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CRT 255T.01: Advanced Routing

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THE UNIVERSITY OF MONTANA—MISSOULA
COLLEGE OF TECHNOLOGY

CRT 255T: Advanced Routing

Fall 2005

Faculty: Penny Jakes penny.jakes@umontana.edu

PHONE: 243-7804

CREDITS: 3

OFFICE HOURS:
As posted or by appointment in office AD17A

COURSE DESCRIPTION:

Analysis, design, and implementation of inter-network routing techniques. Topics include scalability, routing protocols, optimization, and security.

PREREQUISITE(S):

Consent of Instructor

PERFORMANCE OUTCOMES:

At completion of course, students will be able to:

1. Implement equal and unequal-cost load balancing with interior routing protocols.
2. Analyze IP addressing requirements and implement classful or CIDR with route aggregations, VLSM, IP unnumbered, DHCP, helper addresses, supernetting, and fault tolerance.
3. Configure default routing, and floating static routes to optimize convergence and route calculation.
4. Configure, verify, and monitor OSPF operation in single or multiple-areas, with NBMA, full mesh, or point-to-multipoint networks.
5. Utilize OSPF capabilities for route summarization, stub areas, backbone areas, and virtual links.
6. Configure, verify, and monitor EIGRP operation.
7. Optimize routing by controlling updates using policy routing, route distribution, and route maps.
8. Configure, verify, and monitor BGP by controlling attributes, using route reflectors, route filtering, policy routing, redundancy, symmetry and load balancing.
9. Configure IS-IS to operate in an integrated WAN environment.
10. Analyze and implement security using access-lists, lock-and-key, session filtering, reflective access-lists, and context-based access control.

REFERENCES:
Cisco Technical Manual(s)
CCNP Routing Study Guides

EVALUATION:

Assignments will be graded on a point system; total points possible will be announced at the start of each project. Quizzes and tests will also be on a point system. Total points earned will be divided by total points possible to get a percentage with grade conversion as follows:

90 - 100 A
80 - 89 B
70 - 79 C
60 - 69 D

Generally, no work will be accepted after due date unless arrangements are made prior to the due date.

Lab activities, group work will be done on scheduled day only with no opportunity for makeup.

FINAL: 1/4 on-line chapter quizzes
1/4 labs, lab tests, homework
1/4 case study/design project/presentation
1/4 final: on-line, skills

ACCOMMODATION: Eligible students with disabilities will receive appropriate accommodations in this course when requested in a timely way. Please speak with me after class or in my office. Please be prepared to provide a letter from your DSS Coordinator.

STUDENT CONDUCT CODE:

Students are expected to follow the University of Montana Student Code. The code includes the following:

… Academic misconduct is defined as all forms of academic dishonesty, including but not limited to:

- Plagiarism: Representing another person's words, ideas, data or material as one's own.
- Substituting or arranging substitution, for another student during an examination or other academic exercise:
- Knowingly allowing others to offer one's work as their own.

Student Code copies are available at Student Services or www.umt.edu/studentaffairs/

EXPECTATIONS/POLICIES:

1. Class structure will include lectures on new material, assignments, lab assignments, group discussions, research of current periodicals and Internet, review, handouts, pop quizzes, and scheduled tests. Internet and e-mail is used extensively. Course curriculum is on-line.

2. Lab time is given in class for some projects. It is expected the student will need to spend two hours of outside work for each hour in class.

3. As each project is assigned, total points possible, due date, and specific requirements will be announced.

4. BASICS:
   - Treat other students, the instructor, and guests with courtesy and respect.
   - Please do your best to be on-time for class.
   - If you miss or are late, get material from another student.
   - Please listen when others are speaking.
   - Discrimination and harassment of any kind will not be tolerated.
   - Any misuse of the equipment, installing own software, or unprofessional conduct will not be tolerated.
   - For the courtesy of others, put all pagers and cell phones on silent or turn them off. If you need to take a call, do so outside of the classroom
   - Do not use computers during lectures unless you are following the lecture using the on-line curriculum. Check e-mail or surf web before or after class.

COURSE OUTLINE:

I. Scalable Internetworks
- A. Hierarchical Network Design Model
  1. The three-layer hierarchical design model
  2. Router function in the hierarchy
  3. Core layer
  4. Distribution layer
  5. Access layer
- B. Key Characteristics of Scalable Internetworks
  1. Five characteristics of a scalable network
  2. Making the network reliable and available
  3. Making the network responsive
  4. Making the network efficient
  5. Making the network adaptable
  6. Making the network accessible but secure
- C. Case Study
- D. Basic Router Configuration
  1. Getting started and building start.txt
  2. Capturing HyperTerminal and Telnet sessions
  3. Access control list basics and extended ping
  4. Implementing quality of service with priority queuing
- E. Load balancing Lab Exercises
  1. Equal-cost load balancing with RIP
  2. Unequal-cost load balancing with IGRP

