

MS&E 339: Algorithms for Decentralized Finance, Aut 2022-23

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HW 1, handed out: 10/16/2022, due (on gradescope): **10/28/22**, midnight Stanford time

You can do the HW in groups of 2-3

Problem 1: [10pts] Prove that the stationary bankruptcy probability of a node A in a credit network (where the transaction rate between any pair of nodes is 1) is at most $1/(1+C)$ where C is the sum, along all other nodes B, of the credit capacity between A and B (summing up both directions). Assume that all credit values are integers and all transaction sizes are 1.

[Hint: First, observe that (a) any transaction that does not include A as a source or destination does not change the total credit coming into A or going out of A, (b) a transaction with A as the source or destination increases/decreases the total outgoing credit by one. Then ask yourself whether bankruptcy of A can be modeled as a much simpler credit network.]

Problem 2: [10pts] Consider a credit network with N nodes, where the nodes are arranged in a cycle, the capacity between any two adjacent nodes on the cycle is 1, and the capacity between any two non-adjacent nodes is 0. Analyze the success probability between node 1 and node k, where k lies between 2 and n, inclusive. All transaction rates are 1.

Problem 3: [15 pts] Write a product brief (three to five slides, not very dense) on how you could design a stable coin using ideas from credit networks.

Problem 4: [15 pts] You are a rational agent (i.e. a node) in a credit network who is trying to decide how to allocate credit to other nodes in the network. Write your “response” function (in python), that takes as input

- the budget for each agent
- a transaction rate matrix, and
- the amount of credit currently extended by all agents to each other

and outputs the amount of credit you want to extend to every other node, subject to your own budget constraint.

An example response function and example evaluation code is at

<https://colab.research.google.com/drive/14Y2ANPN2C7KUq6zc4ZyouXrK4hWb75pG>

Any reasonable function will get at least 10 pts. There are no right or wrong answers here, but we are looking for an approach that demonstrates some understanding of the underlying issues. We will use these response functions to simulate a network formation game and then analyze its liquidity. The team with the highest average liquidity for their agent across multiple different simulations will get an extra 5 points (i.e. 15 + 5).

Problem 5: [10 pts] Provide a critique (200-300 words) of using credit networks as a model for L2 systems such as lightning.