CSC 422/522: Summer 2017

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Announcements

Powerpoint slides will be posted on the class web pages:

http://webhome.cs.uvic.ca/~wendym/422.html

Or on connex if they contain material that cannot be placed on the web.

Assignment #1 has been posted on the class web page. Programs will be uploaded on connex. Please read it to make sure you understand all the questions.

Welcome to CSC 422/522!

Office hours:

Let me know either at the end of class or by e-mail what time you would like to come by so that I don't have to be there when nobody wants to see me.

TWF 11:30am TF 4:00pm

Asking for help by e-mail is encouraged. Please put CSC 422 or 522 (use the course number of the class you are taking) in your subject header plus an informative subject (use different subjects for different questions) so that your messages are not confused with those from the other class I am teaching.

Outline

- Who is the instructor?
- My research interests.
- Logistics for CSC 422/522- the critical points are included on the course outline and class web pages.

About me:

B.Sc. : Computer Science, McGill University, 1983

M.Math. : Combinatorics and Optimization, University of Waterloo, 1984

Ph.D. in Computer Science: Waterloo, 1988

University of Victoria: started in 1988, currently a full professor









Bring your parents to work day at Google.

My Research: Large Combinatorial Searches

Clique: Set of vertices which are pairwise adjacent



Keller graph with dimension d: vertices which are numbered with each of the 4^d d-digit numbers, digits are to 0, 1, 2, or 3. Two vertices are adjacent if their labels differ in at least two positions, and in at least one position the difference in the labels is 2 mod 4.

Examples (Dimension 5):

- 1 0 1 2 0 0 3 1 2 0 0 1 3 2 0

Adjacent NOT adjacent NOT adjacent

A complete resolution of the Keller maximum clique problem. Jennifer Debroni, John D. Eblen, Michael A. Langston, Wendy Myrvold, Peter W. Shor, Dinesh Weerapurage, SODA, 2011. ⁹ "In a sense, these cases require only patience- and maybe a high speed computer the size of a major galaxy.

No one in his right mind, and no mathematicians either, would set our to sort through 2¹²⁸ possible tilings to check the case of d=7."

p. 24, Barry Cipra and Paul Zorn



Finishing the Keller conjecture only requires the answer to whether the clique order for dimension 7 is 128 or less than 128.

Determining if it was 127 or less than 127 took only 3 days on 64 CPU's.

Determining that the maximum clique order is 124 took 109 days on 64 CPU's.

Funding for CPU's was provided by:



Double checking:



8192 CPU's₁₁



Graphite

Applications of Graph theory to chemistry

Working with Patrick Fowler (chemist)







Triphenylene



 \odot

Phenanthrene



Chrv





Anthracene



Tetracene

Benzenoids

Diamond

Currents in benzenoids (joint work with Patrick Fowler, a chemist):





The graph for naphthalene has 3 perfect matchings:







Randić current model: Consider ordered pairs of perfect matchings.





Occurs 2 times. (AC, CA)





Current flow: counterclockwise in 4n+2 cycles and clockwise in 4n cycles.

Sum the currents for each pair of matchings to get current estimate.

Fullerenes are all-carbon molecules that correspond to 3-regular planar graphs with all face sizes equal to 5 or 6.



The Nobel Prize in Chemistry 1996 was awarded jointly to Robert F. Curl Jr., Sir Harold W. Kroto and Richard E. Smalley *"for their discovery of fullerenes"*.







Pentagons cause grief for some hexagons.

Yellow hexagons- only 2 independent set vertices.

Linear time algorithm for maximum independent set of a fullerene: joint work with Sean Daugherty.

Topological Graph Theory: Algorithms and Obstructions







Torus Obstructions Found So Far:

