1. General Information

1a. Submitted by the College of: ENGINEERING

Date Submitted: 9/26/2013

1b. Department/Division: Computer Science

1c. Contact Person

Name: Miroslaw Truszczynski

Email: mirek@cs.uky.edu

Phone: 7-6738

Responsible Faculty ID (if different from Contact)

Name: Brent Seales

Email: seales@uky.edu

Phone: 7-3961

1d. Requested Effective Date: Specific Term/Year [1] Fall 2014

1e. Should this course be a UK Core Course? Yes

Quantitative Foundations

2. Designation and Description of Proposed Course

2a. Will this course also be offered through Distance Learning?: No

2b. Prefix and Number: CS 261

2c. Full Title: Social Networks: Methods and Tools

2d. Transcript Title:

2e. Cross-listing:

2f. Meeting Patterns

LECTURE: 3

2g. Grading System: Letter (A, B, C, etc.)

2h. Number of credit hours: 3

2i. Is this course repeatable for additional credit? No

If Yes: Maximum number of credit hours:

If Yes: Will this course allow multiple registrations during the same semester?

2j. Course Description for Bulletin: CS 261 Social Networks: Methods and Tools - The complex connectedness of the modern society is a multifaceted phenomenon resulting from the growing density of the human population, the advent of fast global mass transportation infrastructure, the emergence of global companies and markets, and spurred by the Internet and its applications such as the Web, Facebook and Twitter. In this course, we learn about graph theory, game theory and computational tools required to model and analyze social networks, matching markets, web search, network externalities, tipping points, information cascades, epidemics, small worlds, and voting schemes. The course requires no programming background and has no university-level prerequisites.

2k. Prerequisites, if any: None.

2l. Supplementary Teaching Component:

3. Will this course taught off campus? No

If YES, enter the off campus address:

4. Frequency of Course Offering: Fall,

Will the course be offered every year?: Yes

If No, explain:

5. Are facilities and personnel necessary for the proposed new course available?: Yes

If No, explain:

6. What enrollment (per section per semester) may reasonably be expected?: 30-50

7. Anticipated Student Demand

Will this course serve students primarily within the degree program?: No

Will it be of interest to a significant number of students outside the degree pgm?: Yes

If Yes, explain: [var7InterestExplain]

8. Check the category most applicable to this course: Relatively New – Now Being Widely Established,

If No, explain:

9. Course Relationship to Program(s).

a. Is this course part of a proposed new program?: No

If YES, name the proposed new program:

b. Will this course be a new requirement for ANY program?: No

If YES, list affected programs:

10. Information to be Placed on Syllabus.

a. Is the course 400G or 500?: No

b. The syllabus, including course description, student learning outcomes, and grading policies (and 400G-/500-level grading differentiation if applicable, from **10.a** above) are attached: Yes

Distance Learning Form

Instructor Name:

Instructor Email:

Internet/Web-based: No

Interactive Video: No

Hybrid: No

1.How does this course provide for timely and appropriate interaction between students and faculty and among students? Does the course syllabus conform to University Senate Syllabus Guidelines, specifically the Distance Learning Considerations?

2.How do you ensure that the experience for a DL student is comparable to that of a classroom-based student's experience? Aspects to explore: textbooks, course goals, assessment of student learning outcomes, etc.

3.How is the integrity of student work ensured? Please speak to aspects such as password-protected course portals, proctors for exams at interactive video sites; academic offense policy; etc.

4.Will offering this course via DL result in at least 25% or at least 50% (based on total credit hours required for completion) of a degree program being offered via any form of DL, as defined above?

If yes, which percentage, and which program(s)?

5.How are students taking the course via DL assured of equivalent access to student services, similar to that of a student taking the class in a traditional classroom setting?

6.How do course requirements ensure that students make appropriate use of learning resources?

7.Please explain specifically how access is provided to laboratories, facilities, and equipment appropriate to the course or program.

8.How are students informed of procedures for resolving technical complaints? Does the syllabus list the entities available to offer technical help with the delivery and/or receipt of the course, such as the Information Technology Customer Service Center (http://www.uky.edu/UKIT/)?

9.Will the course be delivered via services available through the Distance Learning Program (DLP) and the Academic Technology Group (ATL)? NO

If no, explain how student enrolled in DL courses are able to use the technology employed, as well as how students will be provided with assistance in using said technology.

10.Does the syllabus contain all the required components? NO

11.I, the instructor of record, have read and understood all of the university-level statements regarding DL.

Instructor Name:

SIGNATURE|BJSTOK0|Barbara J Brandenburg|CS 261 NEW College Review|20131213

SIGNATURE|RBROWN|Russell M Brown|CS 261 UKCEC Expert Review|20140211

SIGNATURE|JMETT2|Joanie Ett-Mims|CS 261 CS 261MINOR_TEXT_FOR_TITLECS 261MINOR_TEXT_FOR_TITLE&|20140310

SIGNATURE|JMETT2|Joanie Ett-Mims|CS 261 NEW Undergrad Council Review|20140312

Courses	Request Tracking

New Course Form

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	ID	Attachment
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Delete	2302	CS261-Assignments.zip
Delete	2347	CS261-Dept-Approval-2013.pdf

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Select saved project to retrieve... Get New

(*denotes required fields)

1. General Information

a. * Submitted by the College of: ENGINEERING Submission Date: 9/26/2013

b. * Department/Division: Computer Science

c.

* Contact Person Name: Miroslaw Truszczynski Email: mirek@cs.uky.edu Phone: 7-6738

* Responsible Faculty ID (if different from Contact) Brent Seales Email: seales@uky.edu Phone: 7-3961

d. * Requested Effective Date: ○ Semester following approval OR ◉ Specific Term/Year [1] Fall 2014

e.

Should this course be a UK Core Course? ◉ Yes ○ No

If YES, check the areas that apply:

- ☐ Inquiry - Arts & Creativity
- ☐ Inquiry - Humanities
- ☐ Inquiry - Nat/Math/Phys Sci
- ☐ Inquiry - Social Sciences
- ☐ Composition & Communications - I
- ☐ Composition & Communications - II
- ☑ Quantitative Foundations
- ☐ Statistical Inferential Reasoning
- ☐ U.S. Citizenship, Community, Diversity
- ☐ Global Dynamics

2. Designation and Description of Proposed Course.

a. * Will this course also be offered through Distance Learning? ○ Yes [4] ◉ No

b. * Prefix and Number: CS 261

c. * Full Title: Social Networks: Methods and Tools

d. Transcript Title (if full title is more than 40 characters):

e. To be Cross-Listed [2] with (Prefix and Number):

f. * Courses must be described by at least one of the meeting patterns below. Include number of actual contact hours[3] for each meeting pattern type.

