George Mason University
Graduate Course Approval/Inventory Form

Please complete this form and attach a copy of the syllabus for new courses. Forward it as an email attachment to the Secretary of the Graduate Council. A printed copy of the form with signatures should be brought to the Graduate Council Meeting. Complete the Coordinator Form on page 2, if changes in this course will affect other units.

Please indicate: ___X__ NEW       ___ MODIFY       ___ DELETE

Local Unit: ECE/TCOM

Graduate Council Approval Date:

Course Abbreviation: TCOM

Course Number: 610

Full Course Title: Border Gateway Protocol Routing

Abbreviated Course Title (24 characters max.): BGP Routing

Credit hours: 3.0

Program of Record: MS in Telecommunications

Repeatable for Credit? ___ D=Yes, not within same term Up to hours ___ T=Yes, within the same term Up to hours ___ N=Cannot be repeated for credit

Activity Code (please indicate): __X_ Lecture (LEC) ___ Lab (LAB) ___ Recitation (RCT) ___ Studio (STU) ___ Internship (INT) ___ Independent Study (IND) ___ Seminar (SEM)

Catalog Credit Format 3.0: 3.0: 0

Course Level: GF(500-600) ___X__ GA(700+) ___

Maximum Enrollment: 35

For NEW courses, first term to be offered: Fall 2005

Prerequisites or co-requisites: prerequisite course TCOM 509 and TCOM 515, or equivalent

Catalog Description (35 words or less) Please use catalog format and attach a copy of the syllabus for new courses: Development of Border Gateway Protocol and its application in today’s Internet routing architecture. Evolution of Internet, BGP routing standard specifications (RFCs), interaction between various routing protocols, network BGP routing design principals and procedures for enterprise and ISP networks, BGP’s real-world implementation and configuration syntax, network scalability and convergence issues and the latest extension and proposals for new standards.

For MODIFIED or DELETED courses as appropriate:

Last term offered: Previous Course Abbreviation: Previous number:

Description of modification:

APPROVAL SIGNATURES:

Submitted by: ___Jeremy Allnutt__________________ email: jallnutt@gmu.edu___

Department/Program: ___ECE/MS in Telecommunications ___ Date: __Oct. 18th, 2004___

College Committee: ________________________________ Date: __Oct. 21st, 2004___

Graduate Council Representative: ________________________________ Date: _______________
GEORGE MASON UNIVERSITY  
Course Coordination Form

**Approval from other units:** Not Applicable

Please list those units outside of your own who may be affected by this new, modified, or deleted course. Each of these units must approve this change prior to its being submitted to the Graduate Council for approval.

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Graduate Council approval: ________________________________ Date: __________

Graduate Council representative: __________________________ Date: __________

Provost Office representative: ____________________________ Date: __________
1. CATALOG DESCRIPTION
   (a) TCOM 610 Border Gateway Protocol (BGP) Routing (3:3:0)
   (b) Prerequisites: TCOM 509 and TCOM 515, or equivalent
   (c) Catalog Description:
       Course will discuss development of Border Gateway Protocol and its application in today’s
       Internet routing architecture. It will cover the evolution of Internet, BGP routing standard
       specifications (RFCs), interaction between various routing protocols, network BGP routing
       design principals and procedures for enterprise and ISP networks, BGP’s real-world
       implementation and configuration syntax, network scalability and convergence issues and the
       latest extension and proposals for new standards.

2. JUSTIFICATION
   (a) Course Objectives:
       This course is intended to build upon the general introduction to TCP/IP (TCOM 509) class. This
       course is designed to be largely a theoretical and conceptual rather than a practical and hands-on
       course. Students will be exposed to routing protocol configuration and hands-on experimentation
       in the IP Routing Protocols Lab (TCOM515). The proposed TCOM 610 will give students the
       chance to study Internet routing architecture and examine the BGP protocol in detail. It provides
       students an opportunity to design complex, scalable, redundant and fast-converging BGP routed
       networks for enterprises or Internet service providers (ISP). This course is also intended to
       provide students with the theoretical background to understand the routing protocol design
       process and to participate in the evaluation of routing standards documents such as Internet
       Engineering Task Force’s Request for Comment (RFCs).
   (b) Course Necessity:
       The proposed course is one of a group of elective courses that will be part of the Protocol Course
       Progression in the TCOM program to be made available for advanced TCOM students and
       students from other, related programs who desire to become experts in this area. The course will
       form a necessary building block for Ph.D. students interested in developing Protocol Stacks.
   (c) Relationship to Existing Courses:
       The course is a natural progression for students to take following TCOM 509 and the basic
       network lab/lecture course TCOM 515, which introduce the concepts of routing protocols. This
       course is a companion to IGP Routing (TCOM 609) and may be taken simultaneously. A third
       course, TCOM 611 on MPLS, will require either TCOM 609 or TCOM 610 to be taken as a
       prerequisite. TCOM 609, TCOM 610, and TCOM 611 do not have any overlapping courses at
       George Mason University, although elements of all three courses have been taught previously as
       Advanced Topics course in the TCOM program.