| n/m | ı : | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
|-----|------------|----|----|----|-----|-----|------|-------|-------|-------|-------|------|------|------|-----|-----|----|----|----|----|
| 8 | : | | | | | 1 | | 1 | 1 | | | | | | | | | | | |
| 9 | : | | 2 | 5 | 2 | 9 | 17 | 6 | 2 | 5 | | | | | | | | | | |
| 10 | : | | 15 | 9 | 35 | 40 | 190 | 170 | 102 | 76 | 21 | 1 | | 1 | | | | | | |
| 11 | : | 5 | 2 | 49 | 87 | 270 | 892 | 1878 | 1092 | 501 | 124 | 22 | 4 | 1 | | | | | | |
| 12 | : | 1 | 12 | 6 | 201 | 808 | 2698 | 6688 | 6372 | 1933 | 482 | 94 | 6 | 2 | | | | | | |
| 13 | : | | | 12 | 19 | 820 | 4967 | 12781 | 16704 | 7182 | 1476 | 266 | 52 | 1 | | | | | | |
| 14 | : | | | | 9 | 38 | 2476 | 15219 | 24352 | 16298 | 3858 | 808 | 215 | 19 | | | | | | |
| 15 | : | | | | | | 33 | 3646 | 22402 | 20954 | 8378 | 1859 | 708 | 184 | 5 | | | | | |
| 16 | : | | | | | | | 20 | 2689 | 17469 | 10578 | 3077 | 1282 | 694 | 66 | 1 | | | | |
| 17 | : | | | | | | | | | 837 | 8099 | 4152 | 1090 | 1059 | 368 | 11 | | | | |
| 18 | : | | | | | | | | | | 133 | 2332 | 1471 | 511 | 639 | 102 | 1 | | | |
| 19 | : | | | | | | | | | | | | 393 | 435 | 292 | 255 | 15 | | | |
| 20 | : | | | | | | | | | | | | | 39 | 100 | 164 | 63 | 2 | | |
| 21 | : | | | | | | | | | | | | | | | 12 | 63 | 1 | | |
| 22 | : | | | | | | | | | | | | | | | | 2 | 22 | | |
| 23 | : | | | | | | | | | | | | | | | | | | 4 | |
| 24 | : | | | | | | | | | | | | | | | | | | | 2 |

Course description:

This course provides an introduction to graph theory and graph algorithms. We will start with basic definitions in order to make the class accessible to all. The algorithms studied range from classical polynomial time algorithms for problems such as network flows to those geared towards dealing with intractible problems such as finding a maximum independent set in a graph. The material also includes cutting edge research tactics for solving real world problems. The class is especially valuable for students requiring graph theory and combinatorics as a tool for research in areas such as networks, database, computer graphics, and software engineering.

Course objectives:

 $\cdot To$ provide a solid foundation in graph theory and algorithms.

- •To teach some useful algorithms and algorithm design tactics.
- •To develop research skills which include:

Background literature search,

•Formal writing for graph theory topics (as required for theses, conference or journal papers), and

•Programming graph algorithms.

•To intrigue and excite students about graph theory research topics.

 \cdot To take students to the leading edge of graph theory research.



Optional: Graph Theory and Its Applications, Second Edition, by Jonathan L. Gross and Jay Yellen, Chapman and Hall/CRC Press

Students with a disability

Please let me know as soon as possible how I can accommodate your disability.

It's sometimes possible to go beyond what is first offered by the disability center.

Assignments

This class will have 5 equally weighted assignments. The schedule for the assignments will be available from connex and the class web page. No late assignments except for exceptional circumstances (e.g. RCSD accommodations). The assignment are worth 50% for CSC 422 and 40% for CSC 522.

Literature Review Project

Students will select a pre-approved subdomain of graph algorithms. They will write a paper that defines the problem considered and summarizes some papers in the area. The breadth of the survey is expected to be more substantial for students taking CSC 522. Students who exceed expectations can get bonus marks. The literature review is due on **Friday May 26** at the beginning of class. It can be handed in late at the beginning of class on **Friday June 2** with a 10% late penalty. This project is worth 5% of the final grade for CSC 422 and 10% of the final grade for CSC 522.

Programming Project

Students will design and implement an algorithm (or for CSC 522 students, 2 algorithms) for a hard problem in graph algorithms.

Students who exceed expectations can get bonus marks.

The final submission will include a paper that describes the algorithm, and the program(s).

This programming project counts for 20% of the class mark

for CSC 422 and 25% of the mark for CSC 522. It is due on Sunday August 13 by 11pm.

Quizzes

The course will have 6-8 equally weighted small pop quizzes that are during a class slot. These will count for 10% of your course mark. Your lowest quiz mark will be dropped (and this is how minor illnesses will be accommodated).

Quizzes will start the week of May 16.

Students who arrive to class late and miss the start of a quiz will not be provided with any extra time to finish the quiz. Hence, it is advisable to come to class on time.

There will be an in class Automorphism Group Lab tentatively scheduled for **Friday June 16** that will count for 5% of your mark.

This class has no midterm or final exam.

Attendance

For classes where there is no quiz, attendance will be taken. You can miss up to two classes with no penalty. The attendance counts for 10% of your mark.

Do not ask anyone else to sign the list for you. If you are caught doing this, then your attendance score for the class will be 0.

Grading

| Component | Weight CSC 422 | Weight CSC 522 |
|---------------------------|----------------|----------------|
| Assignments | 50% | 40% |
| Quizzes | 10% | 10% |
| Attendance | 10% | 10% |
| Automorphism Group Lab | 5% | 5% |
| Literature review project | 5% | 10% |
| Programming project | 20% | 25% |