# openBarter

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**abstract**

openBarter is a software defining a barter market. A generalization of representations of values, prices and bids is used to meet together bids that form exchange cycles into draft agreements using a priority order equivalent to that of a regular market using a monetary meidum. By considering value as multi-dimensional, this software proposes a regulation mean for allocation of a large diversity of scarce ecological resources.

openBarter is a database that stores ownership of values, and where primitives can be executed to make new bids or delete them, or to read a price. New bids create draft agreements than can be accepted or refused.

A value is seen as a natural resource and defined by a couple **(quantity,quality)**, where quantity is an integer, and quality a name.

A bid is as a statement of an owner to provide a value defined by (quantity,quality) in exchange of an other quality for a given ratio $\omega$ between provided and received quantities. Like the price this ratio ω measures the relative utility of resources exchanged.

# 1 Search for coincidence

From bids submitted, the database finds possible relations between them. This search uses a graph representation of bids where bids are the nodes of the graph. An arrow links two bids when following conditions are fulfilled:

- the quality provided by the first equals the quality required by the second.
- the value provided by the first is not empty.

The search for coincidence consists in the following steps:

A) Find lists of bids that forms a cycle on the graph of bids,

B) Select the *best* among these cycles, using a rule generalized to multilateral agreements defined in §4,

C) Obtain a fair compromise between the bids of the selected cycle and decrease values provided by bids with the amount of the compromise.

These steps are repeated until no cycle is found.

This search for coincidence is used each time a bid is submitted. At step C, the compromise is recorded as a new agreement. A new bid hence produces a list of draft agreements possibly empty. The whole process is integrated in a single atomic transaction keeping acyclic the graph of bids.

The search for coincidence is also used to search for the best price. This price is requested for a given (quality required, quality provided). At step C, the compromise is used to read a couple (quantity required, quantity provided) so that a price read provides a list of such couples order by price.

# 2 Multilateral exchange

Let's consider a list of ***n*** such bids where the quality offered by one equals the quality required by the other. $\omega_i$ are for these ***n*** bids the ratio between quantity provided and quality required, with $i \in [0, n-1]$ . The quality offered by the last bid equals the quality required by the first so that these bids form a cycle.

Let's suppose an agreement exists between partners, and that each partner provides a given quantity $q_i$ to an other partner. We should have:

$$\omega_i = \frac{q_i}{q_{i-1}} \; for\; i \in [1, n-1]$$

$$\omega_0 = \frac{q_0}{q_{n-1}}$$

If we make the product of those ***n*** expression,

we obtain:

$$\prod_{i=0}^{n-1} \omega_i = \frac{q_0}{q_{n-1}} * \prod_{j=1}^{n-1} \frac{q_i}{q_{i-1}} = 1$$

We see that if an agreement exists, we have:

[1]

$$\prod_{i=0}^{n-1} \omega_i = 1$$

A compromise is required between $\omega_i$ when this condition is not fulfilled.

# 3 Bilateral case

Using the regular definition of price for an exchange between a seller providing 10 Kg of apples in exchange of 20 pounds, the price is 2 pounds/Kg. Likewise, if a seller provides a quantity $g$ of goods to a buyer in exchange of a quantity $m$ of money, the regular definition of price is: $p = \frac{m}{g}$ .

Buyer and seller have usually different ideas of prices, We note the buyer price $p_b$ and the seller price $p_s$. An agreement between the buyer and the seller is the result of a compromise between these prices.

If we consider now the ratio between quantities provided and received. It depends of the view point.

this ratio is $\omega_b$ for the buyer and such as $\omega_b = \frac{m}{g}$

and $\omega_s$ for the seller such as $\omega_s = \frac{g}{m}$ .

We see that $\omega_b = p_b$ and $\omega_s = \frac{1}{p_s}$

### *Agreement*

Agreement on price between the buyer and the seller exists when $p_b = p_s$ . An equivalent statement using expressions $\omega_b$ and $\omega_s$ of price is:

$$\omega_b = \frac{1}{\omega_s} \Rightarrow \omega_b * \omega_s = 1$$

It is the definition of agreement given earlier [1] applied to the bilateral case.

### *Competition*

Using the traditional definition of price, order of preference of prices depends on the point of view.

- For the buyer, $p_{b1} \geq p_{b2}$ means $p_{b2}$ is better than $p_{b1}$ .
- For the seller, $p_{s1} \leq p_{s2}$ means $p_{s2}$ is better than $p_{s1}$ .

These rules are commonly called the best price rule.

### *Compromise*

Compromise is required when buyer and seller do not agree on their prices $p_b$ and $p_s$. We propose to define a simple way to balance offers of partners when $p_b \neq p_s$ . It is the geometric mean of $p_b$ and $p_s$: $p' = \sqrt{p_b * p_s}$ since this represents for each partner the same ratio between initial and final price.

Expressed using $\omega$, we obtain new values $\omega'_s$ and $\omega'_b$ such as their product is 1:

$$\omega_s' = \frac{\omega_s}{\sqrt[2]{\omega_s * \omega_b}}$$

$$\omega_b' = \frac{\omega_b}{\sqrt[2]{\omega_s * \omega_b}}$$

Shortly, the compromise is hence:

[2]
$$\omega' = \frac{\omega}{\sqrt[2]{\omega_s * \omega_b}}$$

# 4 Extension to the multilateral case

A potential agreement is defined by a cycle C of bids having $\omega_i$ where $i \in [0, n-1]$ .