3	Lecture		Laboratory[1]		Recitation		Discussion
	Indep. Study		Clinical		Colloquium		Practicum
	Research		Residency		Seminar		Studio
	Other	If Other, Please explain:					

g. * Identify a grading system: ◉ Letter (A, B, C, etc.) ○ Pass/Fail ○ Graduate School Grade Scale

h. * Number of credits: 3

i. * Is this course repeatable for additional credit? ○ Yes ◉ No

If YES: Maximum number of credit hours:

If YES: Will this course allow multiple registrations during the same semester? ○ Yes ○ No

j. * Course Description for Bulletin:

CS 261 Social Networks: Methods and Tools - The complex connectedness of the modern society is a multifaceted phenomenon resulting from the growing density of the human population, the advent of fast global mass transportation infrastructure, the emergence of global companies and markets, and spurred by the Internet and its applications such as the Web, Facebook and Twitter. In this course, we learn about graph theory, game theory and computational tools required to model and analyze social networks, matching markets, web search, network externalities, tipping points, information cascades, epidemics, small worlds, and voting schemes. The course requires no programming background and has no university-level prerequisites.

k. Prerequisites, if any:

None.

l. Supplementary teaching component, if any: ○ Community-Based Experience ○ Service Learning ○ Both

3. *** Will this course be taught off campus?** ○ Yes ◉ No

If YES, enter the off campus address:

4. **Frequency of Course Offering.**

a. * Course will be offered (check all that apply): ☑ Fall ☐ Spring ☐ Summer ☐ Winter

b. * Will the course be offered every year? ◉ Yes ○ No

If No, explain:

5. *** Are facilities and personnel necessary for the proposed new course available?** ◉ Yes ○ No

If No, explain:

6. *** What enrollment (per section per semester) may reasonably be expected?** 30-50

7. **Anticipated Student Demand.**

a. * Will this course serve students primarily within the degree program? ○ Yes ◉ No

b. * Will it be of interest to a significant number of students outside the degree pgm? ◉ Yes ○ No

If YES, explain:

This is a course proposed for UK Core and designed to appeal to a broad student population cutting across all colleges

8. *** Check the category most applicable to this course:**

☐ Traditional – Offered in Corresponding Departments at Universities Elsewhere
☑ Relatively New – Now Being Widely Established
☐ Not Yet Found in Many (or Any) Other Universities

9. **Course Relationship to Program(s).**

a. * Is this course part of a proposed new program? ○ Yes ◉ No

If YES, name the proposed new program:

b. * Will this course be a new requirement [5] for ANY program? ○ Yes ◉ No

If YES [5], list affected programs::

10. **Information to be Placed on Syllabus.**

a. * Is the course 400G or 500? ○ Yes ◉ No

If YES, the *differentiation for undergraduate and graduate students must be included* in the information required in 10.b. You must include: (i) identi additional assignments by the graduate students; and/or (ii) establishment of different grading criteria in the course for graduate students. (See SR

b. ☑ * The syllabus, including course description, student learning outcomes, and grading policies (and 400G-/500-level grading differentiation if appl 10.a above) are attached.

[1] Courses are typically made effective for the semester following approval. No course will be made effective until all approvals are received.
[2] The chair of the cross-listing department must sign off on the Signature Routing Log.
[3] In general, undergraduate courses are developed on the principle that one semester hour of credit represents one hour of classroom meeting per week for a semester, exclusive of any laboratory meeting. Laboratory meeting, generally, re two hours per week for a semester for one credit hour. (from SR 5.2.1)
[4] You must also submit the Distance Learning Form in order for the proposed course to be considered for DL delivery.
[5] In order to change a program, a program change form must also be submitted.

Rev 8/09

Submit as New Proposal   Save Current Changes

Course Review Form
Quantitative Foundations

Reviewer Recommendation

Accept ☐ Revisions Needed ☐

Course: CS 261 - Social Networks: Methods and Tools

Using the course syllabus as a reference, identify when and how the following learning outcomes are addressed in the course. Since learning outcomes will likely be addressed multiple ways within the same syllabus, please identify a representative example (or examples) for each outcome.

☐ 1. Students must demonstrate proficiency with number sense (e.g., order of magnitude, estimation, comparisons, effect of operations)

Date/location on syllabus or assignment:
Several homework problems, for instance Homework 2, Problem3, Homework 3, Problem 3; discussion of networks (syllabus, course schedule. meeting 2)

Brief Description:
Homework 2, Problem 3 asks for computing probabilities of two network participants becoming friends. The formulas are given, I expect students to know how to use them (cf. part (a)) and how to interpret results (cf. part (b)). Homework 3, Problem 3 asks students to execute a certain algorithmic computation to obtain numeric values representing importance of nodes in a network (a method underlying some of the search engine ranking algorithms). One of the networks discussed (syllabus, course schedule. meeting 2) will be the web. Its characteristics (for instance, the numbers of nodes links, etc.) will be expressed in terms of their orders of magnitude.

☐ 2. Students must demonstrate proficiency with functional relationships between two or more sets of variable values (i.e., when one or more variables depend upon, or are functions of, other variables)

Date/location on syllabus or assignment:
Project 1

Brief Description:
Students will run computer simulations to establish the relationship between variables (the threshold variable, and the %similar parameter of the final "limit" network, and the threshold variable and the number of rounds required to reach the limit).

☐ 3. Students must demonstrate proficiency in relating different representations of such relations (e.g., algebraically or symbolically, as tables of values, as graphs, and verbally)

Date/location on syllabus or assignment:
All homeworks and projects. For instance, Homework 2, Homework 4 and Homework 5

Brief Description:
Graphs (sometimes weighted or labeled) are used to represent social networks in which edges represent some relation between objects represented by nodes, labels on edges represent some characteristic of the relationship (Homework 2, Problem 1). Tables are used to represent players' payoffs in games (Homework 4). Matchings in bipartite graphs represent pairings of buyers and sellers, valuations buyers have on items sold being represented as tables.

☐ 4. Students must demonstrate understanding of relations between numerical values.

