AWS Cloud Computing Practical Guide

Complete Step-by-Step Solutions for All 13 Labs

Course: Cloud Computing AWS
Type: Practical Lab Guide - Complete Solutions
Total Labs: 13
Format: Step-by-step instructions with commands and screenshots guidance

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Lab 1: Install and Configure ESXi

What is ESXi?

VMware ESXi is a bare-metal hypervisor that installs directly on physical servers to create and run virtual machines.

Prerequisites

- Physical server with virtualization support (Intel VT-x or AMD-V)
- Minimum 4GB RAM (8GB+ recommended)
- 32GB storage minimum
- Network adapter
- ESXi ISO file downloaded from VMware

Part A: Install ESXi

Step 1: Create Bootable Media

1. Download ESXi ISO from VMware website
2. Use Rufus or similar tool to create bootable USB
3. Boot server from USB

Step 2: Installation Process

1. Press Enter at ESXi boot screen
2. Accept EULA (F11)
3. Select installation disk

4. Select keyboard layout (US Default)
5. Set root password (minimum 8 characters)
6. Press F11 to confirm installation
7. Reboot after completion

Step 3: Initial Configuration

1. After reboot, press F2 at ESXi screen
2. Login with root credentials
3. Navigate to "Configure Management Network"
4. Configure network settings:
    - Set IPv4 Configuration (static or DHCP)
    - Example: IP: 192.168.1.100, Subnet: 255.255.255.0, Gateway: 192.168.1.1
    - Set DNS servers
5. Press ESC to save and exit
6. Restart management network (Y)

Part B: Access ESXi Web Interface

1. From another computer, open browser
2. Navigate to: `https://[ESXi-IP-Address]`
3. Login with root credentials
4. You can now create and manage VMs

Part C: Create Your First VM

1. Click "Virtual Machines" → "Create/Register VM"
2. Select "Create a new virtual machine"
3. Configure:
    - Name: Test-VM
    - Guest OS: Select appropriate OS
    - Storage: Select datastore
    - CPU: 2 cores
    - Memory: 4GB

- Hard disk: 40GB
- Network: VM Network

4. Mount ISO file for OS installation
5. Power on VM and complete OS installation

Lab 2: Configure CDP, NAT-PAT in SOHO and Enterprise

A. Cisco Discovery Protocol (CDP)

What is CDP? CDP is a Cisco proprietary protocol that discovers information about directly connected Cisco devices.

Configuration Steps (Cisco Router/Switch):

```
! Enable CDP globally (usually enabled by default)
Router> enable
Router# configure terminal
Router(config)# cdp run

! Enable CDP on specific interface
Router(config)# interface gigabitEthernet 0/0
Router(config-if)# cdp enable
Router(config-if)# exit

! Verify CDP
Router# show cdp neighbors
Router# show cdp neighbors detail

! Configure CDP timers
Router(config)# cdp timer 60        ! Send CDP packets every 60 seconds
Router(config)# cdp holdtime 180    ! Hold information for 180 seconds

! Disable CDP (security consideration)
Router(config)# no cdp run          ! Globally
Router(config-if)# no cdp enable    ! Per interface
```

B. NAT Configuration (Network Address Translation)

Static NAT (One-to-One Mapping):

```
! Configure inside and outside interfaces
Router(config)# interface gigabitEthernet 0/0
Router(config-if)# ip address 192.168.1.1 255.255.255.0
Router(config-if)# ip nat inside
Router(config-if)# exit

Router(config)# interface gigabitEthernet 0/1
Router(config-if)# ip address 203.0.113.1 255.255.255.0
Router(config-if)# ip nat outside
Router(config-if)# exit

! Create static NAT mapping
Router(config)# ip nat inside source static 192.168.1.10 203.0.113.10

! Verify
Router# show ip nat translations
Router# show ip nat statistics
```

Dynamic NAT (Pool-Based):

```
! Define inside network
Router(config)# access-list 1 permit 192.168.1.0 0.0.0.255

! Define NAT pool
Router(config)# ip nat pool PUBLIC_POOL 203.0.113.10 203.0.113.20 netmask 255.255.255.0

! Map ACL to pool
Router(config)# ip nat inside source list 1 pool PUBLIC_POOL

! Configure interfaces
Router(config)# interface g0/0
Router(config-if)# ip nat inside
Router(config)# interface g0/1
Router(config-if)# ip nat outside
```

C. PAT Configuration (Port Address Translation / NAT Overload)

PAT with Interface Overload (SOHO Setup):

```
! Define inside network
Router(config)# access-list 1 permit 192.168.1.0 0.0.0.255

! Configure PAT using interface
Router(config)# ip nat inside source list 1 interface gigabitEthernet 0/1 overload

! Configure inside interface
Router(config)# interface g0/0
Router(config-if)# ip address 192.168.1.1 255.255.255.0
Router(config-if)# ip nat inside
Router(config-if)# exit

! Configure outside interface
Router(config)# interface g0/1
Router(config-if)# ip address dhcp
Router(config-if)# ip nat outside
Router(config-if)# exit

! Verify
Router# show ip nat translations
Router# debug ip nat
```

PAT with Pool (Enterprise Setup):

```
! Define ACL
Router(config)# access-list 10 permit 10.0.0.0 0.255.255.255

! Create NAT pool
Router(config)# ip nat pool ENTERPRISE_PAT 203.0.113.1 203.0.113.5 netmask 255.255.255.248

! Enable PAT
Router(config)# ip nat inside source list 10 pool ENTERPRISE_PAT overload

! Configure interfaces
Router(config)# interface range g0/0-2
Router(config-if-range)# ip nat inside
Router(config)# interface g0/3
Router(config-if)# ip nat outside
```

Lab 3: AWS Managerial Tools & Disaster Management Policies

A. AWS CloudWatch (Monitoring)

Step 1: Access CloudWatch

1. Login to AWS Console
2. Navigate to CloudWatch service

Step 2: Create Dashboard

1. Click "Dashboards" → "Create dashboard"
2. Name: Production-Monitoring
3. Add widgets:
    - Line graph for EC2 CPU utilization
    - Number widget for billing
    - Log widget for application logs

Step 3: Set Up Alarms

1. Click "Alarms" → "Create alarm"
2. Select metric (e.g., EC2 > Per-Instance Metrics > CPUUtilization)
3. Conditions: Greater than 80%
4. Period: 5 minutes
5. Actions: Send notification to SNS topic
6. Create SNS topic: High-CPU-Alert
7. Add email subscription
8. Name alarm: High-CPU-Usage

Step 4: Create Billing Alarm

1. Region: Switch to US East (N. Virginia)
2. CloudWatch → Billing → Total Estimated Charge
3. Threshold: > $50
4. Action: Email notification

B. AWS CloudTrail (Auditing)

Configuration Steps:

Step 1: Create Trail

1. Services → CloudTrail
2. Trails → Create trail
3. Trail name: Organization-Audit-Trail
4. Storage location: Create new S3 bucket
5. Bucket name: company-cloudtrail-logs-2024
6. Log file validation: Enabled
7. SNS notification: Optional
8. CloudWatch Logs: Enable
9. Tags: Environment: Production

Step 2: Configure Events

1. Management events: Read/Write
2. Data events: S3, Lambda (optional)
3. Insights events: Enable

Step 3: View Events

1. Event history → Filter by:
    - Event name
    - User name
    - Resource type
    - Time range
2. Example: Find all DeleteBucket API calls

C. AWS Backup (Disaster Recovery)

Step 1: Create Backup Vault

1. AWS Backup → Backup vaults → Create vault
2. Name: Production-Backup-Vault

3. Encryption: Use AWS managed key or custom KMS key
4. Add tags

Step 2: Create Backup Plan

1. Backup plans → Create plan
2. Start with template: Daily-Monthly-1yr-Retention
3. Plan name: Production-Backup-Plan

Backup rule configuration:

- Rule name: Daily-Backups
- Frequency: Daily
- Backup window: 1:00 AM - 3:00 AM
- Retention: 35 days
- Vault: Production-Backup-Vault
- Copy to region: Yes (different region for DR)
- Lifecycle to cold storage: After 7 days

Step 3: Assign Resources

1. Resource assignment → Assign resources
2. Assignment name: Production-Resources
3. IAM role: Default or create new
4. Resource selection:
    - By tags: Environment=Production
    - Or specific resources: Select EC2, RDS, EFS

Step 4: Test Restore

1. Backup vaults → Select vault
2. Recovery points → Choose backup
3. Restore → Configure:
    - Instance type

- Subnet
- Security groups

4. Start restore job
5. Verify restored resource

D. Disaster Recovery Plan

Multi-Region DR Setup:

1. Cross-Region Replication

```
Primary Region: us-east-1
DR Region: us-west-2

S3 Replication:
- Source bucket: Create in us-east-1
- Enable versioning
- Create replication rule:
  • Destination: New bucket in us-west-2
  • IAM role: Auto-create
  • Objects: All
  • Storage class: Same as source

RDS Cross-Region:
- RDS → Select database
- Actions → Create read replica
- Destination region: us-west-2
- Instance specifications: Match production
```

