Trusted Intermediating Agents in Electronic Trade Networks

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1. TRUST ON ELECTRONIC MARKETS

Electronic commerce and trading of information goods significantly impact the role of intermediaries: consumers can bypass intermediating agents by forming direct links to producers. One reason that traditional intermediaries can still make a profit, is that they have more knowledge of the market, so trading via an intermediary saves on search costs [1], allowing the intermediary to charge a markup and make a profit. Another reason is trust and loyalty between consumers and intermediaries (cf. [6]). In this paper we investigate whether trust-based intermediating agents will also be able to make a profit in electronic markets, where other advantages of intermediaries (i.e., advantages of location or scale) disappear, but where trust and reputation mechanisms are becoming popular for helping consumers make purchasing decisions in the face of information overload on the world wide web [2]. We model an electronic market where agents trade an information good over a network. Buyer-agents use a decentralized reputation-based trust mechanism [4] to determine which connections to maintain to sellers of the good (producers and intermediaries), communicating with each other to establish trustworthiness of sellers to which they are not currently connected. The existence of such a reputation mechanism allows intermediating agents to accumulate a base of loyal consumer-agents who are willing to pay the intermediaries' markup in exchange for the intermediating agents' protection against the dynamics of the market place. Using computer simulations, we show that if market dynamics are sufficiently complex, trusted intermediaries are able to increase their market share and make a profit.

1.1 Trust and Reputation

We assume a reputation-based trust mechanism [4], which holds that an agent i's trust in another agent j may be based on i's own personal prior experiences with j, or (as reputation) on other agents' experiences with j, at least to the extent that communication with those other agents has given i access to those experiences. As j provides more evidence of being able to fulfill a certain task, i will come to expect—or *trust*—j to perform well on that task in the future also. This is captured by the beta probability density function [3], which can be used to represent probability distributions of *binary* events. Consider a process with two possible outcomes: a seller j charges agent i a good (g_j^i) or a bad (b_j^i) price. If the number of agent i's positive and negative past experiences with agent j's pricing are u_j^i and v_j^i, respectively, then we can use the expected value of the probability, for agent i, of observing event g_j (a good price) in the future,

$$E[p^i(g_j^i)] = \frac{u_j^i + 1}{u_j^i + v_j^i + 2}, \quad (1)$$

as agent i's *trust* in agent j as a provider at good prices. Each consumer-agent maintains such trust in every selling agent (producers and intermediaries). *Reputation* entails different agents i and j's sharing of their respective positive and negative feedback information (u_k^x and v_k^x for $x \in \{i, j\}$) concerning a particular capability (such as offering attractive prices) of a third agent k. After this exchange, i and j share the same trust in k, which is interpreted as k's reputation with i and j. Finally, older feedback information should be discounted, to allow reputations to track changing capabilities. We follow [3], and use a discount factor $\lambda = 0.99$.

1.2 The Economic Trade Network

We consider a trade network game where boundedly rational consumers purchase an information good provided by producers and intermediaries. In each period of the game, each consumer buys a single unit of an information good, either directly from a producer or through an intermediary. Trade can only occur if there is a connection, a link, between a consumer and a seller; see Fig. 1, where dashed lines indicate intermediated links, while solid lines

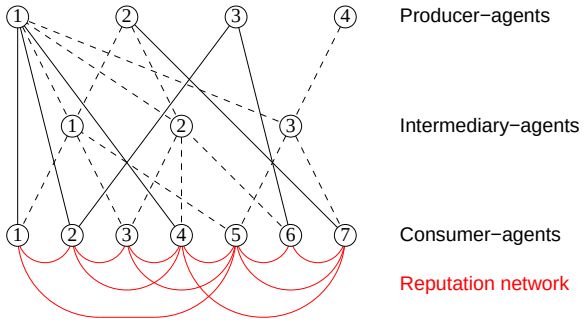

Figure 1: Trade network combined with a reputation network.

are direct links between consumers and producers. **Consumers** are cost minimizers, who purchase the good from their linked seller offering the lowest price. They strategically decide which links

AAMAS'05, July 25-29, 2005, Utrecht, Netherlands.

to form (to the sellers they trust the most), while gaining information about sellers they are not currently connected to by exchanging reputation information with their neighbors in the social network (red/shaded in Fig. 1), which we assume to have a small world topology [5].

In each trade period, **producers** decide which price to charge during that period. Since the costs of advertising and changing prices are very low online, frequent price fluctuations are observed in online shops. To model this situation, we consider three levels of price fluctuations: (1) fixed price, (2) producers draw their next price from a normal distribution $N(\mu, 0.1)$, with μ drawn randomly from $U[0, 1]$ and fixed over time, (3) producers draw their next price directly from $U[0, 1]$.