Date/location on syllabus or assignment:
For instance, Homework 1, Problem 3 and Project 2

Brief Description:
Homework 1, Problem 3 asks students to consider two measures of aggregate distance between nodes in a network that are often quite close to each other. Students are asked to show examples of networks where these quantities are quite different (in fact, that they can be arbitrarily far from each other). Project 2 requires that students run a simulation experiment and collect data showing how changes in a network affect some network parameters.

☐ 5. Students must demonstrate that they can apply fundamental elements of mathematical, logical, or statistical knowledge to model and solve problems drawn from real life.

a) Students must be able to recast and formulate everyday problems into appropriate mathematical or logistical systems, represent those problems symbolically, and express them visually or verbally.

Date/location on syllabus or assignment:
The course is about modeling phenomena by networks and games. Most problems are related to constructing or interpreting such models. For instance, Homework 5, Problem 4, Homework 6, Problem 3.

Brief Description:
Problem 4 from Homework 5, requires that students understand that buyer-seller markets can be modeled by bipartite graphs, that perfect matchings represent final trades, and that valuations and prices determine payoffs. Problem 3 from Homework 6 tests students' understanding of networks as models of how diseases spread.

b) Students must be able to apply the rules, procedures, and techniques of appropriate deductive systems to analyze and solve problems.

Date/location on syllabus or assignment:
All assignments. For instance Homework 3, Problems 3 and 4, Homework 4, Problem 2, Homework 5, Problem 4

Brief Description:
Problems 3 and 4 from Homework 3 require that students can follow an algorithmic method to compute some numeric parameters. Problem 2 from Homework 4 tests students' ability to follow a method to compute equilibria in games. Problem 4 from Homework 5 requires that students can execute an algorithm to compute perfect matchings in graphs.

c) Students must be able to apply correct methods of argument and proof to validate (or invalidate) their analyses, confirm their results, and to consider alternative solutions.

Date/location on syllabus or assignment:
Several assignments. For instance, Homework 3, Problem 2

Brief Description:
That problem requires that students use logical reasoning (understanding symmetry properties in a network) to compute certain quantity (the number of particular triangles in a network).

d) Students must be able to interpret and communicate their results in various forms, including in writing and speech, graphically and numerically.

Date/location on syllabus or assignment:
All assignments and projects. For instance, Projects 1 and 2, Homeworks 1 and 2.

Brief Description:
The projects require written reports describing an experiment, data collected and an analysis of the results. All projects require presenting numeric information in the form of tables. Homework assignments require working with graphs.
If the number of students in the class allows it, each student will be required to make a short oral presentation discussing a solution to one of the homework problems.

e) Students must be able to identify and evaluate arguments that contain erroneous or fallacious reasoning, and detect/describe the limitations of particular models or misinterpretations of data, graphs, and descriptive statistics.

Date/location on syllabus or assignment:
Homework 4, Problems 4 and 5, Homework 6, Problem 4

Brief Description:
Problems 4 and 5 from Homework 5 explicitly ask whether certain claims are correct. In addition, students are asked to justify their answer. Problem 4 from Homework 6 asks students to analyze whether a solution to a certain problem is optimal and if not, to suggest a better one.

f) Students must address Information Literacy as presented within curriculum for the science of quantitative reasoning. This involves problem solving, the use of estimation, thinking strategies for basic facts, formulating and investigating questions from problem situations, use of computers and calculators, or other technologies.

Date/location on syllabus or assignment:
All homework assignments and projects

Brief Description:
All assignments require problem solving skills, use of estimation (students are required to perform and interpret calculations e.g., in Homework 6, Problem 1), thinking strategies for basic facts (e.g., Homework 3, Problem 2), the use of estimates in formulating and investigating questions from problem situations (e.g., Homework 1, Problems 2 and 3, Homework 6, Problem4), use of calculators (e.g., Homework 3, Problems 3 and 4), and use of computers (Projects 1 and 2),

☒ At least 30% of the course addresses the items 1 – 4 on this checklist, and at least 40% of the course addresses items 5 a) – e) on the checklist.

Reviewer's Comments

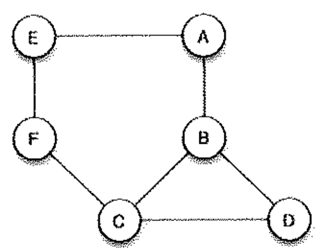
CS 261 – Social Networks: Methods and Tools
Fall 2014, Hmwk 1

(There are three problems in this assignment)

1. (EK 2010, Chapter 2, Problem 1) One reason for graph theory's power as a modeling tool is the fluidity with which one can formalize properties of large systems using the language of graphs, and then systematically explore their consequences. In this set of questions, we will work through an example of this process using the concept of a *pivotal* node.

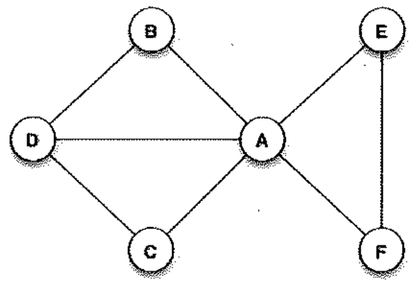
   First, recall from Chapter 2 that a *shortest path* between two nodes is a path of the minimum possible length. We say that a node X is pivotal for a pair of distinct nodes Y and Z if X lies on every shortest path between Y and Z, and X is not equal to either Y or Z.

   For example, in the graph below, node B is pivotal for two pairs: the pair consisting of A and C, and the pair consisting of A and D. (Notice that B is not pivotal for the pair consisting of D and E since there are two different shortest paths connecting D and E, one of which (using C and F) doesn't pass through B. So B is not on every shortest path between D and E.) On the other hand, node D is not pivotal for any pair.



   a. Give an example of a graph in which *every* node is pivotal for at least one pair of nodes. Explain your answer.
   b. Give an example of a graph in which *every* node is pivotal for at least two different pairs of nodes. Explain your answer.
   c. Give an example of a graph having at least four nodes in which there is a single node X that is pivotal for *every* pair of nodes (not counting pairs that include X). Explain your answer.

2. (EK 2010, Problem 2) In this problem, we consider a related cluster of definitions, which seek to formalize the idea that certain nodes can play a "gatekeeping" role in a network. The first definition is the following: we say that a node X is a *gatekeeper* if for some other two nodes *Y* and *Z*, every path from *Y* to *Z* passes through *X*. For example, in the graph below, node *A* is a gatekeeper, since it lies for example on every path from *B* to *E*. (It also lies on every path between other pairs of nodes — for example, the pair *D* and *E*, as well as other pairs.)