2. Route 53 Failover

1. Route 53 → Hosted zones
2. Create record:
   - Name: www.example.com
   - Type: A record
   - Routing policy: Failover
   - Primary record: us-east-1 load balancer
   - Secondary record: us-west-2 load balancer
   - Health check: Create for primary

- Protocol: HTTPS
- Port: 443
- Path: /health

Lab 4: AWS Storage Management, Basic Security & Create VPC with Database Management

A. S3 Storage Management

Step 1: Create and Configure S3 Bucket

1. Navigate to S3 console
2. Create bucket:
    - Name: my-company-data-2024 (globally unique)
    - Region: us-east-1
    - Block all public access: Enabled
    - Versioning: Enable
    - Tags: Project=DataStorage
    - Encryption: Enable (SSE-S3)
3. Configure lifecycle rules:
    - Management → Lifecycle rules → Create rule
    - Rule name: Archival-Policy
    - Scope: All objects
    - Actions:
        - Transition to S3 Standard-IA after 30 days
        - Transition to Glacier after 90 days
        - Delete after 365 days

Step 2: S3 Security Configuration Bucket Policy Example:

```
json
```

```
{
 "Version": "2012-10-17",
 "Statement": [
  {
   "Sid": "AllowAppAccess",
   "Effect": "Allow",
   "Principal": {
    "AWS": "arn:aws:iam::123456789012:role/AppRole"
   },
   "Action": [
    "s3:GetObject",
    "s3:PutObject"
   ],
   "Resource": "arn:aws:s3:::my-company-data-2024/*"
  }
 ]
}
```

Apply policy:

- Bucket → Permissions → Bucket policy
- Paste JSON → Save

B. EBS Management

Create and Attach EBS Volume:

1. EC2 → Elastic Block Store → Volumes
2. Create volume:
    - Type: gp3 (General Purpose SSD)
    - Size: 100 GiB
    - IOPS: 3000
    - Throughput: 125 MB/s
    - Availability Zone: Same as EC2 instance
    - Encryption: Enable
    - Snapshot: None (or select existing)
3. Attach to instance:
    - Select volume → Actions → Attach volume

- Instance: Select target EC2
- Device: /dev/sdf

4. On EC2 instance (Linux):

```
bash

sudo lsblk                    # List block devices
sudo mkfs -t ext4 /dev/xvdf   # Format volume
sudo mkdir /data              # Create mount point
sudo mount /dev/xvdf /data    # Mount volume

# Make permanent:
sudo blkid /dev/xvdf          # Get UUID
sudo nano /etc/fstab
# Add: UUID=xxx /data ext4 defaults 0 2
```

C. Create VPC with Database

Complete VPC Setup:

Step 1: Create VPC

1. VPC Dashboard → Your VPCs → Create VPC
    - Name: Production-VPC
    - IPv4 CIDR: 10.0.0.0/16
    - IPv6: No IPv6 CIDR block
    - Tenancy: Default
    - Tags: Environment=Production

Step 2: Create Subnets Create 4 subnets (2 public, 2 private in different AZs):

Public Subnet 1:

- VPC: Production-VPC
- Name: Public-Subnet-1A
- AZ: us-east-1a
- CIDR: 10.0.1.0/24

Public Subnet 2:

- Name: Public-Subnet-1B
- AZ: us-east-1b
- CIDR: 10.0.2.0/24

Private Subnet 1:

- Name: Private-Subnet-1A
- AZ: us-east-1a
- CIDR: 10.0.11.0/24

Private Subnet 2:

- Name: Private-Subnet-1B
- AZ: us-east-1b
- CIDR: 10.0.12.0/24

Step 3: Internet Gateway

1. Internet Gateways → Create IGW
    - Name: Production-IGW
2. Actions → Attach to VPC → Select Production-VPC

Step 4: NAT Gateway

1. NAT Gateways → Create NAT gateway
    - Name: Production-NAT
    - Subnet: Public-Subnet-1A
    - Elastic IP: Allocate new

Step 5: Route Tables

Public Route Table:

1. Create route table:
    - Name: Public-RT
    - VPC: Production-VPC
2. Add routes:

- Destination: 0.0.0.0/0
- Target: Production-IGW

3. Associate subnets:
    - Public-Subnet-1A
    - Public-Subnet-1B

Private Route Table:

1. Create route table:
    - Name: Private-RT
2. Add routes:
    - Destination: 0.0.0.0/0
    - Target: Production-NAT
3. Associate subnets:
    - Private-Subnet-1A
    - Private-Subnet-1B

Step 6: Security Groups

Web Server Security Group:

- Name: WebServer-SG
- Inbound rules:
    - HTTP (80) from 0.0.0.0/0
    - HTTPS (443) from 0.0.0.0/0
    - SSH (22) from Your-IP/32
- Outbound: All traffic

Database Security Group:

- Name: Database-SG
- Inbound rules:
    - MySQL (3306) from WebServer-SG
    - PostgreSQL (5432) from WebServer-SG

- Outbound: None needed

Step 7: Deploy RDS Database

1. RDS → Create database
2. Configuration:
    - Engine: MySQL / PostgreSQL
    - Version: Latest
    - Template: Production
    - DB identifier: production-db
    - Master username: admin
    - Password: [Strong password]
    - Instance class: db.t3.medium
    - Storage: 100 GB gp3
    - VPC: Production-VPC
    - Subnet group: Create new
        - Name: db-subnet-group
        - Subnets: Private-Subnet-1A, Private-Subnet-1B
    - Public access: No
    - Security group: Database-SG
    - Initial database: myapp
    - Backup retention: 7 days
    - Encryption: Enable
    - Monitoring: Enhanced monitoring

Step 8: Launch EC2 in Public Subnet

1. EC2 → Launch instance
    - AMI: Amazon Linux 2
    - Instance type: t2.micro
    - Network: Production-VPC
    - Subnet: Public-Subnet-1A
    - Auto-assign public IP: Enable

- Security group: WebServer-SG
- Key pair: Create/select key

2. User data (install web server):

```bash
#!/bin/bash
yum update -y
yum install -y httpd
systemctl start httpd
systemctl enable httpd
echo "<h1>Web Server in Production VPC</h1>" > /var/www/html/index.html
```

Step 9: Test Connectivity

1. SSH to EC2:

```bash
ssh -i keypair.pem ec2-user@[public-ip]
```

2. Test database connection:

```bash
mysql -h [rds-endpoint] -u admin -p
```

3. Test internet from private subnet (should work through NAT Gateway)

Lab 5: Plan and Design File Server and Distribution File Server

Windows Server File Server Setup

Step 1: Install File Server Role

1. Server Manager → Add Roles and Features
2. Installation Type: Role-based
3. Server: Select local server

4. Server Roles: Check "File and Storage Services"
    - Expand and select:
        - File Server
        - File Server Resource Manager
        - DFS Namespaces
        - DFS Replication
5. Complete installation

Step 2: Create Shared Folders

1. Server Manager → File and Storage Services → Shares
2. New Share Wizard:
    - Profile: SMB Share - Quick
    - Location: C:\Shares
    - Share name: CompanyDocs
    - Settings:
        - Enable access-based enumeration
        - Enable continuous availability (optional)
    - Permissions:
        - Administrators: Full Control
        - Domain Users: Read/Write
        - Everyone: Remove
3. Create share

Step 3: Configure NTFS Permissions

1. Navigate to C:\Shares\CompanyDocs
2. Right-click → Properties → Security
3. Configure permissions:
    - Administrators: Full Control
    - Accounting_Group: Modify
    - HR_Group: Read & Execute

- Remove inheritance if needed

4. Advanced → Disable inheritance → Convert

Step 4: DFS Setup (Distributed File System)

1. Server Manager → Tools → DFS Management
2. New Namespace:
    - Namespace server: YourServer
    - Name: CompanyFiles
    - Type: Domain-based
    - Path: \domain.com\CompanyFiles
3. Add folders:
    - New Folder → Name: Documents
    - Add folder target: \Server1\CompanyDocs
    - Add folder target: \Server2\CompanyDocs (for replication)
4. Configure replication:
    - Right-click folder → Replicate Folder
    - Replication group: CompanyDocs-RG
    - Members: Server1, Server2
    - Topology: Full mesh
    - Schedule: Continuously

Step 5: File Server Resource Manager

1. Server Manager → Tools → File Server Resource Manager
2. Create quota:
    - Quota Templates → Create Quota
    - Path: C:\Shares\CompanyDocs\Users
    - Template: 200 GB Limit
    - Auto apply: Yes
3. Create file screen:
    - File Screening → Create File Screen
    - Path: C:\Shares\CompanyDocs

- Template: Block Audio and Video Files
- Active screening (blocks saves)

4. Storage reports:
    - Storage Reports Management → Schedule New Report
    - Reports: Large Files, Quota Usage
    - Schedule: Weekly
    - Delivery: Email to admin

