Strategies and reputation - a microeconomic description of the Golem marketplace

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1 Introduction

1.1 Reader notes

Every important statement is labelled as <u>Conclusion</u> - consider skimming through them if you're not interested in the reasoning.

This document is quite formal, but please don't expect clean, bulletproof implications only. The purpose of this document is to present the topic and conclusions while maintaining resonable level of brievity.

1.2 Abstract

This document provides a simple microeconomic model of the Golem marketplace. Following questions are answered within the model:

- What do we exactly mean by the "reputation"?

- What is the exact problem we hope to solve with the reputation mechanism?

- What are the other, non-reputation approaches to the main problem?

- How to measure the quality of our solutions? I.e. how to know if we succeeded?

The problem is approached from the highest point of view - no specific solutions are proposed, only general classes of solutions are discussed. With an exception of a few details/examples this document describes just a "general" marketplace (replace "provider/requestor" with "seller/buyer").

1.3 Definitions

Agent - A decision-making entity (person, company, etc.).
Utility - A total happiness of an agent.
Utility function U - A function $U : StateOfTheWorld-> \mathbb{R}$, defined for a

particular agent, that represents the agents utility in a given situation.

Expected utility - For every possible decision an agent can make (D) and every possible state of the world w, there is some probability $P : (D, w) \to [0, 1]$ that given decision will lead to the given state of the world. Agents don't have the full knowledge about P, they know only some information I and an estimation of P based on this information: $P_I : (D, w) \to [0, 1]$. The expected utility $E : (I, U, D) - > \mathbb{R}$ is defined as follows:

$$E(I, U, D) = \sum_{w \in all\_possible\_world\_states} U(w) * P_I(D, w) \tag{1}$$

We'll usually use a shorter notation $E(I, U, D) = E_A(D)$ to describe "expected utility of agent A, who has information I and utility function D".

In other words, for agent A and decision D, $E_A(D)$ is "how happy agent A expects to be if they do D".

Golem - [TODO better definition?] Everything that influences the utility resulting from the interactions with the Golem Network protocol - the protocol itself, available software, state of the market etc.

1.4 Additional assumptions

1. The Expected Utility Hypothesis[1]: every agent tries to maximize their expected utility.

2. Every agent can costlessy access and analyze all of the publicly available information about Golem. Thanks to this assumption we can remove I from the equations - we no longer care about "what agent knows", but only about "what really is". This is a major simplification that might not be a good approximation of the "real world" Golem market, but we accept it for the sake of the brevity of this document. Also "truth about Golem is known" is an ideal world we would like to live in.

3. The expected utility and money are interchangeable, that is - for every agent A and a pair of decisions $(D_1, D_2) : E_A(D_1) < E_A(D_2)$, there is an amount of money X that can be given to the agent so that $E_A(D_1) + U_A(X) = E_A(D_2)$. This way we can treat utilities as if they were money, and thus compare them between different agents.

4. Lets define the Golem Value as:

$$V_G = \sum_{A \in all\_agents\_using\_Golem} E_A(USE\_GOLEM) \tag{2}$$

(Note that - because of assumptions 1 and 2 - E_A is always positive, decision "use Golem" is only made by agents who profit from it).

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[1]https://en.wikipedia.org/wiki/Expected_utility_hypothesis

We assume that maximization of V_G is one of the goals of the Golem Factory - and from the point of view of this document, the only goal.

2 The purpose of the reputation

2.1 Dissolving the Golem Value

Let's define $E_P(a)$ and $E_R(a)$ as the expected utility of action "take part in agreement a as (respectively) provider/requestor", and C_A as the cost of the participation in the Golem market for agent A that is not related to any particular agreement (e.g. opprotunity cost[2] of the hardware used as a provider, or the cost of writing the requestor agent). Now, we can rewrite the V_G equation as:

$$V_G = \sum_{a \in all\_agreements} (E_P(a) + E_R(a)) - \sum_{A \in all\_agents\_using\_Golem} C_A \quad (3)$$

Let's split $E_P(a)$ into few separate parts:

$$E_P(a) = E_{PN}(a) + E_{PG}(a) - E_{PL}(a) \quad (4)$$

Where $E_{PN}(a)$ is the nominal value of the agreement, $E_{PG}(a)$ is the providers additional gain that goes against the agreement (e.g. because of provider is using some other way the resources that should be available to the requestor), and $E_{PL}(a)$ are unexpected loses suffered by the provider because of the requestor not fulfilling their part of the agreement (e.g. by not paying the due amount).