This definition has a certain "global" flavor, since it requires that we think about paths in the full graph in order to decide whether a particular node is a gatekeeper. A more "local" version of this definition might involve only looking at the neighbors of a node. Here's a way to make this precise: we say that a node X is a *local gatekeeper* if there are two neighbors of *X*, say *Y* and *Z*, that are not connected by an edge. (That is, for *X* to be a local gatekeeper, there should be two nodes *Y* and *Z* so that *Y* and *Z* each have edges to *X*, but not to each other.) So for example, in the graph above, node *A* is a local gatekeeper as well as being a gatekeeper; node *D*, on the other hand, is a local gatekeeper but not a gatekeeper. (Node *D* has neighbors *B* and *C* that are not connected by an edge; however, every pair of nodes — including *B* and *C* — can be connected by a path that does not go through *D*.)

So we have two new definitions: *gatekeeper* and *local gatekeeper*. When faced with new mathematical definitions, a strategy that is often useful is to explore them first through examples, and then to assess them at a more general level and try to relate them to other ideas and definitions. Let's try this in the next few questions.

a. Give an example (together with an explanation) of a graph in which more than half of all nodes are gatekeepers.
b. Give an example (together with an explanation) of a graph in which there are no gatekeepers, but in which every node is a local gatekeeper.

3. (EK 2010, Chapter 2, Problem 3) When we think about a single aggregate measure to summarize the distances between the nodes in a given graph, there are two natural quantities that come to mind. One is the diameter, which we define to be the maximum distance between any pair of nodes in the graph. Another is the average distance, which — as the term suggests — is the average distance over all pairs of nodes in the graph.

   In many graphs, these two quantities are close to each other in value. But there are graphs where they can be very different.

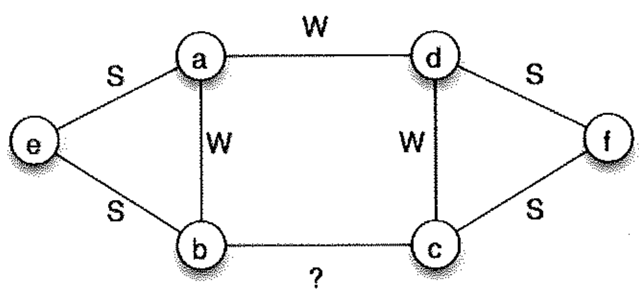
   a. Describe an example of a graph where the diameter is more than three times as large as the average distance.
   b. Describe how you could extend your construction to produce graphs in which the diameter exceeds the average distance by as large a factor as you'd like. (That is, for every number c, can you produce a graph in which the diameter is more than c times as large as the average distance?)

CS 261 – Social Networks: Methods and Tools

Fall 2014, Hmwk 2

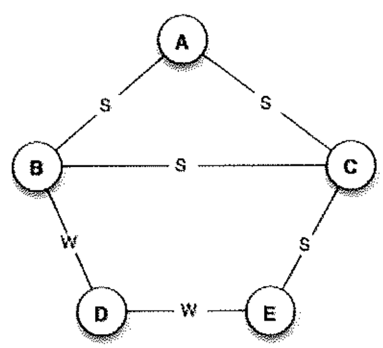
(There are three problems in this assignment)

1. (EK 2010, Chapter 3, Problem 2) Consider the graph below, in which each edge — except the edge connecting *b* and *c* — is labeled as a strong tie (S) or a weak tie (W).



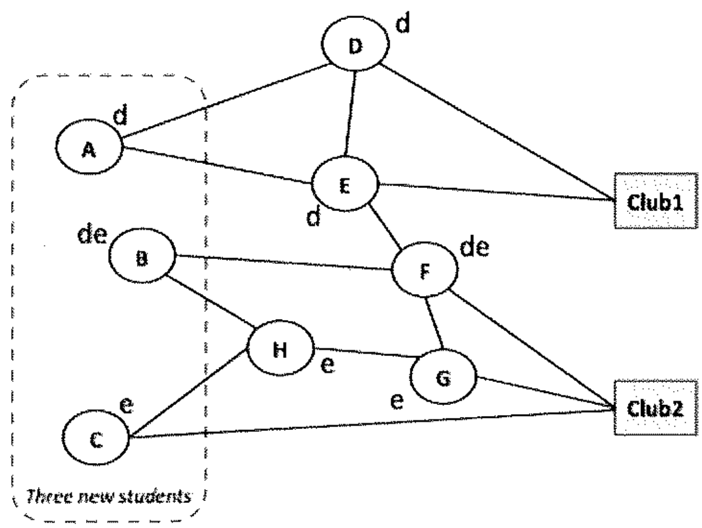
   a. According to the theory of strong and weak ties, with the strong triadic closure assumption, how would you expect the edge connecting *b* and *c* to be labeled? Give a brief (1-3 sentence) explanation for your answer.
   b. In the same graph, identify all local bridges (if any)

2. (EK 2010, Chapter 3, Problem 5) In the social network depicted below, with each edge labeled as either a strong or weak tie, which nodes satisfy the Strong Triadic Closure Property from



Chapter 3, and which do not? Provide an explanation for your answer.

3. (Boutilier-Borodin, University of Toronto Course) Consider the following social-affiliation network consisting of some college friends and two clubs in their college town that they like to (predominately) frequent on Friday evenings. Three new students, Alice (A), Bikash (B) and



Claire (C), have just transferred to the college. Alice and Bikash each have a friend or two in the group already, but know little about the clubs; Claire has already decided to hang out at Club 2 based on a trip to scope out the town before she transferred. We're interested in how new friendships or memberships might form.

Unlike typical social-affiliation networks, we are going to dig a little deeper into the *common interests* of the people in the network to make more fine-grained predictions of their social and affiliation patterns. Each person in the network likes one or both of two musical genres: either *Electroclash* or *Dubstep*, and the interests are indicated on the network by labels *d*, *e* or *de*, accordingly. Consider these tastes in musical genres to be immutable.

