St. Francis Xavier University
Department of Computer Science

CSCI 435: Algorithms and Complexity
Week 4 Discussion Questions
Winter 2023

[Kar93] David R. Karger. Global Min-Cuts in RNC, and Other Ramifications of a Simple Min-Cut Algorithm. *Proc. of SODA 1993*, 21–30, 1993.

David Karger is a professor of computer science at the Massachusetts Institute of Technology, and the namesake of Karger's algorithm for computing minimum cuts in a graph. His work focuses on applications of randomization to various optimization problems.

Read the first three sections of this article, but feel free to skip over the proofs if you like. Then, consider the following questions.

1. What is the complexity class RNC? You may need to do a bit of background reading to find the answer; start by reading up on the complexity class NC.
2. In this paper, Karger occasionally uses the notation $\widetilde{O}(f(n))$ when describing the runtime of some algorithm. What does this notation mean, and why might it be useful?
3. How does the contraction algorithm relate to the construction of a minimum spanning tree? What connection exists between edge contraction and Kruskal's algorithm?
4. In our lecture, we discussed Karger's algorithm only in the case of unweighted graphs. What modification can we make to allow the algorithm to work on weighted graphs?

[Met87] Nicholas Metropolis. The Beginning of the Monte Carlo Method. *Los Alamos Science*, 15:125–130, 1987.

Nicholas Metropolis was a Greek physicist who was educated in the United States of America and later recruited by Robert Oppenheimer to work at the Los Alamos National Laboratory. He pioneered the development of random sampling methods for use on computers performing simulations.

Read the article and consider the following questions.

1. This article discusses events that took place in the very early days of computing, and makes frequent mention of the ENIAC. What is the ENIAC, and what was it designed to do? Why did Ulam propose to implement statistical sampling techniques on the ENIAC?
2. Midway through the article, Metropolis describes an example due to Von Neumann involving neutron chains. At a high level, how might you propose a computer simulate such a computation? What aspects of this simulation would require the use of statistical methods?
3. The article mentions a random number generation procedure known as "middle-square digits". Using the description given in the article, try to implement this algorithm in the language of your choice. Add a method to keep track of numbers your implementation has already produced. How many iterations can your algorithm make until it produces an already-seen number? Do you think this is a particularly good method of generating random numbers?
4. In the concluding section, Metropolis gives a number of examples in which the Monte Carlo method may be used. Find an example of a computational problem that uses the Monte Carlo method (not necessarily a problem listed in this article). What is the problem statement, and how is the method applied in this case?