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A Python-Based VPN Tunnel Emulator

COURSE CODE : CS2403
COURSE: COMPUTER NETWORK

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The Challenge: Connecting Branches Securely

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Security Risk

Standard public internet connections expose sensitive business data to interception, eavesdropping, and unauthorized access threats.

Geographic Dispersal

Modern businesses operate across multiple locations, requiring secure inter-office communication while maintaining operational efficiency.

Cost Constraints

Traditional leased lines are prohibitively expensive for many organizations, limiting connectivity options for distributed enterprises.

Our Mission: Design and implement a secure, scalable, cost-effective Site-to-Site VPN solution that connects distributed offices while maintaining enterprise-grade security and service integration.

OUR SOLUTION ARCHITECTURE

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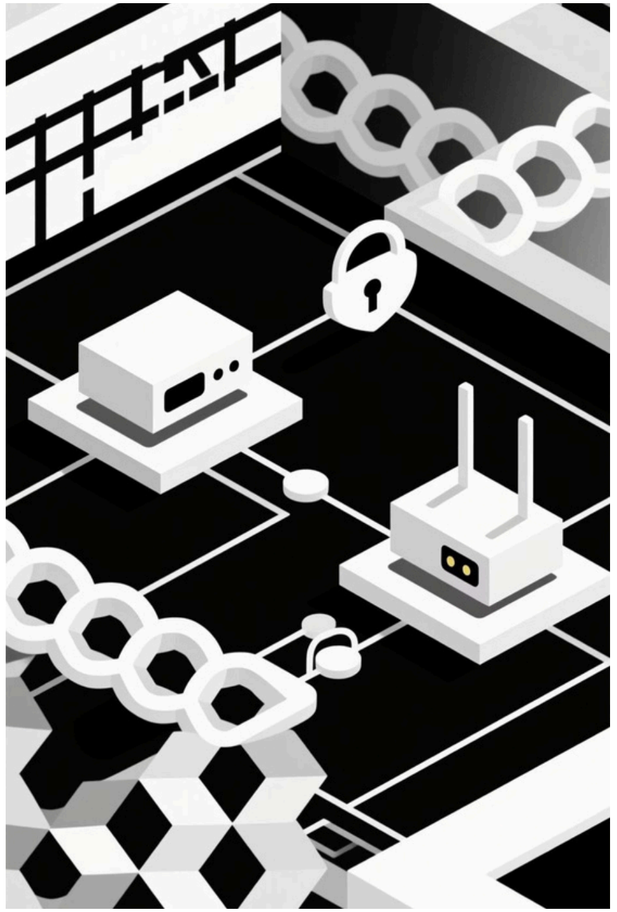
Site 1
Head Office with primary DNS and web services

GRE Tunnel
Secure encrypted virtual connection

Site 2
BranchOffice with full network access



Our architecture creates a unified virtual private network spanning two geographically dispersed sites, enabling seamless resource sharing while maintaining complete network isolation from the public internet.

VPN Core Technology: GRE Tunneling

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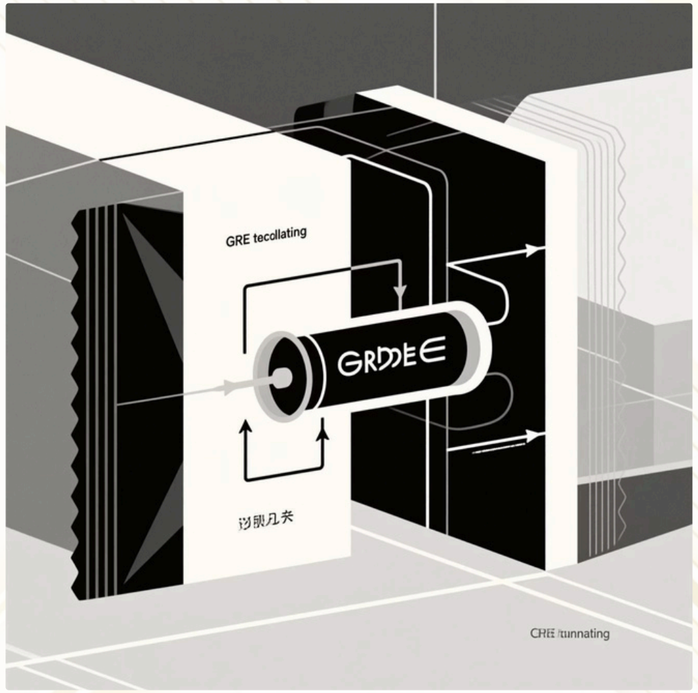
What is GRE?