Consider the following models of triadic, membership and focal closure, where we look at the probability a new link will form during a one-week period:

- *Triadic closure* will occur between two people *X* and *Y* in any given week in a way that depends on both the number of friends they have in common, and the number of musical interests (*e*, *d*, or both) they have in common. Let *X* and *Y* be two unconnected people with *f* common friends during a specific week and *i* common musical interests. The probability of a friendship forming due to triadic closure during the next week is:

  $$Pr(X \text{ and } Y \text{ become friends}) = (1\text{-}0.5^f)(i\text{+}2)/4$$

  For instance, with two common friends ($f = 2$) and one common interest ($i = 1$), the weekly probability of a friendship forming due to triadic closure is

$$(1 - 0.5^2)(1+2)/4 = (1 - 0.25)3/4 = 9/16,$$

that is, there is a 56% chance of a friendship forming.

- *Focal closure* will occur between two people *X* and *Y* in any given week in a way that depends on the number of common musical interests they have in common. Let *X* and *Y* be two unconnected people with a common focal point (club) during a specific week, and *i* common interests. The probability of a friendship forming due to focal closure during the next week is:

  $$\Pr(X \text{ and } Y \text{ become friends}) = (1-0.7^i).$$

  If *X* and *Y* do not have a common focal point, then focal closure does not occur. For instance, with two common interests ($i = 2$), the weekly probability of a friendship (for people with a common focal point) forming due to focal closure is $(1 - 0.7^2) = (1 - 0.49) = 0.51$, that is, there is a 51% chance of a friendship forming.

- *Membership closure* will occur between a person *X* and a club *C* in any given week in a way that depends on the number of *X*'s friends that hang out at *C*. Let *X* and *C* be unconnected (that is, *X* doesn't hang out at *C*), and suppose *X* has *f* friends that do hang out at *C*. The probability of membership closure during the next week is:

  $$\Pr(X \text{ hangs out at } C) = (1 - 0.6^f).$$

- Notice that two unconnected people with both common friends and a common focal point may become friends due to triadic closure or due to focal closure. In any such situation, we treat each closure as acting *independently*, so the probability of closure in such a case is:

  $$p_t + (1-p_t)p_f = 1-(1-p_t)(1-p_f),$$

  where p_t is the probability of triadic closure for the pair (as defined above) and p_f is the probability of focal closure (as defined above).

The following questions refer to this graph.

a. Suppose the network shown illustrates the situation on the week that the new students arrive. Identify each new link that can form due to triadic, focal, or membership closure involving the new students (nodes A, B and C). State the probability that each of these links will form, using the model above, after their first week in town. Very briefly explain your calculation by explaining which form of closure (or forms of closure) you are using to derive your probability (and the number of assumed common friends, interests or any other relevant information).

b. Which new student not currently frequenting a club is most likely to start hanging out at one of the two clubs after the first week? From this small sample of students, how would you characterize each of the two clubs?

c. Which edge in the graph is most *embedded?* (See the definition in Section 3.5 of the text.)

d. Is there some evidence of homophily based on common musical interests (Electroclash or Dubstep) of the people in the graph? Give a quantitative justification for your answer.

e. Which edge in the network is a *bridge?* Justify your response. Does the network break into natural "communities"? If so, what are they, and what is distinctive about each? Speculate on what role the bridge (and the two people that form the end points of the bridge) might play in influencing the musical tastes and behaviors of the people in this network (assuming these tastes are, in fact, somewhat mutable).

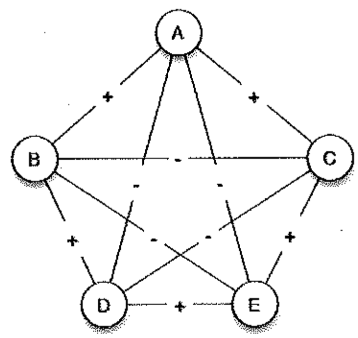
CS 261 – Social Networks: Methods and Tools
Fall 2014, Hmwk 3
(There are four problems in this assignment)

1. (EK 2010, Chapter 5, Problem 1) Suppose that a team of anthropologists is studying a set of three small villages that neighbor one another. Each village has 30 people, consisting of 2-3 extended families. Everyone in each village knows all the people in their own village, as well as the people in the other villages.

   When the anthropologists build the social network on the people in all three villages taken together, they find that each person is friends with all the other people in their own village, and enemies with everyone in the two other villages. This gives them a network on 90 people (i.e., 30 in each village), with positive and negative signs on its edges.

   According to the definitions Chapter 5, is this network on 90 people balanced? Give a brief explanation for your answer.

2. (EK 2010, Chapter 5, Problem 2) Consider the network shown below: there is an edge between each pair of nodes, with five of the edges corresponding to positive relationships, and the other five of the edges corresponding to negative relationships.

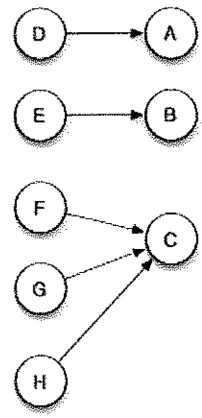


   Each edge in this network participates in three triangles: one formed by each of the additional nodes who is not already an endpoint of the edge. (For example, the *A*-*B* edge participates in a triangle on *A*, *B*, and *C*, a triangle on *A*, *B*, and *D*, and a triangle on *A*, *B*, and *E*. We can list triangles for the other edges in a similar way.) ⍰

   a. For each edge, how many of the triangles it participates in are balanced, and how many are unbalanced. (Notice that because of the symmetry of the network, the answer will be the same for each positive edge, and also for each negative edge; so it is enough to consider this for one of the positive edges and one of the negative edges.)
   b. If the sixth node, *F*, is to join the network, what is the minimum number of imbalanced triangles it will be involved in assuming *F* is in ``like" or ``dislike" relationship with every other node. What is the maximum number? Explain.

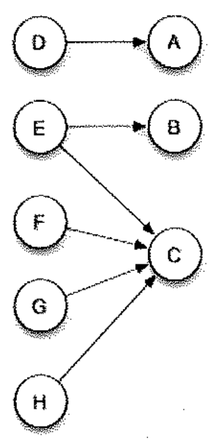
c.

3. (EK 2010, Chapter 14, Problem 2) This problem concerns hub-and-authority method.
   a. Show the values that you get if you run two rounds of computing hub-and-authority values on the network of Web pages shown below. (That is, the values computed by the k-step hub-authority computation when we choose the number of steps k to be 2.)



   Show the values both before and after the final normalization step, in which we divide each authority score by the sum of all authority scores, and divide each hub score by the sum of all hub scores. (We will call the scores obtained after this dividing-down step the normalized scores. It's fine to write the normalized scores as fractions rather than decimals.)

   b. Due to the symmetry of nodes A and B in part (a), you should have seen that they get the same authority scores. Now let's look at what happens to the scores when node E, which links to B, decides to link to C as well. This produces the new network of Web pages shown below.



