Science of Communication Networks
The University of Kansas EECS 784
Spring 2016

James P.G. Sterbenz

Department of Electrical Engineering & Computer Science
Information Technology & Telecommunications Research Center
The University of Kansas

jgps@eeecs.ku.edu

http://www.ittc.ku.edu/~jgps/courses/nets
Communication Networks

AE.1 Administrivia

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AE.1.3 Instructor information and correspondence
AE.1.4 Grading and student expectations

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Communication Networks

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Course Information

High-Level Schedule

• Lecture: Thu. 18:10 – 21:00
  – 3150 Learned (Lawrence)

• Discussion: Tue. 18:10 – 21:00
  – 3150 Learned meets *only* when necessary and announced

• 21 Jan. – 12 May
  – two sectional exams
  – no final exam
    • project presentations in lieu of final exam
  – no lecture 17 Mar. due to spring break
Course Information
Cancellation and Rescheduling

• Cancellation due to weather
  – official closings unlikely
    • follow media announcements

• Rescheduling due to my travel
  – I try *very hard* to avoid rescheduling class
  – project meetings & conferences sometimes interfere
  – this is the cost of an instructor who is active in research
Course Information

Influenza Precautions and Requirements

- **Influenza (including H1N1)**
  - so far no CDC reports in Kansas
  - peak typically in spring semester

- **If you have flu-like symptoms (with fever, aches)**
  - *do not come to class*, but contact me *in advance*
  - be conservative: I’ll work with you to make up material

- **Recommendations**
  - *get the seasonal flu vaccine* (as I have)
    - available by appointment from KU SHS: +1 785 864 9507
  - *carry and use alcohol-based hand sanitiser*
  - *use every time you enter classroom*
Course Information
Influenza Official University Advice

- Provost advice for people with flu-like symptoms
  - stay home
  - isolate yourself until your temperature, without medication, is normal for 24 hours
  - don't go to the Student Health Services or other medical offices if you don't need to; faculty are asked not to require doctor's notes from absent students
  - if you have concerns, call a nurse at Student Health Services or other medical offices
  - students unable to attend class due to illness should contact their professor prior to the absence and make arrangements for completing class assignments
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EECS 784 Student Requirements

• All students
  – EECS or ITTC account (get now if you don’t already have)
  – familiarity with Unix-type CLI
  – familiarity with text editor (e.g. emacs, vi, gedit)
  – ability to generate PDF

• Undergraduate students
  – ULE qualified to take as senior elective
  – engineering GPA ≥ 3.0
    • talk to me if you do not meet this requirement!
Communication Networks
EECS SCN Prerequisites

• Basic working knowledge of:
  – computer systems
  – Internet
  – probability and statistics (EECS 461 equivalent)
  – programming skills (EECS 168 equivalent)

• Another networking course is *not* prerequisite
  – e.g. EECS 780 or 563
  – but will help you understand motivation for theory
Communication Networks
EECS 784 Course Description

Comprehensive introduction to the fundamental science that is the basis for the architecture, design, engineering, and analysis of computer networks. Topics covered will include foundations on:

1. Structure of networks: graph theory, complex systems analysis, centrality, spectral analysis, network flows, and network topology
2. Identification of network entities: naming, addressing, indirection, translation, and location
3. Operation of protocols and information transfer: automata, control theory, Petri nets, layering and cross-layering, protocol data units
4. Policy and tussle: game theory, decision theory
5. Resilience: dependability (reliability, availability, and maintainability), performability, fault tolerance, and survivability

Open source tools will be used for network modelling and analysis

Prerequisites: EECS upper-level eligibility and engineering GPA ≥ 3.0 (for undergraduates), graduate standing, or permission of the instructor.
Communication Networks
Summary of EECS SCN Course Description

• Seminar-style course
  – concepts and examples of systems and protocols
  – readings and mini-lectures
  – student-lead paper presentation and discussion

• Emphasis on
  – structure of networks (graph theory and complex systems)
  – identification of network entities
  – operation of protocols and information transfer
  – policy and tussle (game theory)
  – resilience, survivability, dependability and performability
Communication Networks

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Instructor Information

Background

- Dr. James P.G. Sterbenz
  - Professor, ECCS and ITTC, KU Lawrence, US
  - Visiting Professor, Comp. & Comms., Lancaster Univ., UK
  - Adjunct Professor, Comp., Hong Kong Polytechnic University
  - past research and management positions
    - UMass, BBN Technologies, GTE Laboratories, IBM Research
  - academic background
    - D.Sc., Washington University in St. Louis, 1991
  - research interests
    - resilient, survivable and disruption-tolerant networking
    - Future Internet architecture and programmable networks
    - mobile wireless networking and MANETs
    - high-speed networking and system architecture
Instructor Information

