Reduction Over Time: Easing the Burden of Peer-to-Peer Barter Relationships to Facilitate Mutual Help

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Abstract. A peer-to-peer complementary currency can be a powerful tool for promoting exchanges and building relationships for coordinated activities. *i*-WAT[11] is a proposed such currency usable on the Internet. It is based on the WAT System[15], a polycentric complementary currency using *WAT tickets* as its media of exchange: participants spontaneously issue and circulate the tickets as needed, whose values are backed up by chains of trust. *i*-WAT implements the tickets electronically by exchanging messages signed in OpenPGP[3].

This paper proposes an extension to the design of *i*-WAT to facilitate mutual help among people in need. In particular, we propose additional "reduction" tickets whose values are reduced over time. By deferring redemption of such tickets, the participants can contribute to reduce the debts of the issuers, as well as to accelerate spending. Applications of this feature include a relief to disaster-affected people.

A reference implementation of *i*-WAT has been developed in the form of a plug-in for an XMPP[6][7] instant messaging client. We have been putting the currency system into practical use, to which the proposed feature will be added shortly.

1 Introduction

1.1 Peer-to-Peer Complementary Currency

One of the issues of activity coordination is *incentive-compatibility*[8], roughly restated as the goal of the coordinated activity being accomplished by collection of selfish behaviors. Because it necessitate fair exchanges of resources among participants, the medium of exchange must take an important role.

Money is a well-known medium of exchange, but its scarcity has caused a lot of problems. *Complementary currencies*, or alternative forms of monetary media, have been proposed and tested to achieve an autonomous, sustainable local economy even in short of money. There have been successful cases, such as experiments in Wörgl in 1932 (stamp money[13]), in Comox Valley in 1983 (Local Exchange Trading System[14]) and in Ithaca since 1991 (Ithaca HOURs[10]).

Many of those outcomes are short-lived, however, because most of the existing currencies are dependent on the qualities of their administrations. It would thus benefit the autonomy and sustainability of economy if we could design an administration-free (or peer-to-peer) complementary currency.

We proposed i-WAT[11] in year 2003 as such a currency usable on the Internet, based on the WAT System[15]. The WAT System is a system of polycentric complementary currencies using *WAT tickets* as its media of exchange. A WAT ticket is like a bill of exchange, but without a specified redemption date or place. i-WAT implements the tickets electronically by exchanging messages signed in OpenPGP[3]. It has been put into practical use since June 2004.

1.2   Reduction Over Time to Accelerate Spending

It is known among the practitioners of complementary currencies that reducing the value of the exchange medium over time accelerates spending. The stamp money experiment in Wörgl in 1932 is a well-known example. It was based on the idea of *stamp scrip* introduced by Sylvio Gesell in [9], who believed exchange media must also deteriorate as the exchanged goods do (for this reason, *Reduction Over Time* is dubbed *ROT* hereafter).

A user of stamp money needs to paste a stamp every week on the back of the note, or the note becomes invalid. Users are motivated to spend the scrip before another stamp is required. The stamp is a tax for storage of exchange medium. It is a suitable way to implement ROT in a centralized currency system.

1.3   Contributions of This Paper

If ROT is to be implemented for decentralized currencies, a different approach needs to be taken. We have applied the notion of *calendar money*[5] by Arthur Dahlberg, which has a schedule of reduction printed on the note.

We have realized that this has potential effects of not only promoting exchanges, but also providing participants with means to support peers by sharing debts among one another.

This paper describes WAT/i-WAT concisely, and proposes an extension to the design of i-WAT to realize the above concept. It shows that the extended design is incentive-compatible by a casual analysis.

2   WAT/i-WAT Currency System

2.1   The WAT System

Overview The WAT System[15] is a complementary currency designed by Eiichi Morino, a coauthor of this paper. It has been used broadly as a means for mediating bartering, since its introduction in August 2000.

