Liquidity in Credit Networks: A Little Trust Goes a Long Way

Pranav Dandekar
Stanford University

Ashish Goel
Stanford University

Ramesh Govindan
University of Southern California

Ian Post
Stanford University

Extended Abstract

Credit networks represent a way of modeling trust between entities in a network. Nodes in the network print their own currency and trust each other for a certain amount of each other's currency. This allows the network to serve as a decentralized payment infrastructure — arbitrary payments can be routed through the network by passing IOUs between trusting nodes in their respective currencies — and obviates the need for a common currency.

Credit networks have the property that the loss incurred by nodes in the network due to the presence of malicious nodes is *bounded* and *localized*: a node cannot incur a loss greater than the total credit extended by it to other nodes in the network and the only nodes that incur a loss are the ones that extend credit to the malicious nodes. Also, routing payments in credit networks is not significantly less efficient compared to a centralized network since it only requires a max-flow computation.

These properties make this model useful not only for monetary transactions, but also in any setting where there is a need to model trust between nodes in a network. It has been shown to be particularly well-suited for transactions in exchange economies such as P2P networks where it can be used to improve inefficiencies resulting from asynchronous demand and bilateral trading. It has been used as a way of imposing group budget constraint on bidders in a multi-unit auction. It can also be used in settings such as packet routing in mobile ad-hoc networks and combating spam in viral marketing over social networks. It has applications in military scenarios where it is important to know who to trust.

However, in order for the model to be of practical use it should be able to support repeated transactions between nodes over a long period of time. This motivates the following question which we formulate and study in this paper: if the network is sufficiently well-connected and ha s sufficient credit to begin with, can we sustain transactions in perpetuity without additional injection of credit? How does liquidity depend upon network topology and transaction rates between nodes, and how does it compare with a centralized currency infrastructure with a common currency?

We study these questions under a simple model of repeated transactions: at each time step we pick a pair of nodes (s, t) in the network with probability λ_{st} and try to route a unit payment along the shortest feasible path from s to t. If such a path exists, we route the flow and modify edge capacities along the path. The transaction fails if there is no path from s to t. We show that the success probability of transactions is independent of the path used to route flow between nodes. For symmetric transaction rates, we show analytically and via simulations that the success probability for complete graphs, Erdös-Rényi graphs and preferential attachment graphs goes to one as the size, the density or the credit capacity of the network increases.

Further, we characterize a centralized currency system as a special type of a star network (one where edges to the root have infinite credit capacity, and transactions occur only between leaf nodes) and compute its steady-state success probability. We show how to construct a centralized system that is equivalent to a given credit network and that the steady-state failure probability in complete graphs and Erdös-Rényi networks is at most a constant-factor worse than equivalent centralized currency systems. So in return for all the benefits resulting from the decentralized nature of the system, we do not give up a lot of liquidity compared to a centralized model with a common currency.

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The full version of the paper is available at: **`http://arxiv.org/abs/1007.0515`**.