$E_R(a)$ can be split in a similar way, and by putting this in the V_G equation we get:

[TODO - define E_N, E_G and E_L and use them further, note the E_L conflict]

$$V_G = \sum_{a \in all\_agreements} (E_{PN}(a) + E_{PG}(a) - E_{PL}(a) + E_{RN}(a) + E_{RG}(a) - E_{RL}(a))$$

$$- \sum_{A \in all\_agents\_using\_Golem} C_A$$

$$(5)$$

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[2]https://en.wikipedia.org/wiki/Opportunity_cost

$$V_G = \sum_{a \in all\_agreements} (E_{PN}(a) + E_{PG}(a))$$
$$- \sum_{a \in all\_agreements} (E_{PL}(a) - E_{RG}(a))$$
$$- \sum_{a \in all\_agreements} (E_{RL}(a) - E_{PG}(a)) \qquad (6)$$
$$- \sum_{A \in all\_agents\_using\_Golem} C_A$$

Important note here is that both $\sum_{a \in all\_agreements}(E_{PL}(a) - E_{RG}(a))$ and $\sum_{a \in all\_agreements}(E_{PL}(a) - E_{RG}(a))$ are positive: when someone breaks the agreement, the harm done to the victim is usually greater then the offenders gain[3]. Let's thus define the "expected value of the agreement a value lost due to the participants not fulfilling their part of the agreement", $E_L(a) = (E_{PL}(a) - E_{RG}(a)) + (E_{RL}(a) - E_{PG}(a))$, and rewrite the equation one last time:

$$V_G = \sum_{a \in all\_agreements} (E_{PN}(a) + E_{RN}(a) - E_L(a))$$
$$- \sum_{A \in all\_agents\_using\_Golem} C_A \qquad (7)$$

This equation defines few general ways to increase the V_G:

1. Increase the number of agreements

2. Increase the average nominal value of the agreement (e.g. by providing additional capabilities, like internet connectivity or GPU access)

3. Decrease the average value lost because of actions against the agreement

4. Decrease the cost of the participation in the Golem market (e.g. by creating a better SDKs)

Note that these ways interact with each other: e.g. if we implement some capabilities (to improve 2) that will be hard to use, we'll also worsen 4. Or: the better is the average nominal value of the agreement, the more agreements we'll expect to have. Or - what is important from the POV of this document - if we implement complex safeguards against cheating, they might have negative impact on all the other points.

Keeping that in mind, the rest of the document is aimed at the third direction from the above list.

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[3]TODO: examples/proof/justification?

2.2 Honest strategy

The algorithm behind agent decisions is called a strategy. We define the honesty of the strategy S from the POV of another agent A as:[4]

$$H_A(S) = E(a_S)/E_N(a_S) \qquad (8)$$

Where a_S is the agreement agent A can sign with an agent that uses strategy S. We can average this over all agents A on the market to get some general "honesty index" of a strategy.

The honesty of an agent is the honesty of the strategy they're using. Agents' intentions don't matter here - there's no difference if the agent breaks the agreement on purpose or accidentally.

Agent always tries to maximize their own utility (the "expected utility maximization" assumption), in other words: agent always selects the most profitable strategy. Let's now paraphrase the third goal from the previous section as:

Conclusion 2.1 *The final purpose of the reputation system on Golem is to make honest strategies more profitable than dishonest strategies.*

2.3 Defining reputation

There are few different ways to reduce the profitability of dishonest strategies:

- Make dishonest strategies not available at all, e.g. ensure debit note acceptance forces payment.

- Make dishonest strategies hard to implement, e.g. hide/obfuscate some important components of Golem.

- Add some mechanics that directly penalize dishonesty, e.g. require deposits and confiscate them when dishonesty is proven.

Neither of them has anything to do with the "reputation". So, what exactly is the reputation?

Imagine an honest agent who considers signing an agreement a with agent A. The decision algorithm can be rougly summarized as

1. Calculate the expected value of the decision **not** to sign the agreement, $E(\neg a)$

2. Calculate the expected value of the decision to sign the agreement $E(a)$. By the definition of the honesty factor (eq. 8) it depends on the nominal value of the agreement and the estimated honesty factor of the other agent's strategy: $E(a) = E_N(a) * H(S_A)$

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[4]Different agents might consider different strategies dishonest. E.g. strategy "try to steal data X, otherwise do your best" is dishonest only from the POV of agents who are in possession of data X

3. Sign the agreement if $E_N(a) * H(S_A) > E(\neg a)$

This leads us to a simple observation: the less honest agent is, the better E_N they have to offer to find someone who'll trade with them, and thus to:

Conclusion 2.2 *"Reputation system" is an attempt to solve the problem defined in the conclusion 2.1 in the following way:*

- *Make some additional information available to the market participants*

- *This information can be used to estimate the "honesty index" of an agent, and thus improves the accuracy of the total agreement value estimation*

- *The more accurate is the total agreement value estimation, the less profitable it is to trade with dishonest agents*

- *The less profitable it is to trade with dishonest agents, the fewer/worse agreements they have*

- *The fewer/worse agreements dishonest agents have, the less profitable are dishonest strategies*

3 Final notes

1. "How good is reputation" == "estimate honesty factor" 2. "How useful is reputation" is "utilization of the honesty factor estimation" −¿ Two separate topics: provide the information and ensure the information is used.

E.g. what if there is only a single requestor? Or there are less providers the necessary? −¿ We must take care about the market.