A *WAT ticket*, a physical sheet of paper resembling a bill of exchange, is used as the medium of exchange in the system. A lifecycle of a WAT ticket involves three stages of trading as illustrated in Fig. 1:
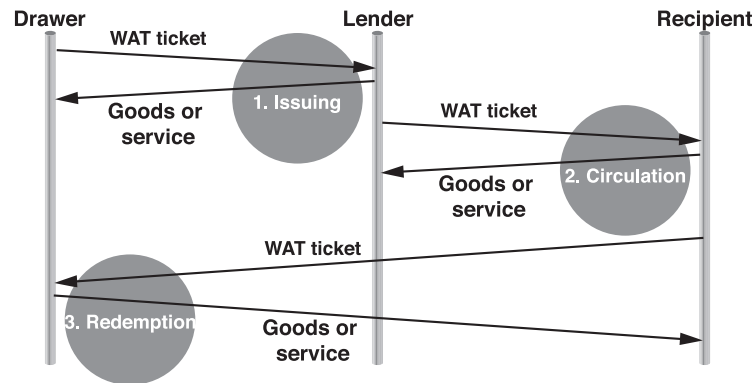
Fig. 1. Three stages of trading with a WAT ticket

1. Issuing – the birth of a WAT ticket
   A *drawer* issues a WAT ticket by writing on an empty form the name of the provider (*lender*) of the goods or service, the amount of debt[1], the present date, and the drawer's signature. The drawer gives the ticket to the lender, and in return obtains some goods or service.
2. Circulation – ordinary exchange
   The person to whom the WAT ticket was given can become a *user*, and use it for another trading. To do so, the user writes the name of the recipient, as well as their own, on the reverse side of the ticket. The recipient will become a new user, repeating which the WAT ticket circulates among people.
3. Redemption – the return of the WAT ticket
   The WAT ticket is invalidated when it returns, as a result of a trade, to the drawer.

Distinctive Features of the WAT System

Autonomy Anyone can spontaneously become a member of the WAT System with a sheet of paper if they follow the above protocol.

Compatibility A WAT ticket is compatible with any other WAT tickets in the world, so that the currency system is operable globally, as long as the drawer can be credited.

Extensibility The protocol illustrated in Fig. 1 defines *the WAT Core*, the essence of the WAT System. An *extended part* can be defined for a new currency based on the WAT System, stating, for example, the region, group and duration in which the tickets are usable, as well as the unit in which the debt is quantified.

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[1] Typically in the unit kWh, which represents cost of producing electricity from natural energy sources.

Table 1. *i*-WAT messages

message	sender	receiver	function
<draw/>	drawer	recipient (lender)	draws an *i*-WAT ticket.
<use/>	user	recipient	uses an *i*-WAT ticket.
<accept/>	recipient	drawer and user	confirms readiness to accept the *i*-WAT ticket once it is validated.
<reject/>	recipient	drawer or user*	rejects an *i*-WAT ticket.
<approve/>	drawer	user and recipient	validates an *i*-WAT ticket, and approves the transaction.
<disapprove/>	drawer	user and recipient	denies an *i*-WAT transaction.

* depending on whether the ticket has just been issued or in circulation, respectively.

Security In case the drawer fails to meet their promise on the ticket, the lender assumes the responsibility for the debt. If the lender fails, the next user takes over. The responsibility follows the chain of endorsements. The longer the chain is, the more firmly backed up the ticket is. Therefore the length of the chain of endorsements represents the extent of trust the ticket has gained.

2.2 *i*-WAT: the Internet WAT System

Overview *i*-WAT is a translation of the WAT Core onto the Internet. We have made a reference implementation available to the public, which has been used mainly by the members of the WAT System.

In *i*-WAT, messages signed in OpenPGP (*i-WAT messages*) are used to implement transfers of an electronically represented WAT ticket (*i-WAT ticket*).

An *i*-WAT ticket contains the identification number, amount of debt and public key user IDs of the drawer, users and recipients. Endorsements are realized by nesting PGP signatures.