Lab 6: Perform LAN LAB

Complete LAN Setup (Two PCs)

Physical Setup: Equipment needed:

- 2 PCs (PC-A and PC-B)
- 1 Switch or crossover cable
- 2 Ethernet cables (if using switch)

Part A: Configure IP Addresses

PC-A Configuration (Windows):

1. Control Panel → Network and Sharing Center
2. Change adapter settings
3. Right-click Ethernet → Properties
4. Select Internet Protocol Version 4 (TCP/IPv4)
5. Configure:
    - IP address: 192.168.1.10
    - Subnet mask: 255.255.255.0
    - Default gateway: (leave blank for direct connection)
    - Preferred DNS: (leave blank)
6. Click OK

PC-B Configuration: Same steps but:

- IP address: 192.168.1.20
- Subnet mask: 255.255.255.0

Linux Configuration (if using Linux):

```
bash

PC-A:
sudo ip addr add 192.168.1.10/24 dev eth0
sudo ip link set eth0 up

PC-B:
sudo ip addr add 192.168.1.20/24 dev eth0
sudo ip link set eth0 up
```

Part B: Create Shared Folder

On PC-A (Windows):

1. Create folder: C:\SharedFolder
2. Right-click → Properties → Sharing tab
3. Advanced Sharing:
    - Check "Share this folder"
    - Share name: SharedData
    - Permissions:
        - Everyone: Full Control (for lab only)
        - In production: Specific users/groups only
4. Click OK
5. Security tab:
    - Edit permissions
    - Add: Everyone (for lab)
    - Allow: Full Control
    - Apply

On PC-B (Create shared folder too):

1. Create folder: C:\SharedFolder
2. Share with same settings
3. Share name: PC-B-Share

Part C: Test Connectivity

From PC-A:

1. Open Command Prompt
2. Ping PC-B:

```
ping 192.168.1.20

Expected output:
Reply from 192.168.1.20: bytes=32 time<1ms TTL=128
Reply from 192.168.1.20: bytes=32 time<1ms TTL=128
```

3. Access shared folder:
    - Open File Explorer
    - Address bar: \192.168.1.20\PC-B-Share
    - Or: \PC-B\PC-B-Share (if name resolution works)
4. Map network drive:
    - Right-click "This PC" → Map network drive
    - Drive: Z:
    - Folder: \192.168.1.20\PC-B-Share
    - Check: Reconnect at sign-in
    - Finish

From PC-B:

1. Ping PC-A:

```bash
ping 192.168.1.10
```

2. Access PC-A's shared folder:

```
\\192.168.1.10\SharedData
```

3. Test file operations:
    - Create a text file in shared folder
    - Verify it appears on host computer

Part D: Troubleshooting

If ping fails:

1. Check firewall: Windows Defender Firewall → Advanced Settings
    - Inbound Rules → Enable:
        - File and Printer Sharing (Echo Request - ICMPv4-In)
2. Verify IP configuration:

```
bash

ipconfig /all
```

3. Check cable connection:
    - LED lights on network ports should be on
4. Verify subnet:
    - Both PCs must be on same subnet (192.168.1.0/24)

If shared folder not accessible:

1. Enable network discovery: Control Panel → Network and Sharing Center → Advanced sharing settings
    - Turn on network discovery
    - Turn on file and printer sharing
2. Check services: services.msc
    - Function Discovery Provider Host: Running
    - Function Discovery Resource Publication: Running

- Server: Running

3. Temporarily disable firewall to test:
    - If it works, create firewall exception

Lab 7: Plan, Design and Configure Domain Controller & Additional Domain Controller

Active Directory Domain Services Setup

Prerequisites:

- Windows Server 2019/2022
- Static IP address: 192.168.1.10
- Server name: DC01
- Minimum 2GB RAM, 40GB disk

Part A: Install Domain Controller

Step 1: Configure Static IP

1. Server Manager → Local Server
2. Click on IPv4 address assigned by DHCP
3. Configure:
    - IP: 192.168.1.10
    - Subnet: 255.255.255.0
    - Gateway: 192.168.1.1
    - DNS: 127.0.0.1 (itself after DC role)

Step 2: Install AD DS Role

1. Server Manager → Add Roles and Features
2. Installation Type: Role-based
3. Server: Select DC01
4. Server Roles: Active Directory Domain Services
5. Add Features (include management tools)

6. Install (don't check restart automatically yet)
7. Wait for installation to complete

Step 3: Promote to Domain Controller

1. Server Manager → Flag icon → Promote this server to domain controller
2. Deployment Configuration:
    - Select: Add a new forest
    - Root domain name: company.local
    - Click Next
3. Domain Controller Options:
    - Forest/Domain functional level: Windows Server 2016
    - Check: Domain Name System (DNS) server
    - Check: Global Catalog (GC)
    - Directory Services Restore Mode (DSRM) password: [Strong password]
    - Click Next
4. DNS Options:
    - Warning about delegation: Click Next (ignore)
5. Additional Options:
    - NetBIOS name: COMPANY (auto-filled)
6. Paths (use defaults):
    - Database: C:\Windows\NTDS
    - Log files: C:\Windows\NTDS
    - SYSVOL: C:\Windows\SYSVOL
7. Review Options → Install
8. Server will automatically restart

Step 4: Post-Installation Verification

1. Login: COMPANY\Administrator
2. Server Manager → Tools → Active Directory Users and Computers
3. Expand company.local

4. Verify default containers:
    - Computers
    - Users
    - Domain Controllers
5. Verify DNS:
    - Tools → DNS
    - Expand DC01 → Forward Lookup Zones → company.local
    - Should see DC01 A record
6. Command line verification:

```bash
dcdiag                  # Domain controller diagnostic
repadmin /showrepl      # Replication status
netdom query fsmo       # Show FSMO role holders
nslookup company.local  # DNS resolution test
```

Part B: Create Organizational Units (OUs)

1. Active Directory Users and Computers
2. Right-click company.local → New → Organizational Unit
3. Create structure:

```
company.local
├── Departments
│   ├── IT
│   ├── HR
│   ├── Finance
│   └── Sales
├── Servers
└── Workstations
```

4. For each OU:
    - Right-click company.local → New → OU
    - Name: IT (uncheck "Protect from deletion" for lab)
    - OK

Part C: Create Users and Groups

Create Users:

1. Navigate to IT OU
2. Right-click IT → New → User
3. User details:
    - First name: John
    - Last name: Smith
    - User logon name: jsmith
    - Click Next
    - Password: P@ssw0rd123
    - Uncheck: User must change password
    - Check: Password never expires (lab only)
    - Click Next → Finish
4. Create additional users:
    - In HR OU: jdoe (Jane Doe)
    - In Finance OU: bwilson (Bob Wilson)
    - In Sales OU: alee (Alice Lee)

Create Security Groups:

1. Right-click IT OU → New → Group
2. Group details:
    - Group name: IT_Admins
    - Group scope: Global
    - Group type: Security
    - OK
3. Add members:
    - Right-click IT_Admins → Properties
    - Members tab → Add
    - Enter: jsmith

- Check Names → OK

4. Create additional groups:
    - HR_Users (in HR OU)
    - Finance_Users (in Finance OU)
    - Sales_Users (in Sales OU)

Part D: Additional Domain Controller (ADC)

Install Second DC:

1. Prepare second server:
    - Windows Server 2019/2022
    - Name: DC02
    - Static IP: 192.168.1.11
    - DNS: 192.168.1.10 (point to first DC)
2. Install AD DS role (same as Part A)
3. Promote to Domain Controller:
    - Deployment: Add domain controller to existing domain
    - Domain: company.local
    - Credentials: COMPANY\Administrator
    - Domain Controller Options:
        - DNS server: Checked
        - Global Catalog: Checked
        - Read-only: Unchecked
    - Install
4. Verify replication:

```
bash

On DC01 or DC02:
repadmin /replsummary
repadmin /showrepl

Should show successful replication between DC01 and DC02
```

Lab 8: Plan and Configure Group Policy Object (GPO)

Complete GPO Configuration Guide

Part A: Create Basic GPO

Step 1: Open Group Policy Management

1. Server Manager → Tools → Group Policy Management
2. Expand Forest → Domains → company.local
3. View existing GPOs under Group Policy Objects

Step 2: Create New GPO

1. Right-click Group Policy Objects → New
2. Name: Desktop Security Policy
3. Source Starter GPO: (none)
4. OK

Part B: Configure Common Policies

Password Policy:

1. Right-click "Desktop Security Policy" → Edit
2. Navigate to: Computer Configuration → Policies → Windows Settings → Security Settings → Account Policies → Password Policy
3. Configure:
    - Minimum password length: 8 characters (Enabled)
    - Password must meet complexity: Enabled
    - Maximum password age: 90 days
    - Minimum password age: 1 day
    - Enforce password history: 5 passwords
    - Store passwords using reversible encryption: Disabled
4. Account Lockout Policy: → Account Policies → Account Lockout Policy
    - Account lockout threshold: 5 invalid attempts