II. Advanced IP Addressing Management
- A. IPv4 Addressing
  1. Address architecture of the Internet
  2. Classes of IP addresses
  3. Subnet masking
- B. IP Addressing Crisis and Solutions
  1. IP Addressing crisis
  2. Classless Interdomain routing (CIDR)
  3. Route aggregation and supernetting
  4. Supernetting and address allocation
- C. VLSM
  1. Variable-Length Subnet Masks
  2. Classless and classfull routing protocols
- D. Route Summarization
  1. An overview of route summarization
  2. Route flapping
- E. Private addressing and NAT
  1. Private IP addresses (RFC 1918)
  2. Discontiguous subnets
  3. Network Address translation (NAT)
- F. IP Unnumbered
- G. DHCP and Easy IP
  1. DHCP overview
  2. DHCP operation
  3. Configuring IOS DHCP server
  4. Easy IP
- H. Helper Addresses
  1. Using helper addresses
  2. Configuring IP helper addresses
- I. IPv6
  1. IP address issues solutions
  2. IPv6 address format
- J. Advanced IP Addressing Management
  1. Configuring VLSM and IP Unnumbered
  2. VLSM
  3. Using DHCP and IP Helper Addresses
  4. Network Address Translation

III. Routing Overview
- A. Routing
  1. Routing fundamentals
  2. Static routing
  3. Configuring dynamic routing
  4. Distance vector routing protocols
  5. Link-state routing protocols
  6. Hybrid routing: EIGRP
- B. Default Routing
  1. Default routing overview
  2. Configuring static default routes
  3. Default routing with IGRP
  4. Default route caveats
- C. Floating Static Routes
  1. Configuring floating static routes
- D. Convergence
  1. Convergence issues
- E. Route Calculation
  1. Route calculation fundamentals
  2. The initiation of routing updates
  3. Routing metrics
- F. Routing Process Configuration
  1. Migrating from RIP to EIGRP
  2. Configuring IGRP
  3. Configuring default routing with RIP and IGRP
  4. Configuring floating static routes

IV. Routing Information Protocol
- A. RIPv2 Overview
  1. RIPv2 operation
  2. Issues addressed by RIPv2
  3. RIPv2 message format
  4. Compatibility with RIPv1
  5. Classless route lookups
  6. Classless routing protocols
  7. Authentication
  8. Limitations of RIPv2
- B. Configuring RIPv2
  1. Basic RIPv2 configuration
  2. Compatibility with RIPv1
  3. Discontiguous subnets and classless routing
  4. Configuring authentication
- C. Verifying RIPv2 operation
  1. **show** commands
  2. **debug** commands
- D. RIPv2 Lab Exercises
  1. Routing between RIPv1 and RIPv2
  2. RIPv2 MD5 authentication

V. EIGRP
- A. EIGRP Fundamentals
  1. EIGRP and IGRP compatibility
  2. EIGRP design
  3. EIGRP terminology
- B. EIGRP Features
  1. EIGRP technologies
  2. Neighbor discovery and recovery
  3. Reliable transport protocol
  4. DUAL finite-state machine
  5. Protocol-dependent modules
- C. EIGRP Components
  1. EIGRP packet types
  2. EIGRP tables
  3. Route tagging with EIGRP
- D. EIGRP Operation
  1. Convergence using EIGRP
- E. Configuring EIGRP
  1. Configuring EIGRP for IP networks
  2. EIGRP and the **bandwidth** command
  3. The **bandwidth-percent** command
  4. Summarizing EIGRP routes for IP
- F. Monitoring EIGRP
  1. Verifying EIGRP operation
- G. EIGRP Configuration Lab
  1. Configuring EIGRP
  2. Configuring EIGRP fault tolerance
  3. Configuring EIGRP summarization
- H. EIGRP Configuration Challenge Lab

VI. OSPF
- A. OSPF Overview
  1. Issues addressed by OSPF
  2. OSPF terminology
  3. OSPF states
  4. OSPF network types
  5. The OSPF Hello protocol
- B. OSPF Operation
  1. Steps of OSPF operation
  2. Step 1: Establish router adjacencies
  3. Step 2: Elect a DR and a BDR
  4. Step 3: Discover routes
  5. Step 4: Select appropriate routes
  6. Step 5: Maintain routing information
- C. OSPF Configuration and Verification
  1. Configuring OSPF on routers within a single area
  2. Optional configuration commands
  3. **show** commands
  4. **clear** and **debug** commands
- D. Configuring OSPF Over NBMA
  1. NBMA overview
  2. Full-Mesh Frame Relay
  3. Partial-Mesh Frame Relay
  4. Point-to-Multipoint OSPF
- E. Multiple OSPF Operation
  1. Creating multiple OSPF areas
  2. OSPF router types
  3. OSPF LSA and area types
  6. Configuring OSPF operation across multiple areas
  7. Flooding LSUs to multiple areas
  8. Updating the routing table
  9. Opaque LSAs
- F. Multiarea OSPF Configuration and Verification
  1. Using and configuring OSPF multiarea components
  2. Configuring OSPF route summarization
  3. Verifying mulitarea OSPF operation
- G. Stub, Totally Stubby Areas, Not-So Stubby Areas
  1. Using stub and totally stubby areas
  2. Stub and totally stub area criteria
  3. Configuring stub and totally stubby areas
  4. OSPF stub area configuration example
  5. OSPF totally stubby configuration example
  6. NSSA overview
  7. How NSSA operates
  8. Configuring NSSA
- H. Virtual Links
  1. Meeting the backbone area requirements
  2. Configuring virtual links
  3. Virtual link configuration example
- I. OSPF Verification and Configuration Lab
  1. Configuring OSPF
  2. Examining the DR/BDR election process
  3. Multiarea OSPF
  4. Configuring a stub area and a totally stubby area
  5. Configuring an NSSA
  6. Configuring virtual links
- J. Creating Mulitarea OSPF Challenge Lab
  1. OSPF challenge lab