Table 1 shows the types of *i*-WAT messages. All *i*-WAT messages are signed by the senders, and are formatted in the canonical form[1] of XML[2] with nested signatures. The messages cause state transfers of a ticket as illustrated in Fig. 2.

Changes from the WAT System Upon translating the WAT Core onto the digital communication domain, we have made the following changes from the state machine of a WAT ticket:

1. Trades need to be asynchronously performed. Intermediate states, such as waiting for acceptance or approval, are introduced.
2. Double-spending needs to be prohibited. The drawer is made responsible for guaranteeing that the circulating ticket is not a fraud. This means that every trade has to be approved by the drawer of the involved ticket.

The semantics of this design and the trust model of *i*-WAT are discussed in detail in [12].
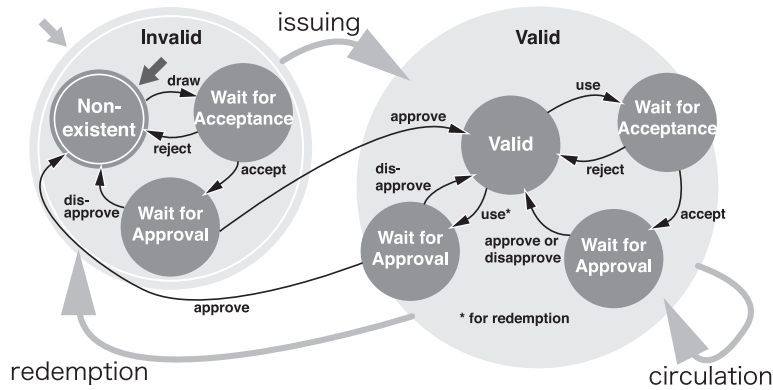
* Gray arrows represent WAT state-transfer.
* Black arrows represent *i*-WAT state-transfer.

Fig. 2. State machine of a WAT/*i*-WAT ticket

Protocol

Issuing – the birth of an i-WAT ticket (Fig. 3)

1. The drawer sends a <draw/> message which contains the public key user IDs of the drawer and lender, identification number and amount of debt. This message becomes the original *i*-WAT ticket after the protocol is completed.
2. The lender sends back the content of the message as an <accept/> message.
3. The drawer sends an <approve/> message to the lender.

Circulation – ordinary exchange (Fig. 4)

1. The user adds to the *i*-WAT ticket the public key user ID of the recipient, and sends it to the recipient as a <use/> message. This message becomes a valid *i*-WAT ticket after the protocol is completed.
2. The recipient forwards the content of the message to the drawer and user as an <accept/> message.
3. The drawer verifies the ticket, and sends an <approve/> message to the user and recipient.

Redemption – the return of the i-WAT ticket (Fig. 5)