Intermediaries buy goods from producers and sell them to consumers, with a markup so that they can make a profit. Since we want the intermediary to have no initial advantages over the average consumer, we allow them the same fixed number of links. As a buyer, the intermediary uses a simple heuristic (the *Keep-one* heuristic) to decide which links to form to producers, viz. to keep the link to the producer offering the lowest price and randomly reform its remaining links.

2. SIMULATION EXPERIMENTS

There are 100 consumers, 40 producers, and 20 intermediaries. Intermediaries and consumers can form 10 links at a time, and the intermediary's markup is 0.1. Consumers have 4 neighbors in their (regular) network, which is rewired with a rewiring probability of 0.05 (cf. [5]). All results are averages over 30 runs of 100 periods. First we let both consumers and intermediaries use the Keep-one heuristic described above. The results for this first experiment are shown in Fig. 2. As expected, when producers use increasingly

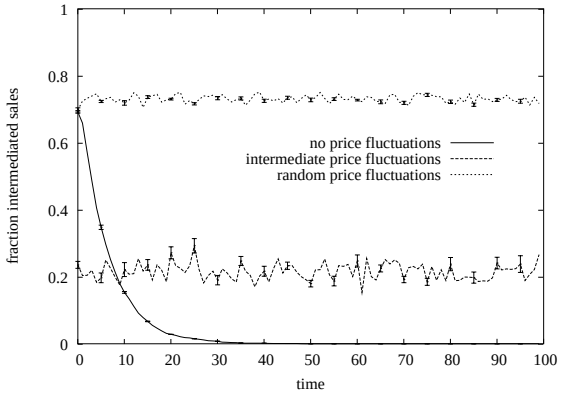

Figure 2: A benchmark.

fluctuating prices (levels 1 through 3), consumers are less able to learn to bypass the intermediary, and larger fractions of total sales are intermediated.

Now we allow the consumers to use the decentralized trust and reputation mechanism. Varying the producers' level of price fluctuations as above, results are given in Fig. 3, which shows that, as price dynamics increase, adding to consumer uncertainty about prices, intermediating agents are again relied upon more often to shield consumers from the dynamics of the market. Moreover, intermediaries gain larger shares of the market for given levels of price fluctuations, as they prove able to provide good prices and are subsequently trusted to do so. When consumer agents base their decisions on trust, higher levels of intermediation are reached, and

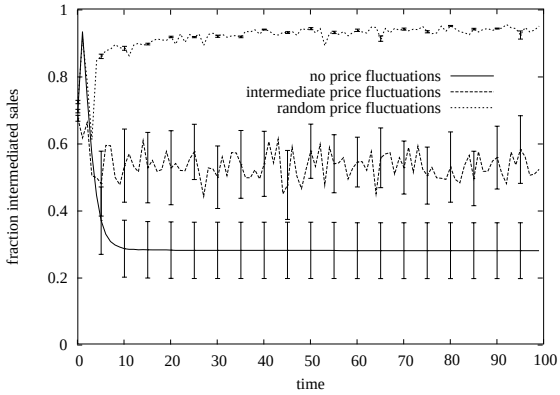

Figure 3: Experimental Results.

more quickly, than in Fig. 2—higher because loyalty hinders efficient market organization, making customers stick to intermediaries whom they trust, but who may not be the cheapest, and faster because consumer agents share reputation information.

To conclude, we assume a small world social network in which we assume consumers' agents to use a decentralized reputation-based trust mechanism for deciding which links to form to sellers of a homogenous information good, for which intermediating agents use a simple heuristic. In such a setting, intermediaries are indeed able to survive and make a profit, even when producers use fixed prices. Initially, the intermediaries have no inherent advantages over the average consumer in terms of knowledge of the market or economies of scale or location. During the simulation, however, they prove able to gain the trust of consumers, by providing relatively stable prices in dynamic market circumstances, thus attracting a base of loyal consumer-agents who are willing to pay the intermediaries' markup in exchange for their protection against the dynamics of the market place. The intermediating agents' advantage increases as market dynamics, in the form of fluctuations of producers' prices, increases. In future work, we would like to further investigate the robustness of the results to changes in some of our assumptions, such as the consumer agents' trust mechanism, and the numbers of agents in the three layers of our network. Also, we would like to investigate what the effect of other intermediating agents' strategies would be.

3. REFERENCES

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