Contact Modes

- **Web:** check the class Web pages first
  - important announcements at top of 2016 page
  - detailed schedule

- **Email:** generally the best means of communication
  - many issues and questions can be quickly resolved
  - use to arrange other appointments

- **Social networks**
  - Facebook: facebook.com/groups/eecs784
  - Google+: gplus.to/eecs784
  - subscribe and *post* if you wish to interact
Instructor Information
Contact Modes

- Interactive
  - skype chat (but not voice unless pre-negotiated)
    - jpgsterbenz
  - phone
- Office hours
  - face-to-face contact
Instructor Information

Office Hours

• Thu. 17:00 – 18:00
  – unless advised otherwise due to meetings or travel
  – 3036 Eaton *by appointment*
  – skype chat or email to confirm in advance

• Or by other appointment
  – email, chat, or call to arrange in advance
  – typically in Lawrence if not travelling
    • 154 Nichols: research office
    • 3036 Eaton: teaching and undergraduate advising office
Instructor and GTA Information

Contact: Email Address

- **Email:** `jgps@eeecs.ku.edu only`
  - begin subject with *exact string* “EECS784 -”
    - no space between “EECS” and “784”
    - blank space between “784” and hyphen
    - email to other addresses will likely be misfiltered and *unread*
  - I generally check email daily
    - email is *unreliable*; retry if no reply within 48 hours
    - if quick reply is needed feel free to skype chat or phone
Instructor Information

Contact: Email Address

- Email with *meaningful* subject lines
  - bad
    Subject: Hi!
    Subject: regarding class
  - good
    Subject: EECS784 - need help with graph metrics
Electronic Mail

Netiquette: Sender Identification Name

• Configure email client with your *name* in ISO-Latin
  – e.g. Ima K.U. Student <ima.student@eecs.ku.edu>

• CJK (Chinese, Japanese, Korean) encodings
  – appear as gibberish to older and non-GUI email clients
  – use only *after* ISO-Latin name
  – e.g.
    James P.G. Sterbenz 司徒傑莫 송재윤 <jpgs@eecs.ku.edu>
Electronic Mail

Netiquette: Sender Identification Signature

- Define a meaningful signature (.sig)
  - name, affiliation, telephone number, URL if you have one
  - max. of ~4 lines (not including separator dashes)
  - max of 72 characters/line, e.g.

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Ima K.U. Student
Electrical Engineering & Computer Science, The University of Kansas
ima.student@eecs.ku.edu www.ittc.ku.edu/~ikus
+1 785 864 4776
Electronic Mail
Netiquette: Formatting

• Email was originally text-only with no formatting
  – many people still like it that way!
    • some people still use text only clients
    • increasing use of PDAs
  – not all clients are MS Outlook!

• Unless pre-negotiated with the recipient:
  – use plain text with no formatting
    • some email clients have formatting on by default
    • some misconfigured (MS-Exchange) servers format anyway
  – do not send email as HTML
  – do not embed images
Electronic Mail

Netiquette: Content and Attachments

• Content issues
  – use meaningful subject lines
  – spellcheck (most modern clients do this)
  – *think* before you send

• Simple emails should not be sent as attachments
  – e.g. MS-Word document containing “where are you now?”

• Do not send very large attachments unless
  – receiver is able to handle them (broadband access)
  – small enough to pass relay & server limits (typ. <10 MB)
Electronic Mail
Netiquette: Professionalism

• Email is like conversation, writing, and attire
  – adapt style to context
  – academic and professional is more formal than with friends

• Style
  – plain text, no embedded images
  – limit jargon and emoticons to someone you know well
  – proofread and think before you send

• Proofread and think before you send!
Electronic Mail
Netiquette: Professionalism

- Avoid free email accounts
  - e.g. hotmail, yahoo
- Gives you a very unprofessional appearance
  - frequently auto-append advertisements
- Frequently spam-blocked
- Use academic or corporate email addresses
  - for professional correspondence
  - gmail has become acceptable for professional appearance
Electronic Mail

Netiquette: Professionalism Examples

To: James Sterbenz <jpgs@eecs.ku.edu>
From: Ima <cool_dude@stupidmail.com>
Subject: need a job!!!