- Account lockout duration: 30 minutes
- Reset account lockout counter after: 30 minutes

Desktop Restrictions: Navigate to: User Configuration → Policies → Administrative Templates → Control Panel

Configure:

- Prohibit access to Control Panel: Enabled
- Settings Page Visibility: hide:display;network;personalization

→ System

- Prevent access to command prompt: Enabled
- Prevent access to registry editing tools: Enabled
- Remove Task Manager: Enabled (use carefully)

→ Desktop

- Remove Recycle Bin icon: Enabled (optional)
- Prohibit user from changing desktop background: Enabled

Software Installation:

1. Download MSI package (e.g., 7-Zip)
2. Place in shared folder: \DC01\Software
3. GPO Editor: Computer Configuration → Policies → Software Settings → Software Installation
4. Right-click → New → Package
5. Path: \DC01\Software\7z1900-x64.msi
6. Deployment method: Assigned
7. OK

Software will install automatically on computer startup

Mapped Drives: User Configuration → Preferences → Windows Settings → Drive Maps

1. Right-click → New → Mapped Drive
2. General tab:

- Action: Create
- Location: \DC01\SharedData
- Label as: Company Data
- Drive letter: Z:
- Reconnect: Checked

3. Common tab:
    - Run in logged-on user's security context: Checked
4. Apply → OK

Folder Redirection: User Configuration → Policies → Windows Settings → Folder Redirection

1. Right-click Documents → Properties
2. Setting: Basic
3. Target folder location: Create folder for each user
4. Root Path: \DC01\UserData%USERNAME%\Documents
5. Settings tab:
    - Grant exclusive rights: Checked
    - Move contents: Checked
6. Apply → OK

Repeat for:

- Desktop
- Pictures
- Music

Part C: Link GPO to OU

Link to Specific OU:

1. Group Policy Management console
2. Navigate to desired OU (e.g., IT)
3. Right-click IT OU → Link an Existing GPO
4. Select "Desktop Security Policy"

5. OK

GPO order (processed bottom to top):

- Default Domain Policy
- Desktop Security Policy

Link to Entire Domain:

1. Right-click company.local → Link an Existing GPO
2. Select desired GPO
3. This applies to all users/computers in domain

Part D: Security Filtering

Apply GPO to Specific Group:

1. Group Policy Management → Select GPO
2. Scope tab → Security Filtering section
3. Remove: Authenticated Users
4. Add → Enter: IT_Admins
5. OK

Now GPO only applies to IT_Admins group members

Part E: Test and Troubleshoot GPO

Force GPO Update:

```
bash

On client computer:
gpupdate /force              # Apply all policies
gpupdate /target:computer    # Computer policies only
gpupdate /target:user        # User policies only

Note: Some policies require logoff/restart
```

View Applied Policies:

```
bash
```

```
gpresult /r                  # Summary report
gpresult /h report.html      # Detailed HTML report
gpresult /scope:computer /v  # Computer policies verbose
gpresult /scope:user /v      # User policies verbose

Review in Group Policy Management:
- Right-click OU → Group Policy Results
- Run wizard to see what applied to specific user/computer
```

Common Troubleshooting:

1. Check GPO link is enabled:
    - Link should not have X icon
    - Right-click link → Link Enabled (checked)
2. Check enforcement:
    - Right-click link → Enforced
    - Enforced GPOs cannot be blocked
3. Verify permissions:
    - GPO → Delegation tab
    - Group must have Read and Apply permissions
4. Check WMI filtering:
    - Scope tab → WMI Filtering
    - (none) means applies to all
5. Event Viewer logs:
    - Applications and Services Logs
    - Microsoft → Windows → GroupPolicy → Operational

Lab 9: Install and Configure Packet Tracer, GNS3 & VMware Environment

A. Install Packet Tracer

System Requirements:

- OS: Windows 10/11, Linux, macOS

- RAM: 4GB minimum (8GB recommended)
- Disk: 2GB free space
- Display: 1024x768 minimum

Installation Steps (Windows):

1. Download:
    - Go to netacad.com
    - Login/create Cisco Networking Academy account
    - Download Packet Tracer (latest version)
2. Install:
    - Run PacketTracer_xxx_windows_64bit.exe
    - Accept license agreement
    - Choose installation directory
    - Create desktop shortcut: Yes
    - Install
3. First Launch:
    - Open Packet Tracer
    - Login with Cisco NetAcad credentials
    - Accept multi-user setup (optional)
4. Basic Interface:
    - Bottom left: Device types (Routers, Switches, End Devices)
    - Bottom right: Connections (copper, fiber, wireless)
    - Workspace: Drag and drop devices

Quick Test:

1. Add devices:
    - 2 PCs from End Devices
    - 1 Switch from Network Devices
2. Connect:
    - Select copper straight-through cable

- Click PC → FastEthernet0
- Click Switch → FastEthernet0/1
- Repeat for second PC to FastEthernet0/2

3. Configure:
    - Click PC0 → Desktop → IP Configuration
    - IP: 192.168.1.10
    - Subnet: 255.255.255.0
    - Repeat for PC1: 192.168.1.11
4. Test:
    - PC0 → Desktop → Command Prompt
    - Type: ping 192.168.1.11
    - Should see replies

B. Install GNS3

System Requirements:

- OS: Windows 10/11, Linux, macOS
- RAM: 8GB minimum (16GB+ recommended)
- CPU: Virtualization support (VT-x/AMD-V)
- Disk: 1GB for GNS3 + space for images

Installation (Windows):

1. Download:
    - Visit gns3.com
    - Download GNS3 all-in-one installer
2. Run installer:
    - Accept license
    - Components to install: ☑ GNS3 ☑ GNS3 VM (VirtualBox recommended) ☑ Wireshark ☑ Npcap (for packet capture) ☐ Solar-PuTTY (optional)
    - Choose installation path
    - Install

3. First Launch Setup:
    - Open GNS3
    - Setup Wizard:
        - Server: Run appliances in virtual machine (GNS3 VM)
        - Path to GNS3 VM: Auto-detected
        - Local server path: Default
    - Finish
4. Start GNS3 VM:
    - GNS3 will start VirtualBox
    - GNS3 VM will boot automatically
    - Wait for "Server ready" message

Add Router IOS Image: LEGAL NOTE: You must own legitimate Cisco hardware or have proper licensing to use IOS images.

1. GNS3 → Edit → Preferences → IOS Routers
2. New:
    - Name: Cisco 2691
    - Platform: c2691
    - Image file: Browse to IOS image (.bin)
    - RAM: 256 MB
    - Network adapters: 2 Fast Ethernet
    - WIC Modules: 2x WIC-2T (serial)
3. Finish

Template will appear in router list

Quick Test Lab:

1. Drag router template to canvas
2. Drag another router
3. Add connection:
    - Select link tool
    - Click R1 → Select interface

- Click R2 → Select interface

4. Start devices:
    - Right-click routers → Start
    - Right-click → Console (opens terminal)
5. Basic config:

```
R1:
enable
configure terminal
interface fastEthernet 0/0
ip address 10.1.1.1 255.255.255.0
no shutdown
exit

R2:
enable
configure terminal
interface fastEthernet 0/0
ip address 10.1.1.2 255.255.255.0
no shutdown
exit
```

6. Test:

```
R1# ping 10.1.1.2
Should see !!!!! (success)
```

C. Install VMware Workstation/ESXi

VMware Workstation Pro:

1. Download:
    - VMware.com → Products → Workstation Pro
    - Download for Windows/Linux
2. Install (Windows):
    - Run installer
    - Accept license

- Installation directory: Default
- Enhanced Keyboard Driver: Yes
- Check for updates: Yes
- Shortcuts: Both
- Install

3. License:
    - Launch VMware
    - Enter license key or use trial
4. Create First VM:
    - File → New Virtual Machine
    - Typical configuration
    - Installer disc: Browse to ISO
    - Guest OS: Linux/Windows
    - Name: TestVM
    - Disk: 40GB, single file
    - Customize:
        - Memory: 4GB
        - Processors: 2
        - Network: NAT
    - Finish
    - Power on VM

VMware ESXi (Already covered in Lab 1)

Lab 10: Plan, Design and Configure DHCP and DNS LABs

A. Windows DHCP Server

Step 1: Install DHCP Role

1. Server Manager → Add Roles
2. Select: DHCP Server

3. Add Features → Install
4. Complete installation

Step 2: Authorize DHCP Server

1. Server Manager → Tools → DHCP
2. Right-click server name → Authorize
3. Right-click → Refresh
4. IPv4 icon should have green checkmark

