Cap Theorem

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CAP Theorem

The CAP theorem applies to the distributed systems that store data.

The CAP theorem states that it is impossible for a distributed data store to simultaneously provide more than two out of the three guarantees, namely consistency, availability, and partition tolerance.

Consistency guarantees that every node in the distributed system returns the same, most successful, and recent write.

Availability is when every request receives a response without the guarantee that it contains the most recent write.

Partition tolerance is when the system continues to function and upholds its guarantees in spite of network partitions.

CAP Theorem

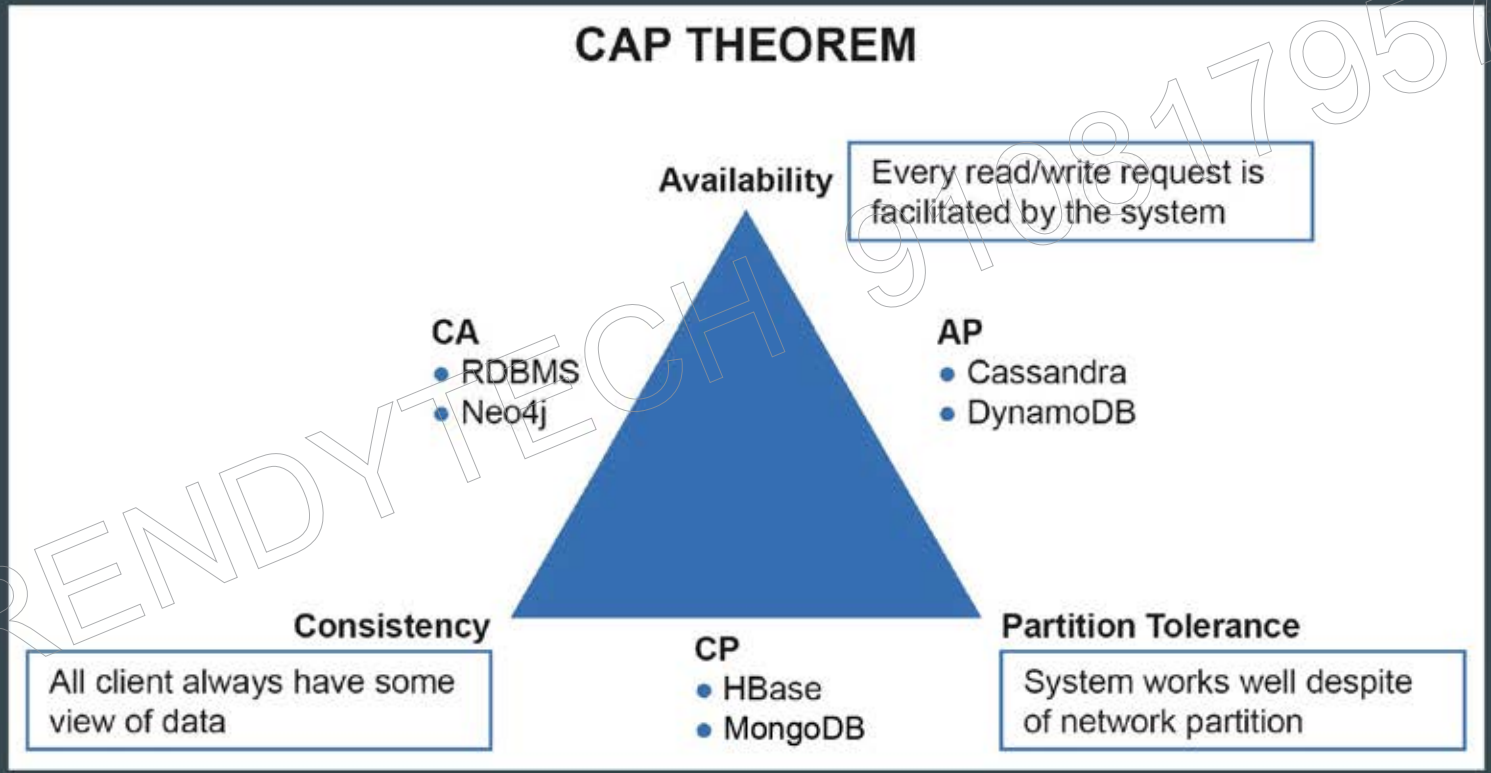
Some of the known systems and guarantees provided by them are mentioned below:

- RDBMS (support SQL): Consistency and availability.