I'm new at KU and really like it 😊
I'm interested in everything and
am bombing this email to all KU professors. I've stopped by your office
in Eaton but you're never there!!! 😓
Do you even have office hours
dude? LOL! Just tell me when I can
dropby too learn what you do
ru there ???!!

cu later,
ima

What's wrong?

Get your free email at Stupidmail.com!
Eat at Joe's: 1234 Mass. Lawrence, KS
Electronic Mail
Netiquette: Professionalism Examples

To: James Sterbenz <jgps@eecs.ku.edu>
From: Ima <cool_dude@stupidmail.com>
Subject: need a job!!

i'm new at KU and realy like it 😊
i'm interested in everything and
am bombing this email to all KU
professors. i've stopped by your offic
in Eaton but your never there!!! 😐
do you even have office hours
dude? LOL! Just tell me when I can
dropby too learn what you do
r u t h e r e ???!!

cu later,
ima

__________
Get your free email at Stupidmail.com!

Eat at Joe's: 1234 Mass. Lawrence, KS

To: James Sterbenz <jgps@eecs.ku.edu>
From: Ima Student <student@eecs.ku.edu>
Subject: Interest in ResiliNets group

Dear Professor Sterbenz,

I am a new M.S. student in the EECS
department with interests in
networking. I have looked at your Web
pages and read the SUMOWIN paper. I am
very interested in this research and
will come to the next ResiliNets group
meeting on Friday. I would like to
discuss the possibility of you becoming
my advisor and want to understand if
there are any funding opportunities.

Sincerely,
Ima Student

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Ima Student       EECS, Univ. of Kansas
student@eecs.ku.edu     +1 785 555 1212
Student Information

Introductions

• Brief Introductions around the room
  – say who you are and why you are here
• Photos to help me learn your names
Student Information
Contact and Background

• Roster information to be filled in pass-around sheet
  – full name, nickname
  – employer if not full-time student
  – email for class distribution list
    • preferred and mandatory .ku.edu address
  – phone numbers will only be used for urgent matters
    • day and evening
  – degree (BS, MS, PhD)
    • major (IT, CS, CoE, EE)
    • focus area if graduate student
    • option if MS (thesis, project, course)
    • advisor name (“none” if you don’t have one yet)
Course Information
Correspondence to Class

- Course information and notes
  - [http://www.ittc.ku.edu/~jgps/courses/scinets](http://www.ittc.ku.edu/~jgps/courses/scinets)
    - notes for each lecture will be posted in PDF
      - check for 2016 date and version on first page
    - navigate to subpage for Spring 2016 specific information
      - announcements, schedule, and deadlines
  - [http://www.ittc.ku.edu/~jgps/courses](http://www.ittc.ku.edu/~jgps/courses)
    - generic information
  - check *regularly* for updates
    - readings and assignments in schedule table in sub-page
    - “last updated” on bottom of page
Course Information

Correspondence to Class

• Class email list
  – all students are *required* by EECS to read `.ku.edu` email
  • I’m willing to use other email addresses...
  • ...but only if they are relatively reliable
    – many free email accounts are not!
    – if there are problems I’ll change your entry to a `.ku.edu` address
  – check email regularly
  – check email every afternoon before class

• Telephone
  – I’ll only phone you if *urgent*
Instructor Information

Contact: Phone and Chat

• Contact information
  – phone
    • Lawrence Nichols office: +1 785 864 7890
    • Lawrence Eaton office: +1 785 864 8846
    • only if urgent (consider \(\Delta\) time) +1 508 944 3067
    • don’t call me at home unless emergency
  – skype: jpgsterbenz
    • ok to use chat judiciously when email not appropriate
      – send meaningful introduction message!
    • don’t use voice unless prearranged by chat
      – I frequently am not in a position to use headset/microphone
Communication Networks

AE.1.4 Grading and Student Expectations

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Course Information

Textbooks and Reading

• Optional textbooks
  – Newman  *Networks: An Introduction*
  – Estrada & Knight  *A First Course in Network Theory*
  – Lewis:  *Network Science*
    • on reserve in Spahr library

• Optional textbook with required reading
  – Day:  *Patterns in Network Architecture*
    • on reserve in Spahr library
Course Information

Textbooks and Reading

• Supplementary textbooks and monographs
  – provide alternative, in-depth, or background coverage
  – on reserve in Spahr libraries

• Additional papers (many are required reading)
  – supplement books
  – experience that will help you write papers
Course Information
Reading