   Similarly to part (a), show the normalized hub and authority values that each node gets when you run the 2-step hub-authority computation on the new network.

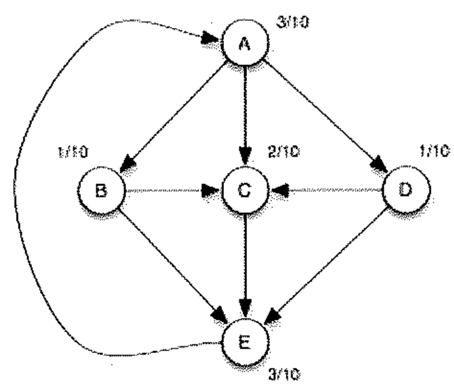
   c. In (b), which of nodes A or B now has the higher authority score? Give a brief explanation in which you provide some intuition for why the difference in authority scores between A and B in (b) turned out the way it did

4. (EK 2010, Chapter 14, Problem 4) Let's consider the limiting values that result from the Basic PageRank Update Rule (i.e. the version where we don't introduce a scaling factor s). In Chapter 14, these limiting values are described as capturing "a kind of equilibrium based on direct endorsement: they are values that remain unchanged when everyone divides up their PageRank and passes it forward across their out-going links."

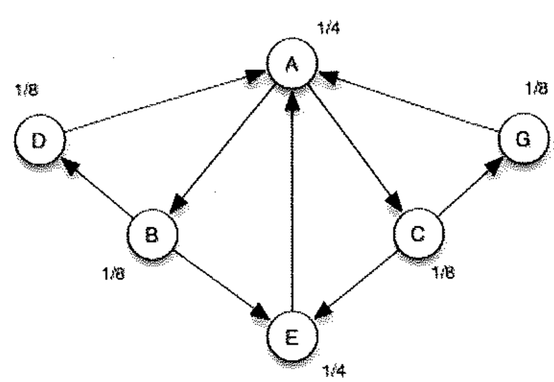
   This description gives a way to check whether an assignment of numbers to a set of Web pages forms an equilibrium set of PageRank values: the numbers should add up to 1, and they should remain unchanged when we apply the Basic PageRank Update Rule.

   For each of the following two networks, use this approach to check whether the numbers indicated in the figure form an equilibrium set of PageRank values. (In cases where the numbers do not form an equilibrium set of PageRank values, you do not need to give numbers that do; you simply need to explain why the given numbers do not.)

   a. Use this approach to check whether the numbers indicated in the figure below form an equilibrium set of PageRank values. (In cases where the numbers do not form an equilibrium set of PageRank values, you do not need to give numbers that do; you simply need to explain why the given numbers do not.)



   b. Use this approach to check whether the numbers indicated in the figure below form an equilibrium set of PageRank values. (In cases where the numbers do not form an equilibrium set of PageRank values, you do not need to give



CS 261 – Social Networks: Methods and Tools
Fall 2014, Hmwk 4
(There are five problems in this assignment)

1. (EK 2010, Chapter 6, Problem 3) Find all pure strategy Nash equilibria in the game below. In the payoff matrix below the rows correspond to player A's strategies and the columns correspond to player B's strategies. The first entry in each box is player A's payoff and the second entry is player B's payoff.

Player B

		L	R
Player A	U	1, 2	3, 2
	D	2, 4	0, 2

For extra credit: Does this game have mixed strategies? Explain why not, or compute them if yes.

2. (EK 2010, Problem 4) Consider the two-player game with players, strategies and payoffs described in the following game matrix.

Player B

		L	M	R
	t	0, 3	6, 2	1, 1
Player A	m	2, 3	0, 1	7, 0
	b	5, 3	4, 2	3, 1

   a. Does either player have a dominant strategy? Explain briefly (1-3 sentences).
   b. Find all pure strategy Nash equilibria for this game.

3. (EK 2010, Problem 11) We've discussed dominant strategies and noted that if a player has a dominant strategy we would expect it to be used. The opposite of a dominant strategy is a strategy that is dominated. The definition of dominated is:

A strategy s_i is dominated if player i has another strategy t_i with the property that player i's payoff is greater from t_i than from s_i no matter what the other players in the game do.

We do not expect a player to use a strategy that is dominated and this can help in finding Nash equilibria. Here is an example of this idea. In this game, M is a dominated strategy (it is

Player B

		L	M	R
Player A	U	2, 4	2, 1	3, 2
	D	1, 2	3, 3	2, 4

dominated by *R*) and player *B* will not use it.

So in analyzing the game we can delete M and look at the remaining game

		Player B	
		L	R
Player A	U	2, 4	3, 2
	D	1, 2	2, 4

Now player A has a dominant strategy (U) and it is easy to see that the Nash equilibrium of the 2-by-2 game is (U,L). You can check the original game to see that (U,L) is a Nash equilibrium. Of course, using this procedure requires that we know that a dominated strategy cannot be used in Nash equilibrium.

Consider any two player game which has at least one (pure strategy) Nash equilibrium. Explain why the strategies used in an equilibrium of this game will not be dominated strategies.

4. (EK 2010, Problem 1) Say whether the following claim is true or false, and provide a brief (1-3 sentence) explanation for your answer.

    Claim: If player *A* in a two-person game has a dominant strategy s_A, then there is a pure strategy Nash equilibrium in which player *A* plays s_A and player *B* plays a best response to s_A.

5. (EK 2010, Problem 2) Consider the following claim:

    Claim: In a Nash equilibrium of a two-player game the total payoff to the two players the largest possible (or as we say, the choice of strategies is social-welfare maximizing).

Is this statement correct or incorrect? If you think it is correct, give a brief (1-3 sentence) explanation for why. If you think it is incorrect, give an example of a game we discussed that shows it to be incorrect, together with a brief (1-3 sentence) explanation.

CS 261 – Social Networks: Methods and Tools
Fall 2014, Hmwk 5

(There are five problems in this assignment)

1. (EK 2010, Chapter 10, Problem 1) In this question we will consider an auction in which there is one seller who wants to sell one unit of a good and a group of bidders who are each interested in purchasing the good. The seller will run a sealed-bid, second-price auction. Your firm will bid in the auction, but it does not know for sure how many other bidders will participate in the auction. There will be either two or three other bidders in addition to your firm. All bidders have independent, private values for the good. Your firm's value for the good is c. What bid should your firm submit, and how does it depend on the number of other bidders who show up? Give a brief (1-3 sentence) explanation for your answer.