Generic RoutingEncapsulation creates a secure virtual

tunnel through the public internet, encapsulating packets from one network and safely delivering them to another. Think of it as a private pipe running through public infrastructure.

How It Works

- Routers ateach site create a virtual Tunnel0 interface
- Original packets are encapsulated with new headers
- Static routing directs traffic through the tunne
- Packets emerge at destination site decapsulated



Security Framework: Access Control Lists

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Default Deny Policy: Explicit Allowance Only

We implemented a zero-trust security model where all traffic is denied by default.

Only explicitly permitted protocols4HTTPS (443), DNS (53), and diagnostic ICMP4 traverse the tunnel. This "default deny" approach ensures that even unknown threats cannot penetrate our network.

1. **Permit HTTPS**
   Secure web traffic for sensitive data transmission and dashboard access
2. **Permit DNS**
   Domain name resolution for service discovery and connectivity
3. **Permit ICMP**
   Diagnostic ping for network trouble shooting and connectivity verification
4. **Deny Everything Else**
   Comprehensive default denial of unauthorized or unnecessary protocols

Integrated Enterprise Services

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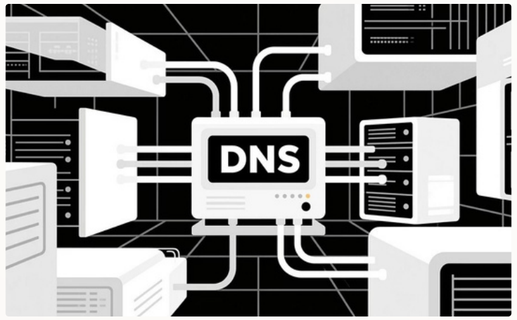


