**HPC Clusters Architecture**

High-Performance Computing (HPC) clusters are designed for parallel processing, enabling complex computations across multiple nodes. An HPC cluster typically consists of the following key components:

**1. Architecture Components**

**1.1 Head Node (Master Node):**

* Manages the cluster.
* Handles scheduling, job submission, and monitoring.
* Examples: Slurm, PBS, or Torque for workload management.

**1.2 Compute Nodes (Worker Nodes):**

* Perform the actual computation.
* Connected through high-speed networks.

**1.3 Storage:**

* Centralized or distributed storage to share data across nodes.
* Examples: NFS, Lustre, GPFS.

**1.4 Network:**

* High-speed interconnects like InfiniBand or Ethernet for communication between nodes.

**1.5 Management Interface:**

* Tools to configure, monitor, and maintain the cluster.
* Examples: Ganglia, Prometheus.

**2. Logical Diagram**

Here’s a textual representation of the architecture:

sql

CopyEdit

+----------------+ +----------------+

| Head Node | <---> | Compute Node |

| (Job Manager) | | 1 |

+----------------+ +----------------+

|

| +----------------+

|--------------> | Compute Node |

| 2 |

+----------------+

.

.

.

+----------------+

| Compute Node |

| N |

+----------------+

Storage (NFS/Shared File System)

|

-------------------------------------

| | |

+-------+ +-------+ +-------+

| Node 1| | Node 2| | Node N|

+-------+ +-------+ +-------+

**3. Example Commands for HPC Cluster Setup**

Below is an example setup using **Slurm Workload Manager**.

**Step 1: Install Required Software**

On all nodes, install necessary packages.

bash

CopyEdit

sudo apt update && sudo apt install slurm-wlm munge nfs-common -y

**Step 2: Configure Head Node**

1. **Install Slurm Controller:**

bash

CopyEdit

sudo apt install slurmctld -y

1. **Create Slurm Configuration (/etc/slurm/slurm.conf):**

bash

CopyEdit

ControlMachine=headnode

NodeName=compute[1-4] CPUs=4 State=UNKNOWN

PartitionName=debug Nodes=ALL Default=YES MaxTime=INFINITE State=UP

1. **Start Slurm Controller:**

bash

CopyEdit

sudo systemctl start slurmctld

**Step 3: Configure Compute Nodes**

1. **Install Slurm Daemon:**

bash

CopyEdit

sudo apt install slurmd -y

1. **Update Configuration (/etc/slurm/slurm.conf):** Same as on the Head Node.
2. **Start Slurm Daemon:**

bash

CopyEdit

sudo systemctl start slurmd

**Step 4: Shared Storage**

1. **Export Directory on Head Node:**

bash

CopyEdit

sudo apt install nfs-kernel-server -y

sudo mkdir /shared

echo "/shared \*(rw,sync,no\_subtree\_check)" | sudo tee -a /etc/exports

sudo exportfs -a

sudo systemctl restart nfs-server

1. **Mount Shared Directory on Compute Nodes:**

bash

CopyEdit

sudo apt install nfs-common -y

sudo mount headnode:/shared /shared

**Step 5: Submit Jobs**

Submit a test job to the cluster:

bash

CopyEdit

echo -e "#!/bin/bash\nsrun hostname" > test\_job.sh

chmod +x test\_job.sh

sbatch test\_job.sh

**4. Diagram**

Here is the diagram illustrating the HPC cluster architecture. Let me know if you'd like further explanation or modifications!