2. (EK 2010, Chapter 10, Problem 2) In this problem we consider second-price sealed bid auctions. Assume that there are two bidders who have independent, private values v_i which are either 1 or 3. For each bidder, the probabilities of 1 and 3 are 1/2. (If there is a tie at a bid of x for the highest bid the winner is selected at random from among the highest bidders and the price is x.)
    a. Show that the seller's expected revenue is 3/2.
    b. Now let's suppose that there are three bidders who have independent, private values v_1, v_2 and v_3, which are either 1 or 3. For each bidder, the probabilities of 1 and 3 are 1/2. What is the seller's expected revenue in this case?
    c. Briefly explain why changing the number of bidders affects the seller's expected revenue

3. (EK 2010, Chapter 10, Problem 6) In this question we will consider the effect of collusion between bidders in a second- price, sealed-bid auction. There is one seller who will sell one object using a second- price sealed-bid auction. The bidders have independent, private values drawn from a distribution on [0,1]. If a bidder with value v gets the object at price p, his payoff is $v - p$; if a bidder does not get the object his payoff is 0. We will consider the possibility of collusion between two bidders who know each others' value for the object. Suppose that the objective of these two colluding bidders is to choose their two bids as to maximize the sum of their payoffs. The bidders can submit any bids they like as long as the bids are in [0, 1].

    a. Let's first consider the case in which there are only two bidders. What two bids should they submit? Explain.

    b. Now suppose that there is a third bidder who is not part of the collusion. Does the existence of this bidder change the optimal bids for the two bidders who are colluding? Explain.

    c. Can you identify the way all the players should bid now? Try to be formal and, in particular, identify all assumptions on which your argument rests, but no formal proof is needed.

4. (EK 2010, Problem 4) Suppose we have a set of 3 sellers labeled *a*, *b*, and *c*, and a set of 3 buyers labeled *x*, *y*, and *z*. Each seller is offering a distinct house for sale, and the valuations of the buyers for the houses are as follows.

Buyer	Value for *a*'s house	Value for *b*'s house	Value for *c*'s house
x	12	9	8
y	10	3	6
z	8	6	5

Suppose that *a* charges a price of 3 for his house, *b* charges a price of 1 for his house, and *c* charges a price of 0. Is this set of prices market-clearing? If so, explain which buyer you would expect to get which house; if not, say which seller or sellers should raise their price(s) in the next round of the bipartite-graph auction procedure from Chapter 10.

5. (EK 2010, Problem 10) Find market-clearing prices using the bipartite graph auction procedure from Chapter 10 for the case when the valuations of x, y and z are given in the table below. *(Note: In some rounds, you may notice that there are multiple choices for the constricted set of buyers A. Under the rules of the auction, you can choose any such constricted set. It's interesting to consider — though not necessary for this question — how the eventual set of market-clearing prices depends on how one chooses among the possible constricted sets.)*

Buyer	Value for *a*'s house	Value for *b*'s house	Value for *c*'s house
x	9	7	4
y	5	9	7
z	11	10	8

CS 261 – Social Networks: Methods and Tools

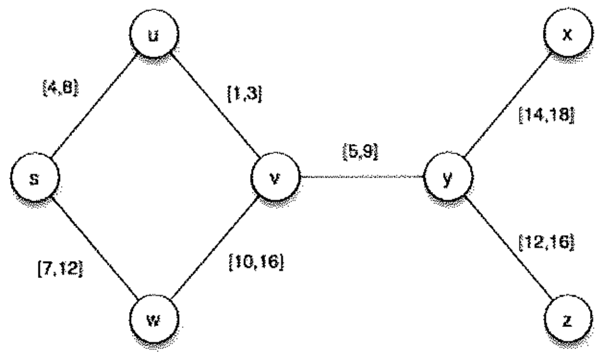
Fall 2014, Hmwk 6

(There are four problems in this assignment)

1. (EK 2010, Chapter 16, Problem 1) In this problem we will ask whether an information cascade can occur if each individual sees only the action of his immediate neighbor rather than the actions of all those who have chosen previously. Let's keep the same setup as in the In Chapter 16, except than when individual i chooses he observes only his own signal and the action of individual $i - 1$.
   a. Briefly explain why the decision problems faced by individuals 1 and 2 are unchanged by this modification to the information network
   b. Individual 3 observes the action of individual 2, but not the action of individual 1. What can 3 infer about 2's signal from 2's action?
   c. Can 3 infer anything about 1's signal from 2's action? Explain.
   d. What should 3 do if he observes a high signal and he knows that 2 Accepted? What if 3's signal was low and 2 Accepted?
   e. Do you think that a cascade can form in this world? Explain why or why not. A formal proof is not necessary, a brief argument is sufficient.

2. (EK 2010, Chapter 17, Problem 2) We discussed goods with positive network effects: ones for which additional users made the good more attractive for everyone. But we know from our earlier discussion of Braess's Paradox that network effects can sometimes be negative: more users can sometimes make an alternative less attractive, rather than more attractive. Some goods actually have both effects. That is, the good may become more attractive as more people use it as long there aren't too many users, and then once there are too many users it becomes less attractive as more people use it. Think of a club in which being a member is more desirable if there is a reasonable number of other members, but once the number of members gets too large the club begins to seem crowded and less attractive. Here we explore how our model of network effects can incorporate such a combination of effects. In keeping with the notation in Chapter 17, let's assume that consumers are named using real numbers between 0 and 1. Individual x has the reservation price $r(x) = 1-x$ before we consider the network effect. The network effect is given by $f(z) = z$ for $z \leq 1/4$ and by $f(z) = (1/2)-z$ for $z \geq 1/4$. So the network benefit to being a user is maximized when the fraction of the population using the product is $z = 1/4$, once the fraction is beyond $1/4$ the benefit declines, and it becomes negative if more than $1/2$ of the population is using it. Suppose that the price of this good is p where $0 < p < 1/16$.
   a. How many equilibria are there? Why? [You do not need to solve for the number(s) of users; a graph and explanation is fine.]
   b. Which equilibria are stable? Why?
   c. Consider an equilibrium in which someone is using the good. Is social welfare maximized at this number of users, or would it go up if there were more users, or would it go up if there were fewer users? Explain. [Again no calculations are necessary; a careful explanation is sufficient.]