- NoSQL Systems: They store data in a distributed manner across a cluster of interconnected machines and provide network partitioning. There are two flavours of NoSQL databases that provide a different set of guarantees:

1. Consistency and partition tolerance (e.g. - HBase, MongoDB)
2. Availability and partition tolerance (e.g. - Cassandra, DynamoDB)

CAP Theorem



CAP Theorem

While designing networked shared-data systems, the system designers should make the trade-off between consistency, availability, and partition tolerance depending upon the type of application.

If one chooses consistency over availability, the system will report an error or a time-out if a particular piece of information is not updated due to network partitioning.

Consider a chat application, using which you send an instant message to your friend. If a network partition occurs during this process, the message will ideally not get delivered and there will be a timeout.

Once the system is up, the exact message that you had sent will be delivered to your friend's inbox.

CAP Theorem

So, in a messaging application, consistency is given preference over availability. Just to ensure instantaneous delivery of messages, the system should not deliver a garbage message.

When one chooses availability over consistency, the system processes the query and returns the newest version of information available, even if the data is not the latest due to network partitioning.

Consider another example of using a travel portal such as MakeMyTrip to check for available hotel rooms. If the portal is unable to fetch the latest prices due to network partition, it's perfectly fine. Instead, other aspects such as the location of the hotel, amenities provided should be the latest.

CAP Theorem

So, in a messaging application, consistency is given preference over availability. Just to ensure instantaneous delivery of messages, the system should not deliver a garbage message.

When one chooses availability over consistency, the system processes the query and returns the newest version of information available, even if the data is not the latest due to network partitioning. Consider another example of using a travel portal such as MakeMyTrip to check for available hotel rooms. If the portal is unable to fetch the latest prices due to network partition, it's perfectly fine because the customer may not be concerned about prices; instead, they are concerned about other aspects such as the location of the hotel, amenities provided, etc. In such scenarios, using a highly available data store is a must because travel portals and e-commerce websites cannot afford website timeout to show consistent results.