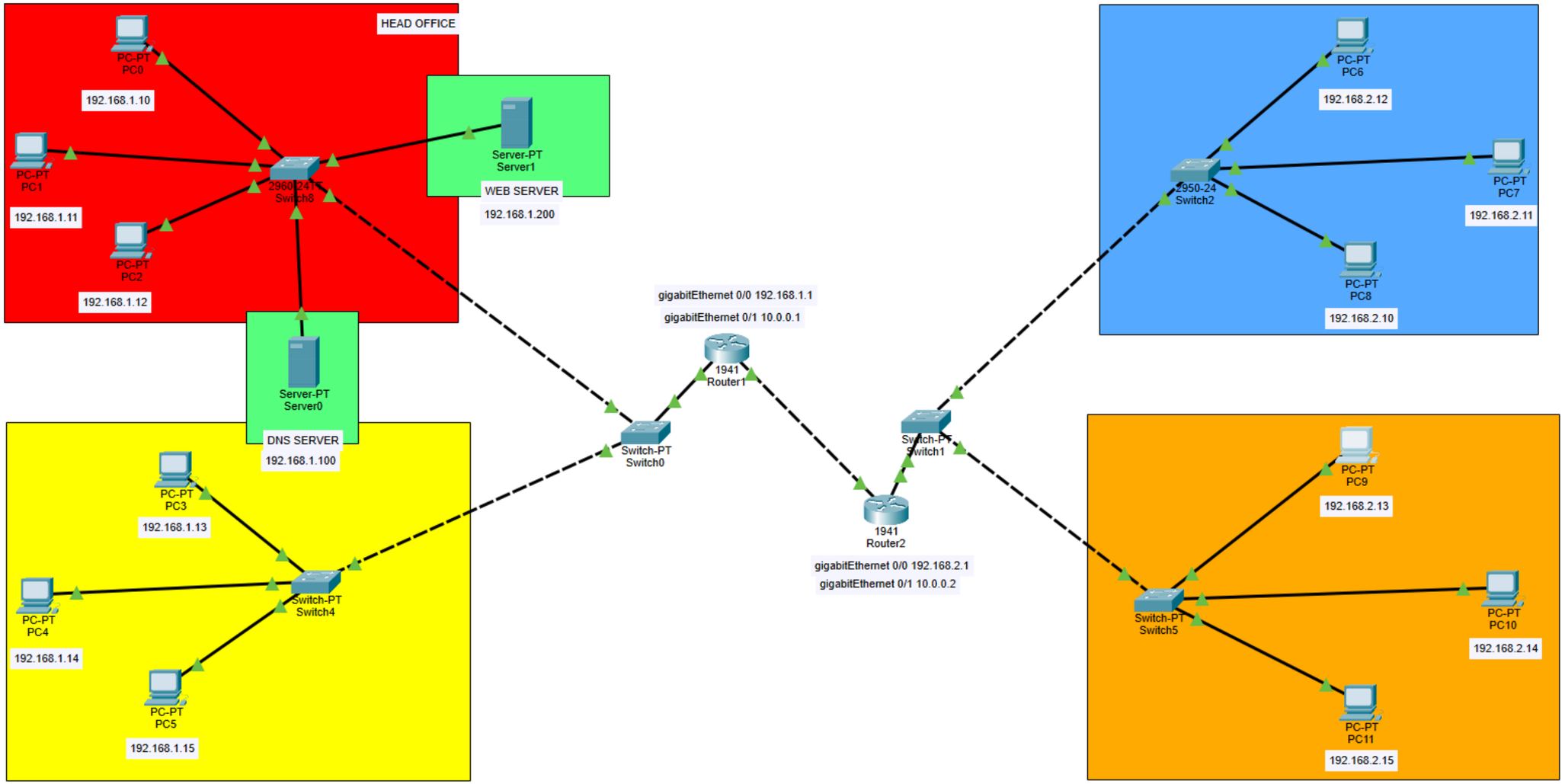
DNS Resolution

Our DNS server provides centralized domain management, translating human-readable names like www.phoenix.com to IP addresses. This creates a unified, manageable namespace across both sites while reducing configuration complexity and improving user experience.

Web Portal

Acentralized Phoenix Networks dashboard provides real-time network health monitoring, status visibility, and administrative controls. The portal is accessible via DNS from both sites, demonstrating integrated service delivery across the VPN.

