complexity of the code.
Stable logical architecture	Design the code in a manner where it does not need to change even if the physical environment has changed.

Data Partitioning Guidance

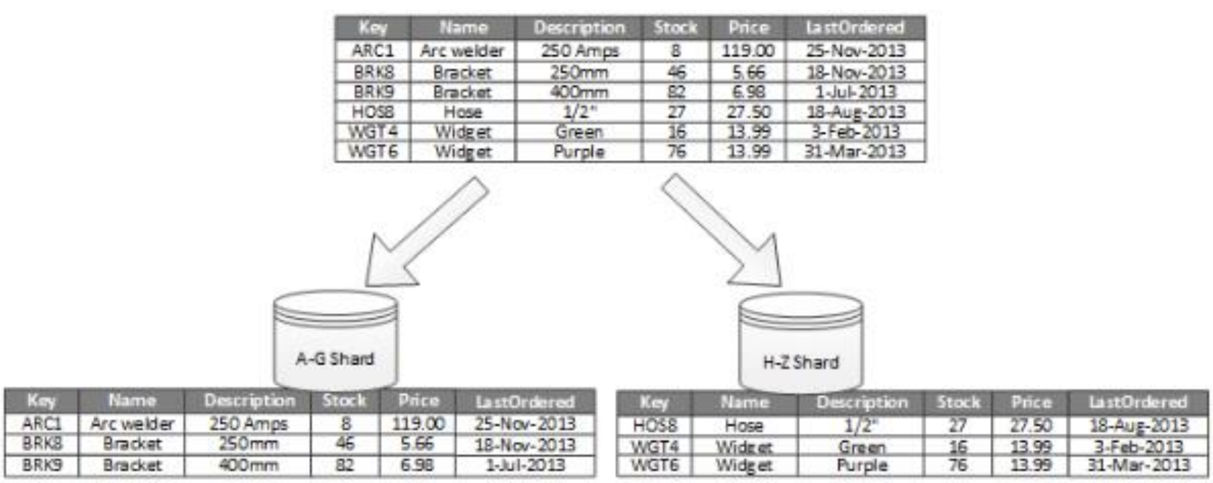
In big data, it is impossible to keep all the data files on one resource which is why partitioning is extremely important. Partitioning allows the data to be stored in separate storage and can have many benefits shown below,

Improvement	Description
Scalability	Increasing the data storage on a single server is limited where having partitions of many drives spread throughout on different nodes will achieve almost unlimited data storage.
Performance	Allows the user to access multiple files or operation in parallel.
Security	User can partition the data with sensitive material and apply various security protocols.
Provide management	Allow the user to manage, monitor, failure protection, and other tasks based on the partition and what each partition contains.
Availability	Allows the user to have access to files through redundancy or even if one partition fails, they will still have access to other partitions.

Designing Partitions

1. Horizontal partitioning (Sharding)

Each partition stores a portion of the data (rows of data) such as records 1-50 and the next partition holds records 51 – 100 where each partition is known as a shard.



Key	Name	Description	Stock	Price	LastOrdered
ARC1	Arc welder	250 Amps	8	119.00	25-Nov-2013
BRK8	Bracket	250mm	46	5.66	18-Nov-2013
BRK9	Bracket	400mm	82	6.98	1-Jul-2013
HOS8	Hose	1/2"	27	27.50	18-Aug-2013
WGT4	Widget	Green	16	13.99	3-Feb-2013
WGT6	Widget	Purple	76	13.99	31-Mar-2013

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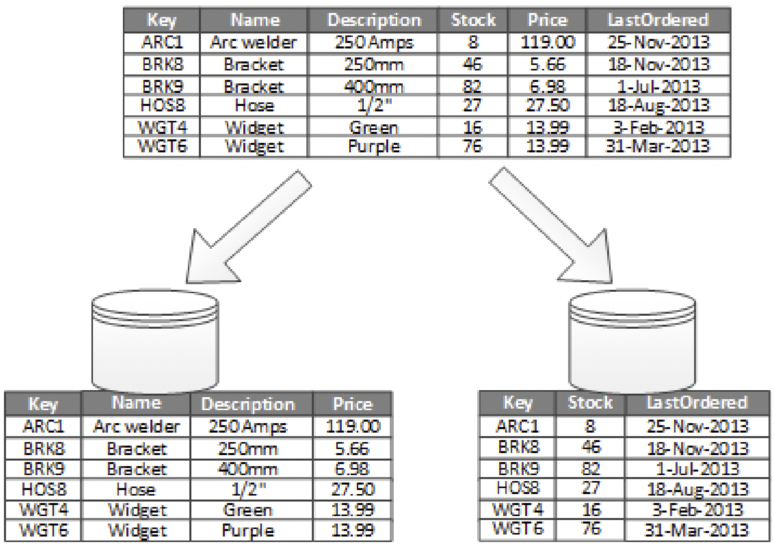
2. Vertical partitioning

Each partition holds a table or a section of the table (columns) such as partition 1 will hold columns 1 – 10 while partition 2 will hold columns 11 – 20. Another example is partition 1 can hold the most used columns while partition two will hold the lesser used columns in the database.



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3. Functional partitioning

Partition is based on the purpose of the data being used or what category it comes under or one primary goal. For example, having read-only data in one partition for faster access and another partition for read-write data. Designing the partition is challenging and should be focused on what the primary goal or main function of the partition is, and it is recommended that all three design partitions should be integrated into the schema.