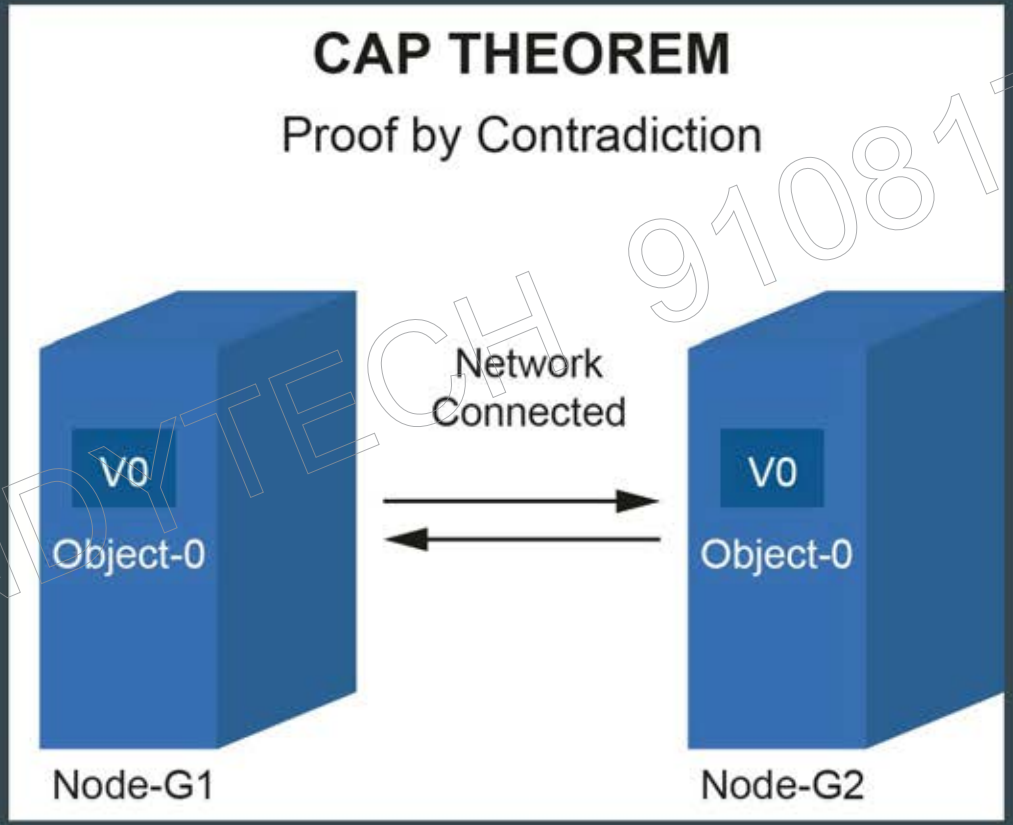
CAP Theorem

Let's look at the proof of the CAP theorem by contradiction.

To prove the CAP theorem by contradiction, we assume a distributed data store that guarantees consistency, availability, and partition tolerance.

Let the data store consist of two nodes G1 and G2, maintaining an object O with an initial value of v0. We will construct an execution of a sequence of queries in which there exists a request that returns an inconsistent response.

CAP Theorem



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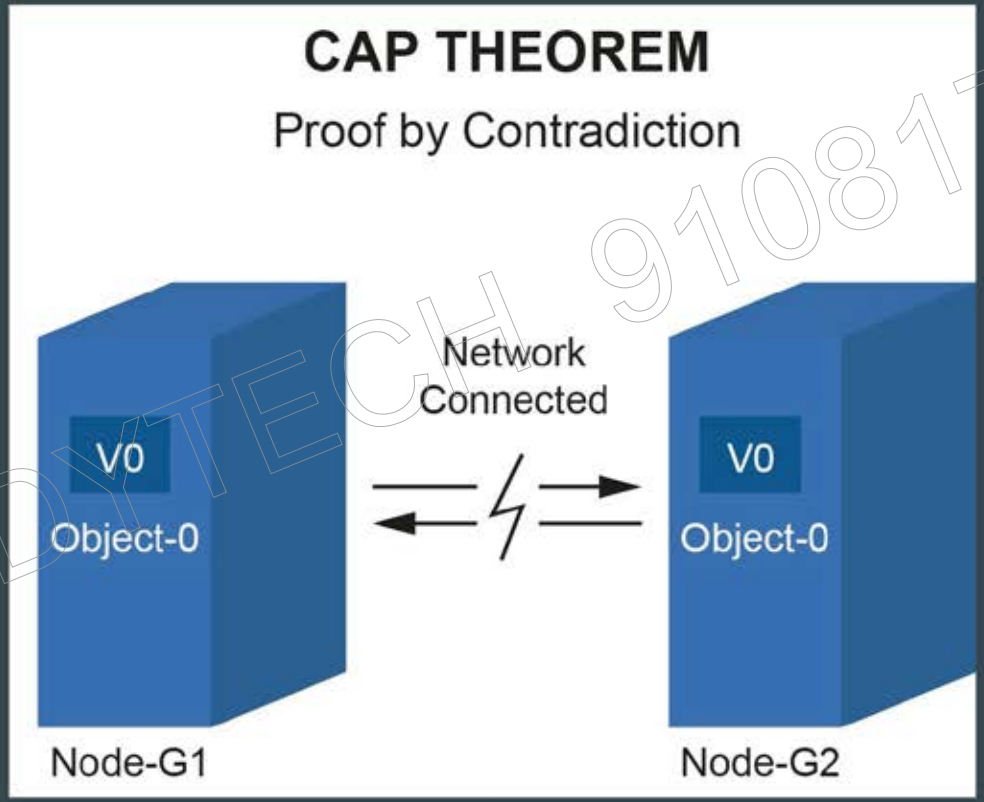