3. APPROVAL HISTORY
   ECE Department Date: October 18\textsuperscript{th}, 2004
   IT&E Graduate Committee Date: October 21\textsuperscript{st}, 2004
   IT&E Dean Date: 
4. SCHEDULING
Every fall semester, starting fall 2005 and every fall thereafter.
Proposed Instructors: Dr. Jeremy Allnutt, Dr. Yunqing Wu, Mr. Tom Van Meter and other suitably qualified faculty.

5. COURSE OUTLINE
(a) Syllabus

Week 1
*Introduction to TCP/IP, IP addressing and Internet evolution:* OSI model; TCP/IP; Internet history; IP addressing; per-hop routing behavior; routing protocols
*Project discussion*

Week 2
*Routing protocol algorithms and BGP routing:* graph theory and IP routing; Dijkstra’s algorithm and Bellman-Ford algorithm; distance vector vs link-state protocol and BGP enhancements; desired routing protocol behaviors; BGP operations

Week 3
*BGP overview and specifications:* BGP’s role in Internet routing, BGP protocol specification (RFC1771), BGP message type and formats, BGP states and state transition, and BGP attributes
*Student BGP design project initiated*

Week 4
*BGP operations and decision process:* BGP neighbor state and operations; BGP attributes and BGP decision process; Enterprise network routing examples; Cisco BGP configuration syntax

Week 5
*Route filtering and routing policy:* route update process; route attribute manipulations (local_pvi, next_hop, AS_PATH, MED, community); inbound and outbound routing policy; Cisco route-map; Peer-group

Week 6
*BGP design and enterprise case study:* BGP design principles; routing design for redundancy, symmetry and load-balancing; default-only vs. full Internet routes; single homed vs. multi-homed

Week 7
*iBGP, Route-reflector and AS confederation:* iBGP vs. eBGP; IGP vs. BGP; routing protocol interaction; route redistribution; BGP scalability; IBGP specifications (RFC2796, RFC3065)

Week 8
*Mid-term exam and project discussion*

Week 9
*ISP services and ISP routing design:* ISP services characteristics; transit services and SLA; Peering and hot-potato routing; Typical ISP network design; ISP routing case study
Week 10
*Routing Registry, Route server, Looking glasses, and BGP routing troubleshooting:* Routing registry and IRR servers; RPSL; Route server projects; ISP looking glasses, general BGP troubleshooting tips

Week 11
*BGP enhancements and security:* BGP capability negotiation; route-refresh and soft-reconfiguration; MD5 authentications for BGP neighbors; S-BGP/soBGP/BGP TTL (RFC2385, RFC2918)

Week 12
*BGP convergence and route-damping:* BGP convergence; BGP timers; BGP convergence factors; route-damping parameters (RFC2439)

Week 13
*MP-BGP and L3VPN:* MP-BGP specifications; MPLS concept; VPN overview; MP-BGP for L3VPN; new feature and directions for BGP (RFC2858, RFC2547)

*Student projects due*

Week 14
*Project presentations/discussion and final examination review:* discuss various ways to implement project; selected project presentation; final exam review presented and discussed; final exam review

Week 15
Final exam

(b) Required Reading and Reference Material

- **Recommended Textbooks (both required):**
  - BGP4, John W. Stewart, ISBN 0-201-37951-1, Addison-Wesley

- **Reference Books:**

- **Online Resources:**
  - Online tutorial and technical presentations from [http://www.nanog.org](http://www.nanog.org) archives
  - Technical white papers from [http://www.cisco.com](http://www.cisco.com) and [http://www.juniper.net](http://www.juniper.net)
  - Various BGP tools and resources from [http://www.bgp4.as/](http://www.bgp4.as/)

(c) Student Evaluation Criteria
Mid-term:  35%
Project:  30%
Final:  35%