Architecture



Architecture

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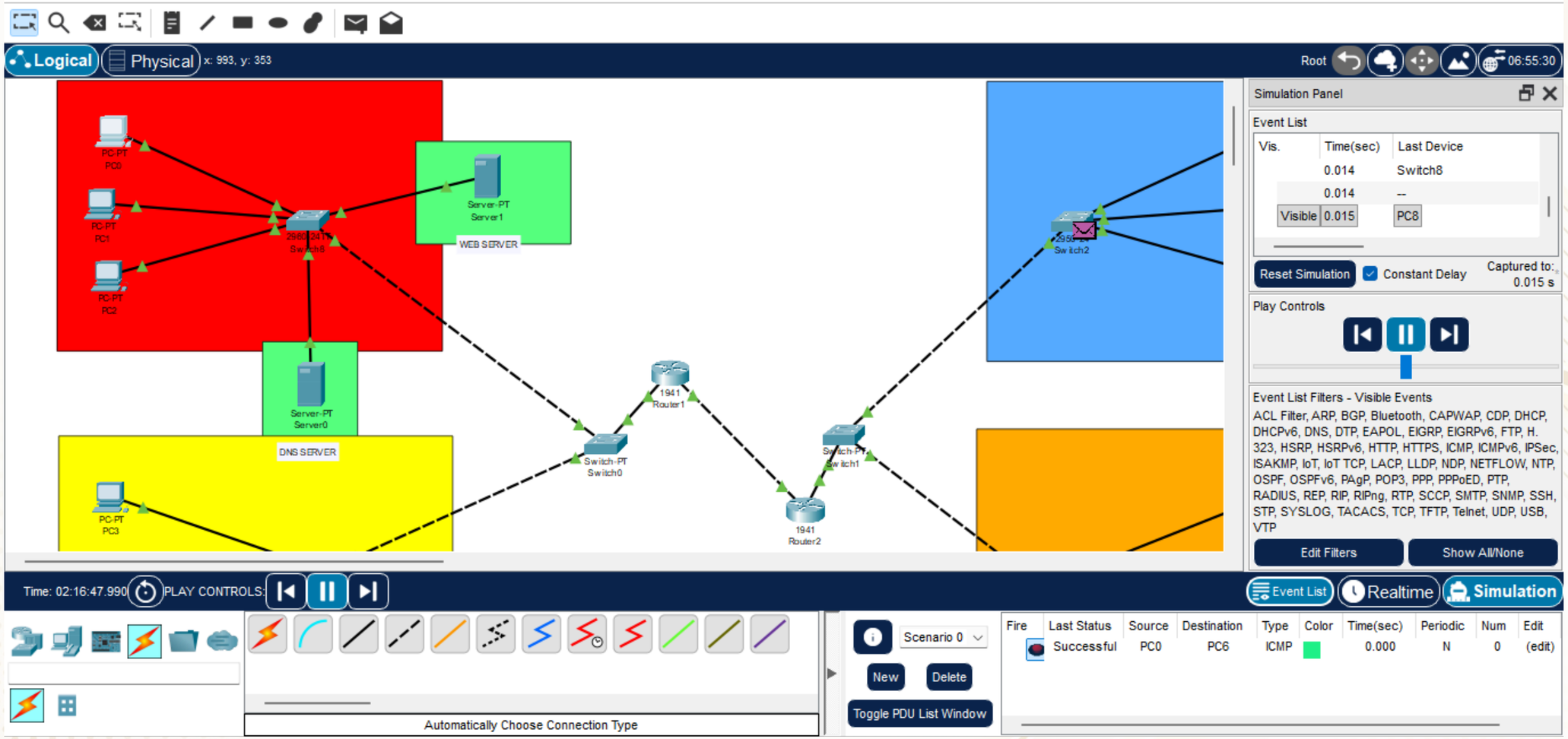

Proof of Concept: Live Validation

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We validated every critical component of our design:

1

TunnelStatus

`show interface tunnel0` confirms "up/up" status. The VPN tunnel is stable and operational, successfully bridging both sites through the public internet.

2

Cross-Site Connectivity

Successful ping from Site 1 (192.168.1.x) to Site 2 (192.168.2.x) demonstrates seamless inter-office communication. Packets traverse the tunnel without loss.

3

Security Filtering

`show access-lists` displays incrementing hit counts, proving ACLs actively monitor and permit traffic according to policy. No unauthorized attempts succeed.

4

ServiceAccessibility

Browser access to www.phoenix.com resolves correctly via DNS and displays the dashboard. Both sites seamlessly access integrated services through the secure tunnel.

Future Work

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Success Achieved

We delivered fully functional, secure enterprise VPN solution demonstrating core networking principles: VPN technology, dynamic routing, security policies, and integrated services.

Scalable Foundation

This blue print provides a proven, cost-effective alternative to expensive leased lines while maintaining enterprise-grade security and performance standards.

Future Enhancement Roadmap

01

IPsec Encryption

Add encryption layer to GRE tunnel for enhanced data confidentiality

02

Dynamic Routing (OSPF)

Implement automatic route discovery for improved scalability

03

Expanded Services

Integrate VoIP, file servers, and multimedia applications

04

Hub-and-Spoke Model

Connect multiple branch offices through centralized hub architecture

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