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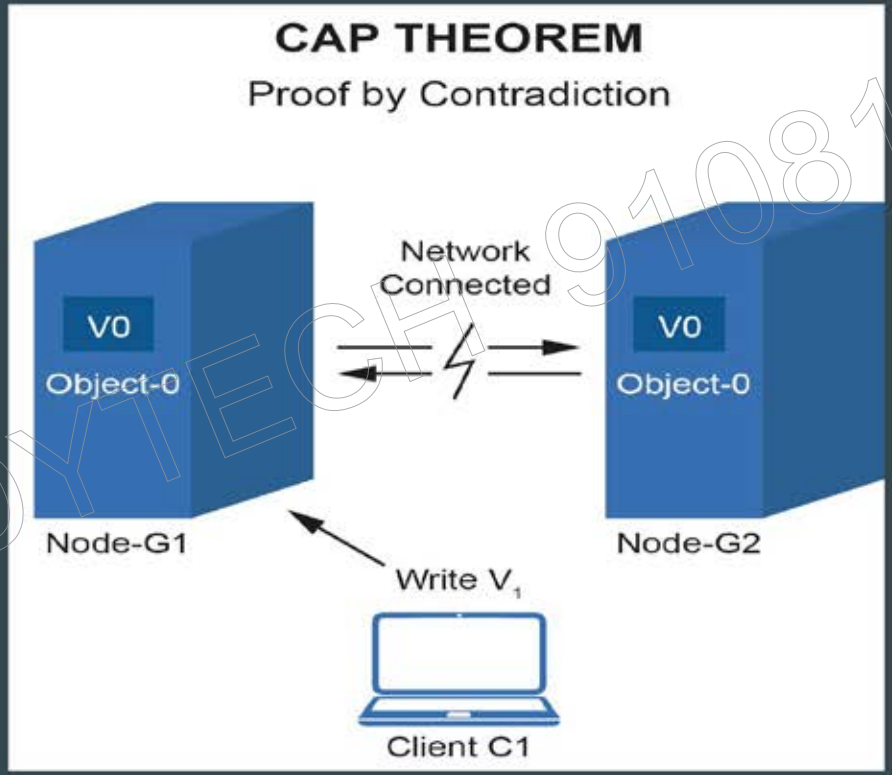

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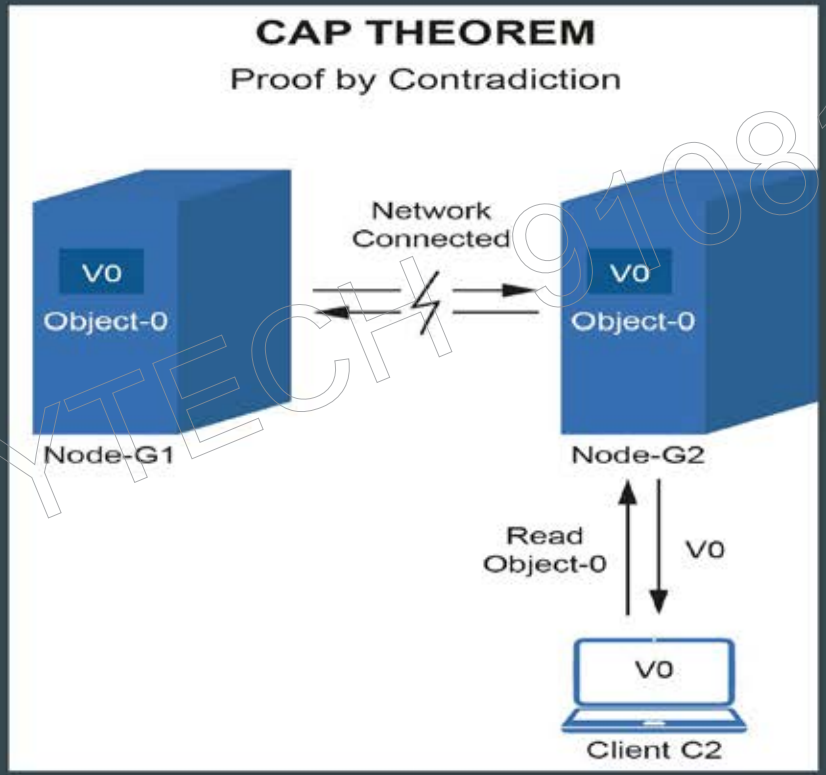

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