1. The user sends a <use/> message to the recipient, who equals the drawer.
2. The drawer verifies the ticket, and invalidates it as the debt is now redeemed. The drawer sends an <approve/> message to the user.
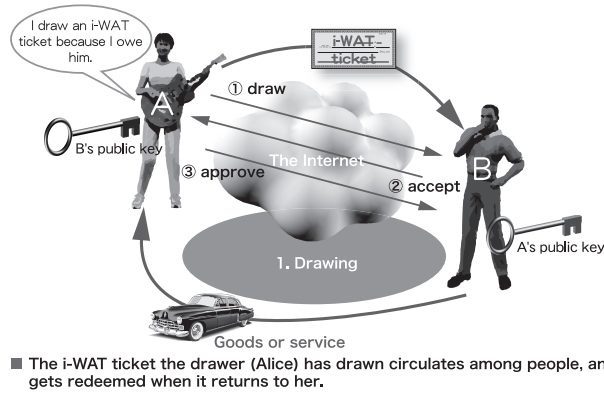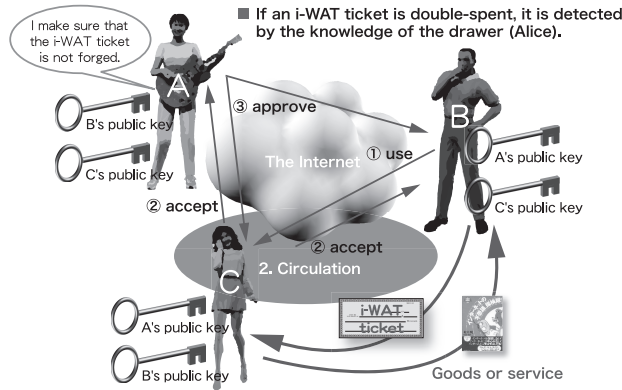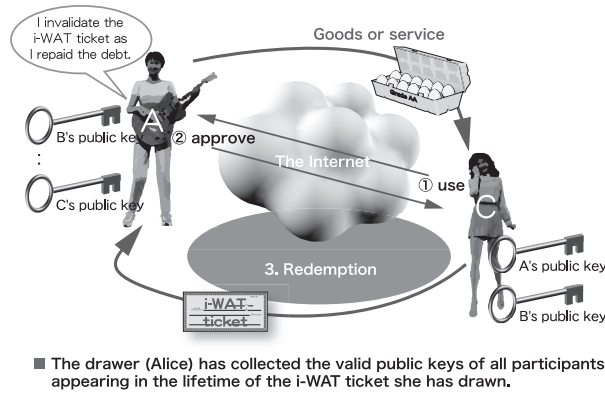
Fig. 3. *i*-WAT transaction 1: issuing

Fig. 4. *i*-WAT transaction 2: circulation

3 ROT: Reduction Over Time

3.1 Concept

We make a generalization to the value of a WAT/*i*-WAT ticket such that it is expressed as a tuple $\langle V_0, V_m, f \rangle$ presented by the drawer, where V_0 is the face value (initial value) of the ticket, V_m is the minimum value, and $f(t)$ is the differentiation (derivative) of a function of time $F(t)$ such that $f(t) \leq 0$ for all t (an extension to allow $f(t) > 0$ is conceivable, but it will be discussed elsewhere). The effective value V_t of a ticket at time t is given by the following equation:

$$V_t = \max(\int_0^t f(t)dt + V_0, V_m)$$

The drawer (Alice) has collected the valid public keys of all participants appearing in the lifetime of the i-WAT ticket she has drawn.

Fig. 5. *i*-WAT transaction 3: redemption

This is a generalization to introduce an additional type of tickets called *reduction* tickets, whose values are reduced over time, limited by a minimum value. For *regular* WAT/*i*-WAT tickets, $f(t)$ is a constant value zero, and $V_0 = V_m$.

Reduction of the value of a ticket means that the drawer's debt is reduced. The cost of reduction is first admitted by the lender who credits the drawer, and then shared among the endorsers as illustrated in Fig. 6. The amount of the total reduction is manifested to the drawer upon redemption. By deferring redemption, participants can help easing the burden of the drawer.

3.2 Incentive-Compatibility of the Design

We show that the design of *reduction* tickets is incentive-compatible by a casual analysis.

Lender's Reasoning The lender may not want to accept a *reduction* ticket because they know that its value will decrease over time if they save it. They can be motivated to accept the ticket, however, if they know that the drawer is in need, such as in a case of aftermath of a natural disaster. They know that they do not have to take all the burden by themselves; they infer that, by the same reasoning as theirs, it is likely that those people around them are also willing to accept the ticket. Therefore the ticket is accepted, and spent as soon as possible to satisfy the need of the lender themselves.