VII IS-IS
- A. IS-IS Fundamentals
  1. OSI protocols
  2. OSI terminology
  3. ES-IS and IS-IS
  4. Integrated IS-IS
  5. OSPF versus IS-IS
- B. ISO Addressing
  1. NSAP's
  2. NETs
  3. ISO addressing with Cisco routers
  4. Identifying systems in IS-IS
- C. IS-IS Operation
  1. High-level view of IS-IS operation
  2. OSI PDU's
  3. IS-IS hello messages
  4. IS-IS link-state PDU (LSP) formats
  5. IS-IS routing levels

6. IS-IS adjacencies
7. Designated Intermediate Systems (DIS) and Pseudonodes (PSN)
8. IS-IS data flow
9. LSP flooding and synchronization
10. IS-IS metrics
11. IS-IS network types
12. SPF algorithm

D. IP Routing with Integrated IS-IS
1. OSI, IP, and dual
2. Suboptimal IS-IS routing
3. Intra-area and Inter-area Integrated IS-IS routing example

E. Configuration of Integrated IS-IS
1. Basic configuration of Integrated IS-IS
2. Multi-Area Integrated IS-IS configuration

F. Integrated IS-IS Operation in a WAN Environment
1. Point-to-point and point-to-mulitpoint operation with IS-IS
2. Configuring Integrated IS-IS in a WAN environment
3. Frame Relay point-to-point scenario with Integrated IS-IS
4. Frame Relay point -to-mulitpoint scenario with Integrated IS-IS
5. Detecting mismatched interfaces with Integrated IS-IS

G. IS-IS Configuration Lab
1. Configuring basic integrated IS-IS
2. Configuring multi-area integrated IS-IS
3. Configuring IS-IS over Frame Relay

VIII. Route Optimization

A. Controlling Routing Update Traffic
1. Controlling routing updates
2. Passive interfaces
3. Filtering routing updates with distribute-list

B. Policy Routing
1. Policy routing overview
2. Policy routing example

C. Route Redistribution
1. Redistribution overview
2. Administrative distance
3. Modifying administrative distance by using the distance command
4. Redistribution guidelines
5. Configuring one-way redistribution
6. Configuring two-way redistribution
7. Redistributing connected and static routes
8. Verifying redistribution operation

D. Route Optimization Configuration
1. Configuring distribute lists and passive interfaces
2. Configuring route maps
3. Unequal-cost load balancing with IGRP

IX. Routing Overview

A. Autonomous Systems
1. Overview of autonomous systems
2. Single-homed autonomous systems
3. Multi-homed non-transit autonomous systems
4. Multi-homed transit autonomous systems
5. When not to use BGP

B. Basic VGP Operations
1. BGP routing updates
2. BGP neighbors
3. BGP message types
4. BGP neighbor negotiation
5. Network-Layer Reachability Information
6. Path attributes

C. Configuring BGP
1. Basic BGP configuration
2. EBGP and IBGP
3. EBGP and IBGP configuration example
4. EBGP multihop
5. Clearing the BGP table
6. Peering
7. How to maintain BGP inside an AS

D. Monitoring BGP operation
1. Verifying BGP operation

E. The BGP Routing Process
1. An overview of the BGP routing process
2. The BGP routing process model
3. Implementing BGP routing policy

F. BGP Attributes
1. Controlling BGP routing with attributes
2. The Next Hop attributes
3. Next Hop behavior on multi-access media
4. Next Hop behavior on NBMA networks
5. The Next Hop attribute
6. Next Hop behavior on multi-access media
7. Next Hop behavior on NBMA networks
8. The AS_Path attribute
9. AS_Path and private AS numbers
10. The Atomic Aggregate attribute
11. The Aggregator attribute
12. The Local Preference attribute
13. Manipulating Local Preference
14. The Weight attribute
15. The Multiple Exit Discriminator attribute
16. MED configuration example
17. The Origin attribute

G. The BGP Decision Process

H. BGP Route Filtering and Policy Routing
1. BGP route filtering
2. Using filters to implement routing policy
3. Using distribute-list to filter BGP routes
4. The **ip prefix-list** command
5. Example ip prefix-list configuration