• How hard is this class?
  – not a “killer class” in terms of homework and projects
  – but it is intellectually challenging with significant reading

• Required readings are *mandatory*
  – you won’t be able to use it on exams

• Reading *must* be done *before* corresponding class
  – you are *doomed* if you get behind on the reading
  – you are responsible for *all* required reading
  • may be on exams *even if not covered in lecture*
  • weekly quiz contributes to your class participation grade
Course Information

Grades

- Grades: modified curve grouped by mode
  - based only on merit; *not* on:
    - employer reimbursement or lack thereof
    - immigration status or potential visa invalidation
    - probationary status at KU
  - qualitative meaning
    - A: exceptional exam results and outstanding term paper
    - B: mastery of material and solid term paper
      *this is the basic expectation for a graduate student*
    - C: slacking but know basic material and marginal paper
    - D: very poor performance on exams or paper
    - F: nonperformance on exams or paper
      *academic misconduct regardless of other grades*
Course Information

Grade Contribution

- Relative grade contribution
  - 30%: two section exams
  - 20%: class participation
    - weekly quizzes on readings
    - questions and interactions with instructor and presenter
  - 20%: paper presentations
  - 30%: project and report
    - extra credit for publishable paper
  - mandatory academic integrity quiz in second class
    - must be made up if you miss this class
  - subject to change: a few SAGE exercises may be added
Course Information
Exam Schedule and Weight

• Section exams: 30%
  – tentative schedule *subject to change*
    • academic integrity quiz on 28 Jan. (required to pass)
    • exam 1 on 25 Feb.
    • exam 2 on 14 April
    • no final exam
Course Information

Exam Characteristics

• Closed book, no electronic devices
  – notify me *in advance* if you know you must miss
  – you will probably have to take the exam in advance

• Exams test *understanding of concepts*
  – not memorisation of facts that could be looked up
  – not focused on the ability to solve problems
  – this will be new to some of you!

• More exam information on
  [http://www.ittc.ku.edu/~jpgs/courses/exams.html](http://www.ittc.ku.edu/~jpgs/courses/exams.html)
Course Information

Exam Questions

• Exams consist of two types of questions
  – sufficient space given to properly and fully answer

• Short answer example (several per page):
  – example question:
    Compare the functionality of the link and transport layers.
Course Information
Exam Questions

• Exams consist of two types of questions
  – sufficient space given to properly and fully answer

• Short answer example (several per page):
  – example question:
    Compare the functionality of the link and transport layers.

• Long answer example (one per page):
  – example exam question:
    Sketch and label a packet flow diagram for stop-and-wait, go-back-n, and selective repeat. Explain the advantages and disadvantages of each scheme.
Course Information
Exam Answers

• Answers must legibly fit in space provided
  – sufficient space given to properly and fully answer
  – be brief; points will be deducted for irrelevant information
    • and you will have a hard time finishing the exam
  – writing on back of page & deep into margins will be ignored
Course Information

Exam Answers: How to Answer

• Example question:
  Compare the functionality of the link and transport layers.
Course Information

Exam Answers: How to Answer

• Example question:
  
  Compare the functionality of the link and transport layers.

  – example correct answer (1 minute to write):
    
    Both the link and transport layer transfer data; the link layer
    hop-by-hop and the transport layer end-to-end.
Course Information

Exam Answers: How Not to Answer

• Example question:

  Compare the functionality of the link and transport layers.

  – example correct answer (1 minute to write):

    Both the link and transport layer transfer data; the link layer hop-by-hop and the transport layer end-to-end.

  – example poor answer (10 minutes to write):

    The link layer is layer 2 in the OSI model, shown in the figure. Examples of link layer protocols include Ethernet, 802.11, SONET, and HDLC. 802.11 was developed in as a replacement for Ethernet, and thus has similar frame structure, shown in Figure 2. Note that 802.11 has more MAC address fields than Ethernet. The reason for the additional address fields has to do with the operation of the 802.11 MAC. Actually I really don’t know the answer to this question, but I did memorise a bunch of stuff on some of these protocols, so I hope that if I write enough that I will get some credit for this question and that if I bomb you with information you will find some reason to give me credit on this problem and so I’m just going to keep writing until time is called on this...
Course Information
Project and Report

- 30% of grade based on project and report
- Purpose and scope:
  - research area of network science in depth
  - technical in nature
    - may lead to MS thesis or PhD dissertation
    - may lead to publication for undergraduate students
    - expected to lead to publication for graduate students
  - either
    - analytical, simulation, or implementation project
    - comprehensive paper survey
  - gain technical writing and presentation experience
Course Information