Step 3: Create DHCP Scope

1. DHCP console → Expand server → IPv4
2. Right-click IPv4 → New Scope
3. Scope Wizard:
    - Name: Office-Network
    - Description: Main office DHCP scope
    - Start IP: 192.168.1.100
    - End IP: 192.168.1.200
    - Length: 24
    - Subnet mask: 255.255.255.0
    - Exclusions:
        - 192.168.1.1-192.168.1.10 (servers)
        - 192.168.1.254 (gateway)
    - Lease duration: 8 days (default)
    - Configure options: Yes
    - Router: 192.168.1.254
    - Domain name: company.local
    - DNS servers: 192.168.1.10 (DC IP)
    - WINS: Skip
    - Activate: Yes
    - Finish
4. Verify:

- Scope should show green arrow (active)

Step 4: Configure DHCP Options

Server Options (Apply to all scopes):

1. Right-click Server Options → Configure Options
2. Common options:
    - 003 Router: 192.168.1.254
    - 006 DNS Servers: 192.168.1.10
    - 015 DNS Domain Name: company.local
    - 042 NTP Servers: 192.168.1.10
    - 046 WINS/NBT Node Type: 0x8 (H-node)

Scope Options (Specific to scope):

1. Right-click Scope Options → Configure Options
2. Override server options if needed

Step 5: Create Reservation

1. Expand scope → Reservations
2. Right-click → New Reservation
3. Details:
    - Reservation name: PrintServer
    - IP address: 192.168.1.50
    - MAC address: 00-15-5D-00-01-0A
    - Description: HP Printer Floor 1
    - Supported types: Both DHCP and BOOTP
4. Add

Benefits: Device always gets same IP

Step 6: Test DHCP

On client computer:

1. Network adapter → Properties

2. TCP/IPv4 → Obtain automatically
3. OK

Command line:

```bash
ipconfig /release       # Release current IP
ipconfig /renew         # Request new IP
ipconfig /all           # Verify DHCP server

Should show:
- IP from DHCP range (100-200)
- DHCP Server: 192.168.1.10
- Default Gateway: 192.168.1.254
- DNS Servers: 192.168.1.10
```

B. Windows DNS Server

Step 1: Install DNS Role

1. Server Manager → Add Roles
2. Select: DNS Server
3. Install (usually installed with AD DS)

Step 2: Configure Forward Lookup Zone

1. Server Manager → Tools → DNS
2. Expand server → Forward Lookup Zones
3. Right-click → New Zone
4. Zone Wizard:
    - Zone type: Primary
    - AD integrated: Yes (if AD installed)
    - Replication scope: All DNS servers in domain
    - Zone name: company.local
    - Dynamic updates: Secure only
    - Finish

Step 3: Create DNS Records

A Records (Host):

1. Expand Forward Lookup Zone → company.local
2. Right-click → New Host (A or AAAA)
3. Details:
    - Name: webserver
    - IP: 192.168.1.100
    - Create PTR record: Checked
4. Add Host

Create additional records:

- mailserver → 192.168.1.101
- fileserver → 192.168.1.102
- dbserver → 192.168.1.103

CNAME Records (Alias):

1. Right-click zone → New Alias (CNAME)
2. Alias name: www
3. FQDN: webserver.company.local
4. OK

Now www.company.local points to webserver

MX Records (Mail):

1. Right-click zone → New Mail Exchanger (MX)
2. Host: (leave blank for @ / zone)
3. Mail server: mailserver.company.local
4. Priority: 10
5. OK

Step 4: Configure Reverse Lookup Zone

1. Right-click Reverse Lookup Zones → New Zone
2. Zone type: Primary, AD integrated
3. Replication: All DNS servers
4. IPv4 Reverse Lookup Zone
5. Network ID: 192.168.1 (Will create 1.168.192.in-addr.arpa)
6. Dynamic updates: Secure only
7. Finish

Verify PTR records:

- Should see PTR records for A records created earlier
- If not, recreate A records with PTR checked

Step 5: Configure Forwarders

1. Right-click server name → Properties
2. Forwarders tab → Edit
3. Add forwarder IPs:
    - 8.8.8.8 (Google DNS)
    - 8.8.4.4 (Google DNS alternate)
    - Or ISP DNS servers
4. OK

Purpose: Forward queries for external domains

Step 6: Test DNS

Command Prompt:

```bash
```

```
nslookup webserver.company.local
# Should return: 192.168.1.100

nslookup 192.168.1.100
# Should return: webserver.company.local

nslookup www.google.com
# Should resolve (via forwarders)
```

Test from client:

bash

```
ping webserver.company.local
ping webserver
# Both should work
```

DNS troubleshooting:

bash

```
ipconfig /displaydns       # Show DNS cache
ipconfig /flushdns         # Clear DNS cache
nslookup -debug domain.com # Detailed query
```

Lab 11: Configure BGP in Enterprise

Basic BGP Configuration (Enterprise)

Network Topology:

```
ISP Router (AS 65001)
    |
    | (203.0.113.1/30)
    |
Company Router (AS 65100)
    |
Internal: 10.0.0.0/8
```

Step 1: ISP Router Configuration

```
ISP-Router> enable
ISP-Router# configure terminal
ISP-Router(config)# hostname ISP-R1
ISP-R1(config)#

! Configure interface to customer
ISP-R1(config)# interface gigabitEthernet 0/0
ISP-R1(config-if)# description Link to Company Router
ISP-R1(config-if)# ip address 203.0.113.1 255.255.255.252
ISP-R1(config-if)# no shutdown
ISP-R1(config-if)# exit

! Configure BGP
ISP-R1(config)# router bgp 65001
ISP-R1(config-router)# bgp router-id 1.1.1.1
ISP-R1(config-router)# neighbor 203.0.113.2 remote-as 65100
ISP-R1(config-router)# neighbor 203.0.113.2 description Company Router
ISP-R1(config-router)#
ISP-R1(config-router)# network 0.0.0.0 mask 0.0.0.0
ISP-R1(config-router)# exit

! Save
ISP-R1# write memory
```

Step 2: Company Router Configuration

```
Company-Router> enable
Company-Router# configure terminal
Company-Router(config)# hostname COMPANY-R1

! WAN interface to ISP
COMPANY-R1(config)# interface gigabitEthernet 0/1
COMPANY-R1(config-if)# description WAN Link to ISP
COMPANY-R1(config-if)# ip address 203.0.113.2 255.255.255.252
COMPANY-R1(config-if)# no shutdown
COMPANY-R1(config-if)# exit

! LAN interface
COMPANY-R1(config)# interface gigabitEthernet 0/0
COMPANY-R1(config-if)# description Internal Network
COMPANY-R1(config-if)# ip address 10.0.0.1 255.255.255.0
COMPANY-R1(config-if)# no shutdown
COMPANY-R1(config-if)# exit

! Configure BGP
COMPANY-R1(config)# router bgp 65100
COMPANY-R1(config-router)# bgp router-id 2.2.2.2
COMPANY-R1(config-router)# neighbor 203.0.113.1 remote-as 65001
COMPANY-R1(config-router)# neighbor 203.0.113.1 description ISP Router
COMPANY-R1(config-router)#
! Advertise internal network
COMPANY-R1(config-router)# network 10.0.0.0 mask 255.255.255.0
COMPANY-R1(config-router)# exit

! Save configuration
COMPANY-R1# write memory
```

Step 3: Verify BGP

bash

```
! Check BGP neighbor status
COMPANY-R1# show ip bgp summary

Expected output:
BGP router identifier 2.2.2.2, local AS number 65100
Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
203.0.113.1     4 65001     xxx     xxx        x    0    0 00:xx:xx        1

! View BGP routes
COMPANY-R1# show ip bgp

! Check routing table
COMPANY-R1# show ip route bgp
B    0.0.0.0/0 [20/0] via 203.0.113.1, 00:15:23

! Detailed neighbor info
COMPANY-R1# show ip bgp neighbors 203.0.113.1
```

Step 4: BGP Route Filtering (Optional)

```
! Create prefix list to control advertisements
COMPANY-R1(config)# ip prefix-list ALLOW_INTERNAL permit 10.0.0.0/8
COMPANY-R1(config)#
COMPANY-R1(config)# router bgp 65100
COMPANY-R1(config-router)# neighbor 203.0.113.1 prefix-list ALLOW_INTERNAL out
COMPANY-R1(config-router)# exit

! Apply route-map for additional control
COMPANY-R1(config)# route-map SET_ATTRIBUTES permit 10
COMPANY-R1(config-route-map)# set metric 100
COMPANY-R1(config-route-map)# exit
COMPANY-R1(config)#
COMPANY-R1(config)# router bgp 65100
COMPANY-R1(config-router)# neighbor 203.0.113.1 route-map SET_ATTRIBUTES out
```

Troubleshooting BGP:

```
Common issues:
1. Neighbor not establishing:
   - Check connectivity: ping 203.0.113.1
   - Verify AS numbers match configuration
   - Check firewall (TCP port 179)

2. No routes received:
   - show ip bgp neighbors 203.0.113.1 advertised-routes
   - show ip bgp neighbors 203.0.113.1 routes

3. Routes not in routing table:
   - Check administrative distance (eBGP = 20)
   - Verify next-hop reachability

Debug commands:
debug ip bgp                # BGP processes
debug ip bgp updates        # Route updates
undebug all                 # Turn off debugging
```

