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1. What Is a SQL Server Failover Cluster Instance (FCI)?

A **Failover Cluster Instance (FCI)** is a **high-availability (HA)** solution where multiple Windows servers (nodes) work together to provide a **single SQL Server instance**. If one node fails, the SQL instance **automatically fails over** to another node with **minimal downtime**.

- **Storage** is shared between nodes (e.g., SAN or shared disk in Azure).
- Only **one node is active** at a time.
- IP address and instance name remain the same after failover — transparent to applications.

2. Prerequisites for Windows and SQL Server Failover Clustering

A. Windows Server Prerequisites

Component	Details
Windows Version	Must be **Enterprise or Datacenter** edition (Standard supports limited clustering).
Same Domain Membership	All nodes must be **joined to the same Active Directory domain**.
Static IP Addresses	Each node needs its own static IP + 1 virtual IP for the cluster.
Hostnames	Each node must have a unique hostname; DNS must resolve properly.
Time Sync	All nodes must have **synchronized system clocks** (important for Kerberos).
Same OS Patch Level	Identical OS version, edition, and patch level on all nodes.
Cluster Shared Volumes (CSV)	Use shared storage like **SAN, iSCSI, or Storage Spaces Direct**. Each node must have access to shared disks.
Windows Features	Install the feature: **Failover Clustering** using Server Manager or PowerShell.Install-WindowsFeature Failover-Clustering –IncludeManagementTools
Cluster Validation	Run **Cluster Validation Wizard** to check network, storage, and system readiness before creating the cluster.

B. SQL Server Prerequisites

Component	Details
SQL Server Edition	Enterprise supports unlimited nodes; Standard supports **2-node** clusters only.
Same SQL Version & Patch	Identical binaries and CU levels on all nodes.
Shared Disk Configuration	SQL Data and Log drives are **shared between nodes** (active node owns them).
Dedicated Service Accounts	Use domain accounts for SQL services (SQL Server, SQL Agent, etc.).
Cluster-aware Installation	Install SQL Server using the “New SQL Server Failover Cluster installation” option.
Instance Name	The same across all nodes; cluster creates a **virtual network name (VNN)** and **virtual IP**.
Permissions	SQL service accounts need Log on as a service and read/write access to shared disks.

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3. Real-Time Use Cases

Scenario	Description
Mission-Critical OLTP Systems	Banking, insurance, retail systems needing near-zero downtime.
On-Premise Data Centers	Where shared SAN storage is available; often used with Always On AGs for DR.
High Availability for Legacy Apps	When apps cannot handle multi-database Always On AGs, FCI provides instance-level HA.
Hybrid Cloud (Azure SQL VM)	Use FCI with Azure Shared Disks for HA within a single region.

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🚀 4. Advantages of SQL Server Failover Clustering

Advantage	Explanation
High Availability	Automatic failover to standby node within seconds.
Single Point of Access	Clients connect to one virtual name/IP regardless of which node is active.
No Data Loss	Storage is shared, so no need for data replication.
Supported by All SQL Features	Works with replication, SSIS, SQL Agent jobs, etc.
Maintenance Flexibility	Patch or reboot one node while the other is active.
Integrated with Windows Clustering	Managed centrally via Failover Cluster Manager.

⚠️ 5. Disadvantages / Limitations

Limitation	Description
Shared Storage Dependency	Both nodes rely on the same SAN — if SAN fails, the cluster fails.
Single Data Copy	No redundancy at the data level (unlike Always On AGs).
Complex Setup & Maintenance	Requires careful planning, validation, and patching coordination.
Expensive Infrastructure	Needs SAN, multiple nodes, and Enterprise licensing for scaling.
Failover Duration	While short (seconds), active connections are dropped and reconnected.
Not a Disaster Recovery Solution	FCI is local HA — for DR, you need AGs, Log Shipping, or Replication.

🧯 6. Common Issues and Resolutions

Issue	Root Cause	Resolution
Cluster validation fails	Misconfigured DNS, permissions, or mismatched OS patching	Fix DNS entries, ensure domain connectivity, same OS build, rerun validation.
SQL service not starting on secondary node	Missing shared disk or incorrect drive letter mapping	Ensure shared disks have the **same drive letters and paths** on all nodes.
Failover taking too long	Hardware delays, storage response, or quorum misconfiguration	Tune quorum (Node Majority or Node + Disk), check storage latency.
Quorum lost	Node count odd/even mismatch after failure	Use **Witness (File Share/Disk)** to maintain quorum.
Virtual network name not accessible	DNS not updated or firewall blocking	Verify cluster name object (CNO) in AD, and open required ports (1433, 3343, RPC).
Patch level mismatch	One node not updated to same SQL CU	Always apply patches **one node at a time** in passive mode, then failover.
Storage ownership not transferring	Storage driver or permission issue	Verify cluster storage ownership can move between nodes (via Failover Cluster Manager).

🧠 7. Best Practices (Real-Time DBA Checklist)

✅ Run **Cluster Validation Wizard** before setup.
✅ Keep **identical configurations** on both nodes (CPU, memory, OS patch, SQL version).
✅ Use **dedicated disks** for data, logs, tempdb, and quorum.
✅ Configure **Cluster Shared Volumes (CSV)** where possible.
✅ Always **backup system databases** before cluster patching.

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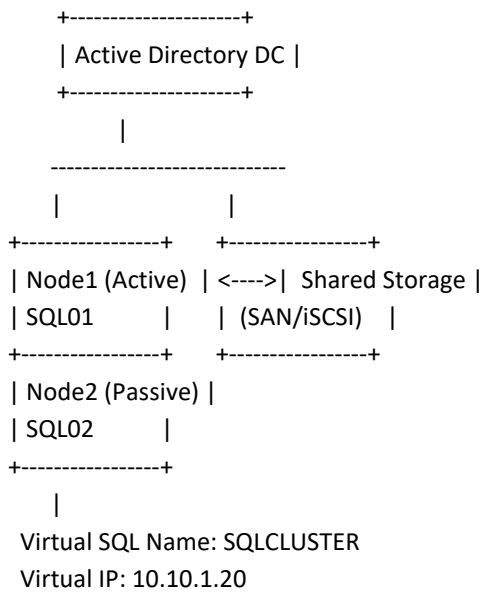
✅ Test **manual failover** after setup.
✅ Monitor with **Cluster Logs and SQL Error Logs**.
✅ Integrate with **SQL Agent alerts** and **Windows Event forwarding**.

🧩 8. Example Architecture (2-Node FCI)



💡 9. Comparison: FCI vs Always On AG

Feature	FCI	Always On AG
Level of HA	Instance-level	Database-level
Storage	Shared	Independent copies
Data Redundancy	No	Yes
Failover Speed	Moderate	Fast
Edition Support	Std: 2-node	Std: 2-replica
Complexity	Lower	Higher
DR Support	No	Yes

🔍 10. Tools for Monitoring and Troubleshooting

- **Failover Cluster Manager**
- **PowerShell (Get-ClusterResource, Get-ClusterGroup)**
- **Cluster.log** (Get-ClusterLog -UseLocalTime)
- **Event Viewer (System/FailoverClustering logs)**
- **SQL Error Logs and Agent Logs**
- **Performance Monitor (Disk, CPU, Memory)**
- **SentryOne / Redgate SQL Monitor** (for failover detection and alerting)