We note $\Omega$ the product $\Omega = \prod_{i=0}^{n-1} \omega_i$ .

The search for coincidence provides a set of cycles that will be transformed into draft agreements in some order that should comply with the best price rule.

We propose to define a total order on this set as follows:

[3]
$$C_1 \leq C_2 \Leftrightarrow \Omega_1 \leq \Omega_2$$

This order defines the maximum cycle of the set of cycles.

When all cycles are bilateral, we have:

$$C_1 \leq C_2 \Leftrightarrow \omega_{b1} * \omega_{s1} \leq \omega_{b2} * \omega_{s2}$$

since $\omega_b = p_b$ and $\omega_s = \frac{1}{p_s}$

we have also $C_1 \leq C_2 \Leftrightarrow \frac{p_{b1}}{p_{s1}} \leq \frac{p_{b2}}{p_{s2}}$ and see that $C_2$ is preferred :

- from the buyer's point of view when $\frac{k}{p_{s1}} \leq \frac{k}{p_{s2}} \Leftrightarrow p_{s2} \leq p_{s1}$

- from the seller's point of view when $\frac{p_{b1}}{k} \leq \frac{p_{b2}}{k} \Leftrightarrow p_{b1} \leq p_{b2}$

That is the rule of best price described in §2. We hence show that the best price rule defines an order on bilateral cycles equivalent to that of the total order [3].

We also propose to define the compromise of $\omega_i$ of a cycle C as $\omega'_i$ such as:

$$\omega_i' = \omega_i * \left\{\frac{1}{\Omega}\right\}^{\frac{1}{n}}$$

by sharing equally Ω between bids using the geometric mean of $\omega_i$, and extending [2].

This is a fair compromise when all partners of the cycle of bids are distinct.

But a partner can make several bids on the same cycle by inserting bids using artificial qualities and take advantage of this compromise rule. That's why we consider the case where some partners have more than one bid on the cycle. The rule is modified as follows: Ω is first shared between partners, the results are then shared between bids of each partner.

Formally let *m* be the number of partners, such as $m \leq n$ and let $b_i$ be the number of bids of the author of the bid *i*. The compromise is:

$$\omega_i' = \omega_i * \left\{\left[\frac{1}{\Omega}\right]^{\frac{1}{m}}\right\}^{\frac{1}{b_i}}$$

or more simply:

[4] $$\omega_i' = \omega_i * \Omega^{-\frac{1}{m * b_i}}$$

The product of $\omega_i'$ that equals to *1* is used to find a compromise between bids of a cycle to obtain the equality [1].

# 5 Draft agreement

Once $\omega_i'$ are obtained, we must find a vector $\vec{Q}$ of integers representing quantities to be exchanged by the draft agreement from quantities offered by bids. A vector $\vec{q}$ of real numbers is first computed as the maximum flow circulation through the cycle with the constraints of $\omega_i'$ and of quantities offered by bids. Rounding of $\vec{q}$ to obtain $\vec{Q}$ has several solutions. We exclude from them those where some coordinate of $\vec{Q}$ is null because a draft agreement where some partners don't provide anything would be unfair. Among remaining candidates, we choose the one minimizing a distance between the two vectors $\vec{q}$ and $\vec{Q}$. The chosen distance is simply the angle between the two vectors.

# 6 Search for the best cycle

The search covers A) and B) of §1. It is done for a given couple (quality required, quality provided). This couple defines a spindle – a sub-graph containing possible paths candidates to form the best cycle. The search first performs an extraction of this spindle. The result is stored in a temporary table of the database, and maximum length L of paths is recorded. The second step performs an adaptation of the Bellman-Ford algorithm that travel L times the spindle to find the cycle with Ω maximum.

When the cycle is found, it is used to form a draft agreement from available stocks offered by bids of the cycle. At that moment, we set a write-lock only on stocks of these bids, verify stocks are big enough to afford the quantity of the agreement, and abort the process if this condition is not verified. This avoids a write-lock on all bids of the spindle that would produce intricate inter-lockings, and allows a parallel computation by different client process on the same database.

This search can also be used  to read the best price on the database for the given couple (quality required, quality provided). For this case, draft formation is not performed.

# 7 Limitations

A maximum number of partners in a cycles has been defined for the following reasons:

- Computation can become very heavy when the dimension of the graph to be explored grows.
- Approval of agreements becomes difficult when the number of partners is too large.
- Algorithms require limitations in case of accidental occurrence of cycles in a graph that should be acyclic. Otherwise, they would run indefinitely and never provide any results.
- A limit also allows representation of data that accelerate computation.

This limit is the reason why liquidity of openBarter is not strictly equal to that of a regular market. However, this difference is not significant when the diversity of qualities is limited to primary resources.

# 8 Implementation

Different implementations have been done:

A first one using a simple mysql database using external scripts using python language. This prototype provided a web interface through which owners could exchange their stocks. This first experiment was operational, but showed that algorithms required to be integrated into the database, and viewed as barter promitives.

A second implementation used postgreSQL and berkeleydb, and algorithms has been developed again using C language to obtain faster computations. This experiment showed the difficulties of integrating in a software two separate memory management.

A third implementation uses only postgreSQL, and new functionalities offered by the recent version 9.1, allowing graph traversal using the *with* clause. Most intensive computation has been implemented in C language, as a data type called *flow* that separate table management of the database, and low level algorithms.

This last version is available with GPL V3 licence on:

http://olivierch.github.com/openBarter