Project Report Submission

• Submit by term paper milestones (23:59 midnight) to jpgs@eecs.ku.edu
  – Subject: line *must* begin with the *exact string* “EECS784 - term paper” followed by the milestone type
  – as MIME attachment in PDF
  – final presentation as MIME attachment in PowerPoint or PDF

• Submission requirements and templates at www.ittc.ku.edu/~jpgs/courses/writing-guide.html
  – students doing a thesis strongly encouraged to use LaTeX
  – my thesis and project advisees *must* use LaTeX
# Course Information

## Term Paper Milestones and Tentative Schedule

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Details</th>
<th>Due date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two ideas</td>
<td>2 ideas with 2 complete references each</td>
<td>22 Feb.</td>
</tr>
<tr>
<td>Proposal</td>
<td>Proposal with 5 complete references</td>
<td>14 Mar.</td>
</tr>
<tr>
<td>Outline</td>
<td>Draft outline with no body text and more refs.</td>
<td>04 Apr.</td>
</tr>
<tr>
<td>Draft report</td>
<td>Mostly complete draft project report</td>
<td>02 May</td>
</tr>
<tr>
<td>Presentation</td>
<td>Presentation to class and discussion</td>
<td>12 May</td>
</tr>
<tr>
<td>Final report</td>
<td>Complete polished report (in lieu of final exam)</td>
<td>12 May</td>
</tr>
</tbody>
</table>

- Series of milestones (generally due on Mon.)
  - flow control process and allow us to discuss progress
    - you will not do well if you wait until the last minute
  - timely submission part of final project report grade
  - milestones not meeting basic requirements not accepted
Course Information
Sources of Literature: Library

• The Library
  – big building with books and paper journals: use it!

• Physically browsing is a wonderful way to brainstorm
  – Spahr Engineering Lib. TK numbers most relevant
  – Anschutz (science) Lib. QA and QC numbers most relevant
Course Information
Sources of Literature: Library

- Online resources at www.ku.edu/libraries
  - selected journals
  - access to archived books and journals
  - interlibrary loan
- You *must* learn how to access digital papers via KU
  - off campus users log into the library first
    - this usage help justify the cost of digital library subscriptions
    - for MacBook users papers sets a proxy
- Example sources of papers
  - www.ittc.ku.edu/~jpgs/courses/source-cite.html
Course Information
Sources of Literature: Web

• The Web
  – source for journal papers
    • ACM, IEEE, LNCS, ScienceDirect (subscriptions through library)
    • individual and project Web pages
  – source for information on research projects
  – source for other information
    • Wikipedia: incredibly useful as launching point to other work
      – rarely appropriate to cite Wikipedia pages
    • non-refereed reports and information
  – compare to a street corner bulletin board: use with care
  – use Web citations very judiciously
    • reports with many URL refs will not get an acceptable grade!
Course Information
Class Participation

• 20% of grade is based on class participation
  – insightful questions and comments on lectures
  – evidence that reading has been done before lecture
  – brownie points
    • find bug in lecture note or book; make a good suggestion
    • email reminder with exact Subject: EECS784 - brownie point

• Interactive class is better for all of us
  – questions, comments, arguments
  – blurt it out; don’t wait: you don’t need to raise your hand
  – this may be a cultural shift for some of you; get used to it

• Reminder: reading before class essential
Course Information

Etiquette

• Try to be on time
  – I understand many are commuting, but...
  – consistent late arrivals are disruptive
• Inform me in advance if you need to miss class
  – we accommodate working professionals
  – we’ll arrange to make up missed material
• No audible mobile phone or pagers
  – if it doesn’t vibrate, turn it off!
• University does not tolerate class disruption
  – protests, sit-ins, heckling, etc. (I guess)
Communication Networks

AE.2 Ethics and Academic Integrity

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AE.3 Course outline
Academic Integrity and Plagiarism

Reading the Riot Act

• Apologies to those that already know this
  – ... especially who’ve heard it from me before
• Opportunity to learn for those who:
  – are inexperienced in writing
  – come from an environment or culture of tolerance
• Warning of the consequences
  – ignorance will not be an excuse
  – ask me if you have any question about this
• Applies to
  – copying homework and lab exercises
  – cheating on exams
  – plagiarism on term paper and presentation
Academic Integrity and Plagiarism
Referencing and Citations