Endorser's Reasoning All participants, if they are aware of the situation of the drawer, will be motivated to:

1. defer redemption of the ticket to support the drawer, and
2. spend it as soon as possible to avoid much reduction of its value and to satisfy their own needs.
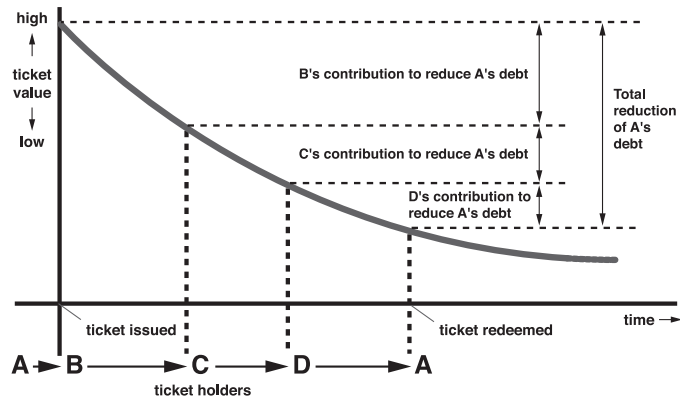
Fig. 6. Giving relief by deferring redemption of a reduction ticket

We predict that a *reduction* ticket will typically circulate at high speed until its effective value reaches the minimum value V_m.

Drawer's Reasoning There is a risk that circulation may be stalled for an *i*-WAT ticket by negligence of the drawer in their role for approving transactions. However, we can show that it is to the drawer's own benefit to maintain the liveness of their tickets:

1. If one is late to respond, or tends to fail to answer requests for redemption, they will lose trust from others. Then it will become more difficult for them to have their tickets accepted for future trades.
2. If one is quick to respond, and accepts requests for redemption with certainty, they will gain more trust from others. Since their tickets become easier to use, they may attract more load. But it will become easier for them to draw tickets at will in the future, and initiate trades spontaneously to obtain goods or services.

3.3 Protocol

Reduction tickets can be incorporated to the system with minimal changes to the existing *i*-WAT protocol.

Since it is unrealistic to assume that the clocks of all participating computers are synchronized with precision, the time is ultimately measured by the computer of the drawer.

The timestamp of the drawer's or user's signature (depending on whether the trade is issuing or circulation) defines the effective value of a *reduction* ticket, to which the recipient either agrees or disagrees. The drawer (or their software agent) is responsible to check that the timestamp belongs to the past for them when they approve a transaction.

3.4 Applications

Applications of *reduction* tickets include relief to disaster-affected people.

We are sure that everyone is hurt by the tsunami which swept the coastlines of Southeast Asian countries on December 26, 2004, killed an unprecedented number of people and took means of life away from literally millions.

We have made a proposal to *ccTsunami*[4], which is an open forum on the Internet for discussing and implementing programs to support the tsunami-affected places with complementary currencies. In the proposal, *i*-WAT tickets are issued by an NGO which promises to exchange the tickets with WAT tickets issued by the disaster-affected people, so that people in need do not need to use computers.

4 Ongoing and Future Works

4.1 Implementation

We have been developing a reference implementation of *i*-WAT as a plug-in for *wija*, an XMPP (Extensible Messaging and Presence Protocol)[6][7] messaging client. Although we cannot quantify the number of users because of the nature of the WAT System, many who have experienced the physical WAT System are using *i*-WAT despite of technical difficulties they may be suffering. We are in a continous process of improving the ease of use of the system.

Implementation of the proposed ROT feature is in progress. It will be included in the bundled plug-in for the new version of *wija* to be released in March 2005.

wija is available at http://www.media-art-online.org/wija/.

4.2 Formal Analysis

We are working on a more formal analysis to show that the ROT feature is incentive-compatible. A partial result shows that an equilibrium is achieved when the scheduled minimum value of a *reduction* ticket is zero. Although this is compatible with everyone's benefit, it may cause a moral hazard such that the drawer issues as many tickets as they want. We are pursuing an operational design which mitigates this hazard.

4.3 Future Work

Once the new implementation is ready, we will experiment on actual usage of the ROT feature to verify the prediction that the *reduction* tickets typically circulate at high speed until their effective values hit the minimum.

5   Conclusions

This paper proposed an extension to the design of *i*-WAT to implement *reduction over time*, which has potential effects of both promoting exchanges and providing participants with means to support peers, by sharing debts among one another as a form of currency. The extended design is shown to be incentive-compatible by a casual analysis. The implementation will be available to the public shortly.

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