3. (EK 2010, Chapter 21, Problem 1) Suppose you are studying the spread of a rare disease among the set of people pictured in below. The contacts among these people are as depicted in the network in the figure, with a time interval on each edge showing when the period of contact occurred. We assume that the period of observation runs from time 0 to time 20.



   a. Suppose that *s* is the only individual who had the disease at time 0. Which nodes could potentially have acquired the disease by the end of the observation period, at time 20?
   b. Suppose that you find, in fact, that all nodes have the disease at time 20. You're fairly certain that the disease couldn't have been introduced into this group from other sources, and so you suspect instead that a value you're using as the start or end of one of the time intervals is incorrect. Can you find a single number, designating the start or end of one of the time intervals, that you could change so that in the resulting network, it's possible for the disease to have flowed from s to every other node?

4. (EK 2010, Chapter 21, Problem 3) Imagine that you're advising a group of agricultural officials who are investigating measures to control the outbreak of an epidemic in its early stages within a livestock population. On short notice, they are able to try controlling the extent to which the animals come in contact with each other, and they are also able to introduce higher levels of sanitization to reduce the probability that one animal passes the disease to another.

   Both of these measures cost money, and the estimates of the costs are as follows. If the officials spend x dollars controlling the extent to which animals come into contact with each other, then they expect each animal to come into contact with $40 - x/200{,}000$ others. If the officials spend y dollars introducing sanitization measures to reduce the probability of transmission, then they expect the probability an infected animal passes it to another animal contact to be 0.04-$y/100{,}000{,}000$. The officials have two million dollars budgeted for this activity. Their current plan is to spend one million on each of the two kinds of measures. Using what you know about epidemics, would you advise them that this is a good use of the available money? If so, why? If not, can you suggest a better way to allocate the money?

CS 261 – Social Networks: Methods and Tools
Fall 2014, Project 1

1. (Boutilier-Borodin, University of Toronto Course) The following question requires you to use the **NetLogo** software package (available to use or download at http://ccl.northwestern.edu/netlogo/)

   Start Netlogo and load the Segregation model from the Models Library. This implements a version of the Schelling model discussed in class. You need to run *five* simulations of the Segregation model setting the parameters as follows: consider two different numbers of agents, 900 and 2500; and consider four settings of the threshold variable (or "% similar-wanted" as it is called in the software), 20%, 30% and 55%. Notice that you have six combinations of settings, and must run five simulations for each. (You can set the speed faster to ensure each simulation proceeds quickly, or slower if you want to watch the patterns emerge).

   For each simulation, record the final "% Similar" once the simulation converges (when all agents are happy) and the number of rounds of movement, or "Ticks" required. For each of the six combinations of settings, report: (i) the average (over the five simulations) of "% Similar" value and the "Ticks" value at convergence in the table provided; (ii) the minimum value observed over the five simulations; and (iii) the maximum value. *Please hand in the table on the final page of the assignment with these values to make marking easier.* On the basis of your observations, draw some qualitative conclusions about the impact of the number of agents and the similarity threshold on the final degree of population homogeneity and the time taken for the Schelling model to converge. Provide possible explanations for these observed patterns.

	N=900		N=2500	
	% Sim	Ticks	% Sim	Ticks
T=20%	Avg	Avg	Avg	Avg
	Min	Min	Min	Min
	Max	Max	Max	Max
T=30%	Avg	Avg	Avg	Avg
	Min	Min	Min	Min
	Max	Max	Max	Max
T=55%	Avg	Avg	Avg	Avg
	Min	Min	Min	Min
	Max	Max	Max	Max

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	Min	Min	Min	Min
	Max	Max	Max	Max
T=55%	Avg	Avg	Avg	Avg
	Min	Min	Min	Min
	Max	Max	Max	Max

CS 261 – Social Networks: Methods and Tools
Fall 2014, Project 1

1. (Boutilier-Borodin, University of Toronto Course) The following question requires you to use the **NetLogo** software package (available to use or download at http://ccl.northwestern.edu/netlogo/)

   Start Netlogo and load the Small Worlds model from the Models Library (it is listed under the Networks models). This allows one to create a ring network, then "rewire it" by adding edges from one node to another randomly with some probability. Read the description of the model and play around with it to get a feel for what it does.

   Now what you need to do is.

   - Set the number of nodes num-nodes to 50.
   - Hit setup to create a ring network of 50 nodes.
   - Record the average path length at this initial stage.
   - Set the rewiring probability to 0.1. Then hit rewire-all and observe resulting network. Record the updated value of the "average path length" (give it a couple of seconds to update). Repeat this seven more times so you record a total of eight average path length values. Note: Don't hit setup after each trial: this will allow you to see a plot of the eight values. If you do hit setup, don't worry, you can still proceed safely.
   - Repeat the previous step (with a new setup, and generating eight average path lengths) for rewiring probabilities 0.25, 0.5 and 0.75. ⍰

   Please answer the following questions:

   a. What is the average path length before any rewiring?
   b. Provide a table (see the one attached at the end of the assignment) with the eight average path length values for each of the four settings of the rewiring probabilities. Also include the average, max and min recorded value for each of the four settings.
   c. Describe any qualitative conclusions you have regarding how the rewiring probability impacts average path length in this ring network of 50 nodes, including the impact of increasing the probability from a small level (e.g., from 0.1 to 0.25) versus increasing it from a larger initial level (e.g., from 0.5 to 0.75); the variance in the resulting average path length; and anything else that strikes you as interesting.
   d. Does the way in which rewiring is implemented in the NetLogo model (i.e., the method by which random edges are added) provide reasonable support for decentralized search or poor support? Please explain your thinking.

Rewiring	Eight Average Path Lengths	Average	Minimum	Maximum
Pr = 0.1				
Pr = 0.25				
Pr = 0.5				
Pr = 0.75				

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September 27, 2013

MEMORANDUM

TO: Mirek Truszczynski
FROM: Brent Seales WBS
SUBJECT: New Course Proposal CS 261

The new course proposal for CS 261 Social Networks was vetted by the Computer Science faculty on Monday, 26 August 2013. Minor revisions were suggested, which were completed the following week and then voted on by email by the faculty. By a faculty vote of 16 in favor and none opposed on 11 September 2013, the revised course proposal was approved by the department for submission to the next level in the approval process.