Lab 12: Perform IOS Backup and Restore, then Configure OSPF for Enterprise Network

A. IOS Backup and Restore

Step 1: Backup IOS to TFTP Server

```bash
```

```
# Setup TFTP server on PC (use Tftpd64 software)
# Configure PC with IP: 192.168.1.100
# Start TFTP server, note directory location

Router> enable
Router# show flash:
# Note IOS filename (e.g., c2900-universalk9-mz.SPA.151-4.M4.bin)

# Verify connectivity to TFTP server
Router# ping 192.168.1.100

# Copy IOS to TFTP server
Router# copy flash:c2900-universalk9-mz.SPA.151-4.M4.bin tftp:
Address or name of remote host []? 192.168.1.100
Destination filename [c2900-universalk9-mz.SPA.151-4.M4.bin]? [Enter]
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
[OK - xxxx bytes copied in xx.xxx secs]

# Backup running configuration
Router# copy running-config tftp:
Address or name of remote host []? 192.168.1.100
Destination filename [router-confg]? router1-backup.cfg
!!
[OK]

# Backup startup configuration
Router# copy startup-config tftp:
```

Step 2: Restore IOS from TFTP

bash

```
# Verify current flash contents
Router# show flash:

# Delete old IOS (if needed for space)
Router# delete flash:old-ios.bin
Delete filename [old-ios.bin]? [Enter]
Delete flash:old-ios.bin? [confirm] [Enter]

# Copy new IOS from TFTP
Router# copy tftp: flash:
Address or name of remote host []? 192.168.1.100
Source filename []? c2900-universalk9-mz.SPA.151-4.M4.bin
Destination filename [c2900-universalk9-mz.SPA.151-4.M4.bin]? [Enter]
Accessing tftp://192.168.1.100/c2900...
Loading from 192.168.1.100: !!!!!!!!!!!!!!!!
[OK - copied xxxxx bytes in xx.xx secs]

# Verify IOS in flash
Router# show flash:

# Set boot variable
Router# configure terminal
Router(config)# boot system flash:c2900-universalk9-mz.SPA.151-4.M4.bin
Router(config)# exit
Router# write memory

# Reload router
Router# reload
Proceed with reload? [confirm] [Enter]
```

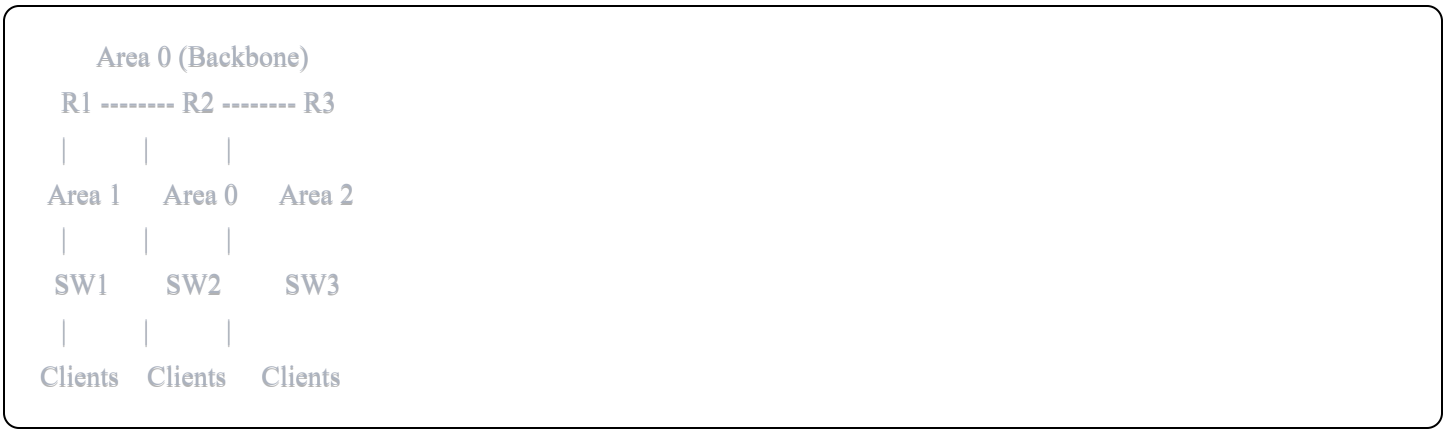
Step 3: Restore Configuration

```
bash
```

```
# After reload, restore configuration
Router> enable
Router# copy tftp: running-config
Address or name of remote host []? 192.168.1.100
Source filename []? router1-backup.cfg
Destination filename [running-config]? [Enter]
Accessing tftp://192.168.1.100/router1-backup.cfg...
Loading from 192.168.1.100: !
[OK - xxx bytes]

# Verify configuration loaded
Router# show running-config

# Save to startup-config
Router# copy running-config startup-config
```

B. Configure OSPF for Enterprise Network

Network Topology:



Step 1: Configure R1 (Area Border Router - ABR)

```
R1> enable
R1# configure terminal
R1(config)# hostname R1

! Configure interfaces
R1(config)# interface gigabitEthernet 0/0
R1(config-if)# description Link to R2
R1(config-if)# ip address 10.0.12.1 255.255.255.252
R1(config-if)# no shutdown
R1(config-if)# exit

R1(config)# interface gigabitEthernet 0/1
R1(config-if)# description Area 1 Network
R1(config-if)# ip address 192.168.1.1 255.255.255.0
R1(config-if)# no shutdown
R1(config-if)# exit

! Configure OSPF
R1(config)# router ospf 1
R1(config-router)# router-id 1.1.1.1
R1(config-router)# network 10.0.12.0 0.0.0.3 area 0
R1(config-router)# network 192.168.1.0 0.0.0.255 area 1
R1(config-router)# passive-interface gigabitEthernet 0/1
R1(config-router)# exit

! Save
R1# write memory
```

Step 2: Configure R2 (Core Router)

```
R2# configure terminal
R2(config)# hostname R2

! Interface to R1
R2(config)# interface gigabitEthernet 0/0
R2(config-if)# description Link to R1
R2(config-if)# ip address 10.0.12.2 255.255.255.252
R2(config-if)# no shutdown
R2(config-if)# exit

! Interface to R3
R2(config)# interface gigabitEthernet 0/1
R2(config-if)# description Link to R3
R2(config-if)# ip address 10.0.23.1 255.255.255.252
R2(config-if)# no shutdown
R2(config-if)# exit

! Loopback for testing
R2(config)# interface loopback 0
R2(config-if)# ip address 2.2.2.2 255.255.255.255
R2(config-if)# exit

! Configure OSPF
R2(config)# router ospf 1
R2(config-router)# router-id 2.2.2.2
R2(config-router)# network 10.0.12.0 0.0.0.3 area 0
R2(config-router)# network 10.0.23.0 0.0.0.3 area 0
R2(config-router)# network 2.2.2.2 0.0.0.0 area 0
R2(config-router)# exit

R2# write memory
```

Step 3: Configure R3 (ABR)

```
R3# configure terminal
R3(config)# hostname R3

! Interface to R2
R3(config)# interface gigabitEthernet 0/0
R3(config-if)# description Link to R2
R3(config-if)# ip address 10.0.23.2 255.255.255.252
R3(config-if)# no shutdown
R3(config-if)# exit

! Interface to Area 2
R3(config)# interface gigabitEthernet 0/1
R3(config-if)# description Area 2 Network
R3(config-if)# ip address 192.168.2.1 255.255.255.0
R3(config-if)# no shutdown
R3(config-if)# exit

! Configure OSPF
R3(config)# router ospf 1
R3(config-router)# router-id 3.3.3.3
R3(config-router)# network 10.0.23.0 0.0.0.3 area 0
R3(config-router)# network 192.168.2.0 0.0.0.255 area 2
R3(config-router)# passive-interface gigabitEthernet 0/1
R3(config-router)# exit

R3# write memory
```

Step 4: Verify OSPF

bash

```
! Check OSPF neighbors
R1# show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
2.2.2.2           1   FULL/DR         00:00:35    10.0.12.2       GigabitEthernet0/0

! View OSPF database
R1# show ip ospf database

! Check routing table
R1# show ip route ospf
O IA  192.168.2.0/24 [110/3] via 10.0.12.2, 00:05:23, GigabitEthernet0/0
      2.0.0.0/32 is subnetted, 1 subnets
O        2.2.2.2 [110/2] via 10.0.12.2, 00:10:15, GigabitEthernet0/0

! Test connectivity
R1# ping 192.168.2.1
!!!!!
Success rate is 100 percent (5/5)

! Detailed OSPF interface info
R1# show ip ospf interface brief
Interface    PID   Area   IP Address/Mask    Cost  State Nbrs F/C
Gi0/0        1     0      10.0.12.1/30       1     DR    1/1
Gi0/1        1     1      192.168.1.1/24     1     DR    0/0
```

