## 🧠 Kubernetes Cluster — Complete Summary

### 🔹 What Is a Kubernetes Cluster?

A **Kubernetes cluster** is the environment where containerized applications are deployed, managed, and scaled. It includes:

#### 1. ****Control Plane**** (Master node):

* **API Server**: Receives commands from kubectl
* **Scheduler**: Decides which node runs which Pod
* **Controller Manager**: Runs background logic like ReplicaSets
* **etcd**: Cluster state storage (key-value store)

#### 2. ****Worker Nodes****:

* Run the **actual applications** (Pods)
* Each has:
  + kubelet: Talks to API server
  + kube-proxy: Manages networking
  + Container runtime (Docker, containerd)

### 🔹 Can You Create Multiple Clusters on One System?

✅ **Yes** — tools like minikube and kind let you create multiple clusters:

bash

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minikube start -p cluster1

minikube start -p cluster2

Each cluster is isolated and has its own control plane and nodes.

Switch between clusters using:

bash

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kubectl config get-contexts

kubectl config use-context <context-name>

### 🔹 Is One Cluster for One App?

🟡 Not necessarily.

* One cluster can run **multiple apps**.
* Each app can include:
  + Frontend (React, Angular)
  + Backend (Node, Django, Spring)
  + DB (Postgres, MongoDB)
* Use **Namespaces** to separate apps logically.
* Use **labels, services, and resource quotas** to manage isolation.

### 🔹 Where Does a Pod Run?

* The **Scheduler** decides which **worker node** the Pod runs on.
* Decision based on:
  + Available CPU/RAM
  + Node selectors or affinity rules
  + Taints/tolerations

Check where a pod is running:

bash

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kubectl get pods -o wide

### 🔹 Can a Cluster Be on One System?

✅ Yes — for development and testing:

* Tools: minikube, kind, MicroK8s
* Single-node cluster: Control plane + worker node run on the same machine

✅ In production:

* Multi-node clusters run on **multiple machines**, often in the cloud.

### 🔹 Common Error: "connection refused" on kubectl apply

If you see:

pgsql

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failed to download openapi: Get "http://localhost:8080/openapi/v2": connection refused

It means:

* The **API server isn’t reachable**.
* Most likely, the **cluster isn’t running** or kubectl is misconfigured.

Fix:

bash

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minikube start

kubectl apply -f pod.yaml

🧠 Can You Run Multiple Pods of the Same App on One Node?

### ✅ YES — It’s Common Practice

* Kubernetes will schedule multiple pods on a node **if there's enough CPU and RAM**
* This is **efficient resource usage**

### ⚠️ BUT in Production:

* **Avoid putting all replicas on the same node**
* If that node fails, your app goes down
* Use features like:
  + **Pod anti-affinity**
  + **Node selectors**
  + **Taints and tolerations**
  + **Multiple nodes or AZs**

## 🖥️ Can a Cluster Be on One System?

### ✅ YES — Single System Cluster (e.g., your laptop)

Tools:

* minikube
* kind
* MicroK8s

These tools simulate a cluster with both:

* Control plane
* Worker node(s)

## 🧰 How Minikube Works Internally

Minikube creates a **local Kubernetes cluster** inside a **VM or container** on your system.

### 🛠️ How it simulates a cluster:

* Starts a **control plane node**
* You can **add multiple nodes** (for testing multi-node clusters):

bash

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minikube start --nodes=3

This runs 3 virtualized nodes inside your system, acting like:

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minikube-m01 → control plane

minikube-m02 → worker

minikube-m03 → worker

You can verify with:

bash

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kubectl get nodes