• All sources *must* be properly referenced and cited
  – authors, “paper name”, *journal*, date, publisher, page–range
    • also URL if from obscure source (e.g. university tech reports)
    • see course Web page or for examples

• Cite whenever
  – work is related or ideas are used
  – text is quoted or paraphrased
  – diagrams are reproduced or incorporated (even if redrawn)
Academic Integrity and Plagiarism

Proper Quoting and Paraphrasing

• Quoting text or paraphrasing
  – “quotation marks” for sentence or less
  – blockquote for multiple sentences

• Beware of read-then-write in two windows
  – never ever cut-and-paste from others into your own work
  – take intermediate notes from which you write
Academic Integrity and Plagiarism
Excessive Quoting and Paraphrasing

• Quoting is *rarely* needed
  – example: quoting or paraphrasing definition or principle

• Sequence of quotes *doesn’t* show understanding
  – not a shortcut to English writing skills
    • better to be in your *own* imperfect English
  – papers with excessive quotes will not receive decent grade
    • even if properly quoted
Academic Integrity and Plagiarism
Detection and Sanctions

• Plagiarism is remarkably easy for me to detect
  – inconsistent writing styles and language use
  – technical depth beyond the supposed author
  – inconsistent terminology

• Tools: Web makes both plagiarism & detection easier
  • Web search on suspicious phrases
  • automated tools match and highlight with fuzzy searches

• Plagiarism will result in F for course
  – and possible further sanctions
  – it is highly unlikely that you will get away with it!
    • but students still try every semester; you have been warned
Academic Integrity and Plagiarism

Academic Integrity Quiz

• Homework this week: read
  http://www.ittc.ku.edu/~jpgs/courses/academic-integrity.html
  http://www.ittc.ku.edu/~jpgs/courses/source-cite.html

• You **must understand** this material
  – ask me if you have *any* question
  – goal is for new students to learn

• Next week: academic integrity quiz
AE.1 Administrivia
AE.2 Ethics and academic integrity
AE.3 Course outline
   I. Fundamentals of network graphs
   II. Advanced network graphs
   III. Tussle, network architecture, resilience
EECS 784 Outline

I: Fundamentals of Network Graphs

I: Fundamentals of network graphs
  GT: Graph theory
  GS: Graph spectra and network topology
  RN: Regular networks
  RG: Random graphs

II: Advanced network graphs

III: Tussle, network architecture, resilience
EECS 784 Outline
GT: Graph Theory

• How to model network as a graph
  – nodes are vertices; links are edges

• Graph properties and representation
  – representation, e.g. adjacency matrix
  – metrics

• Centrality
  – vertex or edge importance
EECS 784 Outline

ST: Graph Spectra and Network Topology

- Spectral graph metrics
- Understanding data network topology
EECS 784 Outline
RN: Regular Networks

- Types and properties of regular network graphs
  - linear, ring
  - Manhattan, torus
  - star, tree
  - ...

- Application to networks
  - interconnection networks
EECS 784 Outline

RG: Random Graphs

• ER (Erdős-Rényi) and Gilbert random models
• Other random graph models
  – random geometric
  – Waxman
• Application to modelling Internet
  – Waxman as layer 3 model
EECS 784 Outline

II: Advanced Network Graphs

I: Fundamental of network graphs

II: Advanced network graphs
   - SW: Small-world networks
   - SF: Scale-free networks
   - NF: Network flows and routing

III: Tussle, network architecture, resilience
EECS 784 Outline
SW: Small-World Networks

• Small-world networks
  – low diameter (longest shortest-path between vertex pairs)
• Milgram experiment: six degrees of separation
• Properties
  – low diameter
  – transitivity
• Metrics
  – cliques
  – clustering coëfficient
EECS 784 Outline
SF: Scale-Free Networks

- Power-law degree distribution
  - low diameter (longest shortest-path between vertex pairs)
- Measured property vs. structure
  - Doyle (HOT) vs. Barabási
- Generation
  - cumulative advantage ("rich get richer")
  - preferential attachment
EECS 784 Outline
NF: Network Flows and Routing

- Traffic flows
  - beyond connectivity
- Routing algorithms
  - weighted graphs
  - link state routing
EECS 784 Outline

III: Tussle, Network Architecture, Resilience

I: Fundamentals of network graphs
II: Advanced network graphs
III: Tussle, network architecture, resilience

TG: Tussle and game theory
ID: Identification and addressing
PR: Protocols, automata, control systems, layering
RD: Dependability and resilience
EECS 784
Communication Networks

• And now, the course begins...
  (after some preliminaries)