Step 5: Advanced OSPF Configuration

bash

```
! Configure OSPF cost manually
R1(config)# interface gigabitEthernet 0/0
R1(config-if)# ip ospf cost 50
R1(config-if)# exit

! Configure OSPF authentication (area level)
R1(config)# router ospf 1
R1(config-router)# area 0 authentication message-digest
R1(config-router)# exit
R1(config)# interface gigabitEthernet 0/0
R1(config-if)# ip ospf message-digest-key 1 md5 MySecretKey123
R1(config-if)# exit

! Configure default route propagation
R2(config)# router ospf 1
R2(config-router)# default-information originate
R2(config-router)# exit

! Tune OSPF timers
R1(config)# interface gigabitEthernet 0/0
R1(config-if)# ip ospf hello-interval 5
R1(config-if)# ip ospf dead-interval 20
R1(config-if)# exit

! Route summarization at ABR
R1(config)# router ospf 1
R1(config-router)# area 1 range 192.168.0.0 255.255.252.0
R1(config-router)# exit
```

OSPF Troubleshooting:

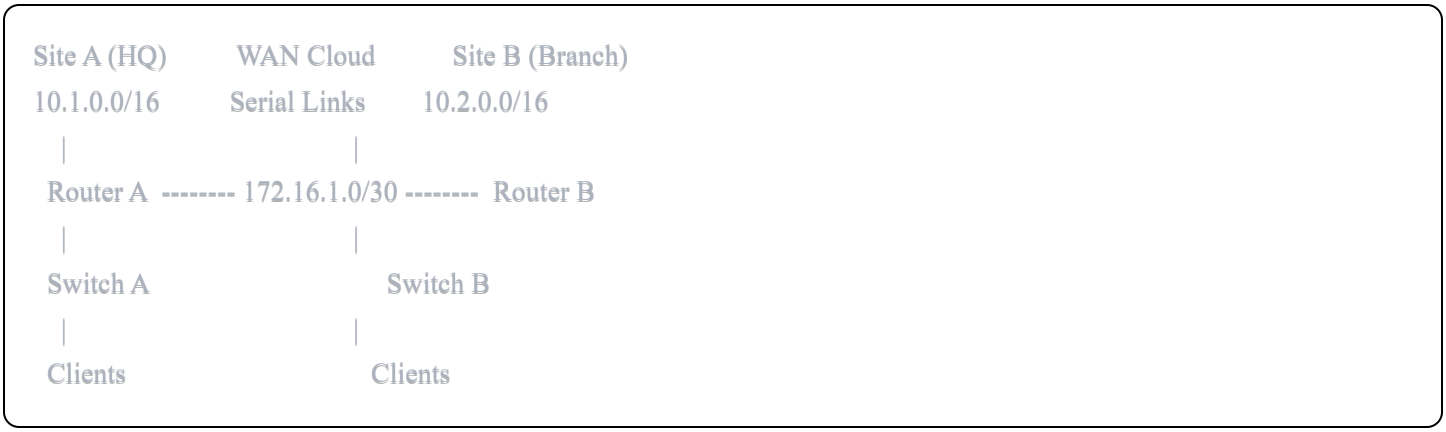
```
bash
```

```
! Verify OSPF is running
show ip protocols

! Check interface OSPF status
show ip ospf interface

! View OSPF process ID
show ip ospf

! Debug OSPF (use carefully)
debug ip ospf adj          # Adjacency formation
debug ip ospf events       # OSPF events
debug ip ospf packets      # OSPF packets

Common issues:
1. Neighbors not forming:
   - Check network connectivity (ping)
   - Verify area numbers match
   - Check authentication configuration
   - Verify hello/dead timers match
   - Check MTU settings

2. Routes not appearing:
   - Verify network statements
   - Check passive interfaces
   - Review area configuration

3. Slow convergence:
   - Tune hello/dead timers
   - Check for flapping links
   - Review network design
```

Lab 13: Design WAN LAB, Perform Static Routing & Configure Access-List

A. Design WAN Lab

Network Topology:



Equipment Required:

- 2 Routers with serial interfaces
- 2 Switches (Layer 2)
- 4 PCs (or more)
- Serial cables (DCE/DTE)
- Ethernet cables

Step 1: Configure Site A (HQ) Router

```
RouterA> enable
RouterA# configure terminal
RouterA(config)# hostname SiteA-R1

! Configure LAN interface
SiteA-R1(config)# interface gigabitEthernet 0/0
SiteA-R1(config-if)# description LAN Interface Site A
SiteA-R1(config-if)# ip address 10.1.0.1 255.255.0.0
SiteA-R1(config-if)# no shutdown
SiteA-R1(config-if)# exit

! Configure WAN interface (DCE side - provides clock)
SiteA-R1(config)# interface serial 0/0/0
SiteA-R1(config-if)# description WAN Link to Site B
SiteA-R1(config-if)# ip address 172.16.1.1 255.255.255.252
SiteA-R1(config-if)# clock rate 128000
SiteA-R1(config-if)# bandwidth 128
SiteA-R1(config-if)# no shutdown
SiteA-R1(config-if)# exit

! Configure default gateway (or static route)
SiteA-R1(config)# ip route 10.2.0.0 255.255.0.0 172.16.1.2
SiteA-R1(config)# exit
SiteA-R1# write memory
```

Step 2: Configure Site B (Branch) Router

```
RouterB> enable
RouterB# configure terminal
RouterB(config)# hostname SiteB-R1

! Configure LAN interface
SiteB-R1(config)# interface gigabitEthernet 0/0
SiteB-R1(config-if)# description LAN Interface Site B
SiteB-R1(config-if)# ip address 10.2.0.1 255.255.0.0
SiteB-R1(config-if)# no shutdown
SiteB-R1(config-if)# exit

! Configure WAN interface (DTE side)
SiteB-R1(config)# interface serial 0/0/0
SiteB-R1(config-if)# description WAN Link to Site A
SiteB-R1(config-if)# ip address 172.16.1.2 255.255.255.252
SiteB-R1(config-if)# bandwidth 128
SiteB-R1(config-if)# no shutdown
SiteB-R1(config-if)# exit

! Configure static route
SiteB-R1(config)# ip route 10.1.0.0 255.255.0.0 172.16.1.1
SiteB-R1(config)# exit
SiteB-R1# write memory
```

Step 3: Configure Switches

bash

```
! Switch A (Site A)
SwitchA> enable
SwitchA# configure terminal
SwitchA(config)# hostname SiteA-SW1
SwitchA(config)# interface vlan 1
SwitchA(config-if)# ip address 10.1.0.10 255.255.0.0
SwitchA(config-if)# no shutdown
SwitchA(config-if)# exit
SwitchA(config)# ip default-gateway 10.1.0.1
SwitchA(config)# exit
SwitchA# write memory

! Switch B (Site B) - Similar configuration
SwitchB(config)# interface vlan 1
SwitchB(config-if)# ip address 10.2.0.10 255.255.0.0
SwitchB(config-if)# no shutdown
SwitchB(config)# ip default-gateway 10.2.0.1
```

Step 4: Configure End Devices

```
Site A PC1:
IP: 10.1.0.100
Subnet: 255.255.0.0
Gateway: 10.1.0.1
DNS: 8.8.8.8

Site A PC2:
IP: 10.1.0.101
Subnet: 255.255.0.0
Gateway: 10.1.0.1

Site B PC1:
IP: 10.2.0.100
Subnet: 255.255.0.0
Gateway: 10.2.0.1
DNS: 8.8.8.8

Site B PC2:
IP: 10.2.0.101
Subnet: 255.255.0.0
Gateway: 10.2.0.1
```

B. Static Routing Configuration

Basic Static Routes (Already configured above):

```
! Site A Router
ip route 10.2.0.0 255.255.0.0 172.16.1.2

! Site B Router
ip route 10.1.0.0 255.255.0.0 172.16.1.1
```

Advanced Static Routing Scenarios:

1. Default Static Route

```
! Send all unknown traffic to specific next-hop
SiteB-R1(config)# ip route 0.0.0.0 0.0.0.0 172.16.1.1

! Or to specific interface
SiteB-R1(config)# ip route 0.0.0.0 0.0.0.0 serial 0/0/0

! With administrative distance (for redundancy)
SiteB-R1(config)# ip route 0.0.0.0 0.0.0.0 172.16.1.1 10
SiteB-R1(config)# ip route 0.0.0.0 0.0.0.0 172.16.2.1 20
! First route preferred (lower AD)
```

2. Floating Static Route (Backup)

```
! Primary route via OSPF (AD=110)
! Backup static route with higher AD
SiteA-R1(config)# ip route 10.2.0.0 255.255.0.0 172.16.1.2 150

! This route only activates if OSPF route fails
```

3. Static Route with Exit Interface

```
! Using next-hop IP
ip route 192.168.3.0 255.255.255.0 172.16.1.2

! Using exit interface
ip route 192.168.3.0 255.255.255.0 serial 0/0/0

! Using both (recommended for serial links)
ip route 192.168.3.0 255.255.255.0 serial 0/0/0 172.16.1.2
```

4. Multiple Path Static Routes (Load Balancing)

```
SiteA-R1(config)# ip route 10.3.0.0 255.255.0.0 172.16.1.2
SiteA-R1(config)# ip route 10.3.0.0 255.255.0.0 172.16.2.2

! Both routes have equal cost, traffic load-balanced
```

Verify Static Routes:

bash

```
! View routing table
show ip route
show ip route static

! Test connectivity
ping 10.2.0.100 source 10.1.0.100
traceroute 10.2.0.100

! Show route for specific destination
show ip route 10.2.0.100
```

C. Configure Access Control Lists (ACLs)

Standard ACL (Filters by Source IP only)

```
! Deny specific host, permit all others
SiteA-R1(config)# access-list 10 deny host 10.1.0.150
SiteA-R1(config)# access-list 10 permit any

! Apply to interface
SiteA-R1(config)# interface serial 0/0/0
SiteA-R1(config-if)# ip access-group 10 out
SiteA-R1(config-if)# exit

! Permit specific network only
SiteA-R1(config)# access-list 20 permit 10.1.0.0 0.0.255.255
SiteA-R1(config)# access-list 20 deny any
```

Extended ACL (Filters by Source, Destination, Protocol, Port)

```
! Block web traffic from Site B to specific server
SiteA-R1(config)# access-list 100 deny tcp 10.2.0.0 0.0.255.255 host 10.1.0.50 eq 80
SiteA-R1(config)# access-list 100 deny tcp 10.2.0.0 0.0.255.255 host 10.1.0.50 eq 443
SiteA-R1(config)# access-list 100 permit ip any any

! Apply inbound on interface
SiteA-R1(config)# interface serial 0/0/0
SiteA-R1(config-if)# ip access-group 100 in
SiteA-R1(config-if)# exit

! Allow SSH only from admin network
SiteA-R1(config)# access-list 110 permit tcp 10.1.1.0 0.0.0.255 any eq 22
SiteA-R1(config)# access-list 110 deny tcp any any eq 22
SiteA-R1(config)# access-list 110 permit ip any any

! Block ICMP (ping) from specific subnet
SiteA-R1(config)# access-list 120 deny icmp 10.2.100.0 0.0.0.255 any echo
SiteA-R1(config)# access-list 120 permit ip any any
```

Named ACLs (More flexible)

```
! Create named standard ACL
SiteA-R1(config)# ip access-list standard BLOCK_GUEST_VLAN
SiteA-R1(config-std-nacl)# deny 10.1.100.0 0.0.0.255
SiteA-R1(config-std-nacl)# permit any
SiteA-R1(config-std-nacl)# exit

! Create named extended ACL
SiteA-R1(config)# ip access-list extended FIREWALL_RULES
SiteA-R1(config-ext-nacl)# remark Allow established connections
SiteA-R1(config-ext-nacl)# permit tcp any any established
SiteA-R1(config-ext-nacl)# remark Block Telnet
SiteA-R1(config-ext-nacl)# deny tcp any any eq 23
SiteA-R1(config-ext-nacl)# remark Allow HTTPS
SiteA-R1(config-ext-nacl)# permit tcp any any eq 443
SiteA-R1(config-ext-nacl)# remark Allow DNS
SiteA-R1(config-ext-nacl)# permit udp any any eq 53
SiteA-R1(config-ext-nacl)# remark Deny all other traffic
SiteA-R1(config-ext-nacl)# deny ip any any log
SiteA-R1(config-ext-nacl)# exit

! Apply named ACL
SiteA-R1(config)# interface gigabitEthernet 0/0
SiteA-R1(config-if)# ip access-group FIREWALL_RULES in
```

Common ACL Examples:

1. Restrict VTY Access (Telnet/SSH to router)

```
SiteA-R1(config)# access-list 50 permit 10.1.1.0 0.0.0.255
SiteA-R1(config)# access-list 50 deny any
SiteA-R1(config)# line vty 0 4
SiteA-R1(config-line)# access-class 50 in
SiteA-R1(config-line)# exit
```

2. Allow Only Specific Services

```
! Allow only HTTP, HTTPS, DNS, and ICMP
SiteA-R1(config)# ip access-list extended INTERNET_ACCESS
SiteA-R1(config-ext-nacl)# permit tcp any any eq 80
SiteA-R1(config-ext-nacl)# permit tcp any any eq 443
SiteA-R1(config-ext-nacl)# permit udp any any eq 53
SiteA-R1(config-ext-nacl)# permit icmp any any echo
SiteA-R1(config-ext-nacl)# permit icmp any any echo-reply
SiteA-R1(config-ext-nacl)# deny ip any any
SiteA-R1(config-ext-nacl)# exit
```

3. Time-Based ACL

```
! Create time range
SiteA-R1(config)# time-range BUSINESS_HOURS
SiteA-R1(config-time-range)# periodic weekdays 9:00 to 17:00
SiteA-R1(config-time-range)# exit

! Apply to ACL
SiteA-R1(config)# ip access-list extended TIME_POLICY
SiteA-R1(config-ext-nacl)# permit tcp any any eq 80 time-range BUSINESS_HOURS
SiteA-R1(config-ext-nacl)# deny tcp any any eq 80
SiteA-R1(config-ext-nacl)# exit
```

Verify ACLs:

bash

```
! View all ACLs
show access-lists

! View specific ACL
show access-lists 100
show ip access-list FIREWALL_RULES

! View ACL statistics
show ip access-lists

! Show where ACLs are applied
show ip interface gigabitEthernet 0/0

! Clear ACL counters
clear access-list counters 100
```

ACL Best Practices:

1. Place standard ACLs close to destination
2. Place extended ACLs close to source
3. Always include implicit deny at end (automatic)
4. Process ACLs top-down, first match wins
5. Use named ACLs for better management
6. Add remarks for documentation
7. Be careful with deny any - can lock you out
8. Test before applying to production
9. One ACL per interface, per direction, per protocol
10. Remember: inbound = before routing, outbound = after routing

---

Summary & Exam Tips

All 13 Labs Covered:

1. ✅ ESXi Installation & Configuration
2. ✅ CDP, NAT-PAT Configuration
3. ✅ AWS Management Tools & Disaster Recovery
4. ✅ AWS Storage, Security & VPC with Database
5. ✅ File Server Design & DFS
6. ✅ LAN Lab (2 PC Setup)
7. ✅ Domain Controller & Additional DC
8. ✅ Group Policy Object (GPO)
9. ✅ Packet Tracer, GNS3, VMware Installation
10. ✅ DHCP & DNS Configuration
11. ✅ BGP Enterprise Configuration
12. ✅ IOS Backup/Restore & OSPF
13. ✅ WAN Lab, Static Routing & Access Lists

Practical Exam Tips:

Time Management (2 hours 30 minutes):

- Allocate 10-15 minutes per lab
- Quick labs (5-7 minutes): LAN, BGP, Static Routing
- Medium labs (10-15 minutes): DHCP, DNS, VPC
- Long labs (15-20 minutes): ESXi, Domain Controller, OSPF

Common Mistakes to Avoid:

1. **Not saving configurations**: Always `write memory` or `copy run start`
2. **Wrong subnet masks**: Double-check CIDR calculations
3. **Forgetting clock rate**: DCE side of serial connections needs clock rate
4. **Security group rules**: Remember inbound vs outbound
5. **DNS pointing**: Make sure DNS points to correct server
6. **OSPF area mismatches**: Verify area numbers on both sides
7. **ACL placement**: Standard near destination, extended near source
8. **NAT interfaces**: Inside vs outside configuration

Must-Know Commands:

Cisco IOS:

```
show running-config        # Current configuration
show ip interface brief    # IP addresses and status
show ip route              # Routing table
show ip protocols          # Routing protocols
ping [ip]                  # Test connectivity
traceroute [ip]            # Path to destination
write memory               # Save configuration
```

Windows Server:

```
ipconfig /all              # Network configuration
dcdiag                     # DC diagnostics
repadmin /showrepl         # AD replication
gpupdate /force            # Update GPO
nslookup [hostname]        # DNS lookup
```

AWS CLI (if needed):

```
aws ec2 describe-instances       # List EC2 instances
aws s3 ls                        # List S3 buckets
aws vpc describe-vpcs            # List VPCs
```

Troubleshooting Checklist:

- [ ] Physical connectivity (cables, lights)
- [ ] IP configuration (correct IP, subnet, gateway)
- [ ] Routing (show ip route)
- [ ] Firewall/Security Groups
- [ ] DNS resolution
- [ ] Services running (DHCP, DNS, HTTP)
- [ ] Logs (Event Viewer, CloudWatch)

Practice Strategy:

1. Do each lab 3 times minimum
2. Time yourself on third attempt
3. Practice without notes on final run
4. Create your own variations
5. Document common errors

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Good luck with your practical exam! 🚀