Collective intelligence for idea management with Internet-based information aggregation markets

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Abstract

Purpose – The purpose of this paper is to explore the use of information aggregation markets (IAMs) for community-based idea management and to present IDeM, a novel Internet-based software tool that can be used for generating and evaluating new ideas utilizing the concept of IAMs.

Design/methodology/approach – Starting with a review of existing methods for collective intelligence, IAMs are identified as a prominent method for collective intelligence. Specific requirements for exploring IAMs for idea management are derived. Based on these requirements, a software tool for implementing IAMs in the context of idea management is developed (IDeM). IDeM has been evaluated and evaluation results are used to identify IDeM's benefits and limitations. A review of related work points out the innovative characteristics of IDeM.

Findings – Evaluation results indicate that IAMs is an efficient method for idea generation and evaluation. Moreover IDeM is perceived both as easy to use and efficient in supporting idea generation and evaluation.

Practical implications – IDeM can be used by commercial or other organizations for supporting generation and evaluation of new ideas.

Originality/value – IDeM's innovative aspects are: in addition to trading, it allows users involvement by means of new idea submission, rating of ideas and commenting on ideas; it confronts the uncertainty of new idea related events by offering an expert based valuation mechanism.; and it extends the typical output of IAM tools – which is price of idea-stocks – by calculating the volume weighted average price.

Keywords Innovation, Information exchange, Internet marketing, Stock markets, Ideas generation

Paper type Research paper

Introduction

Contemporary research on innovation stresses the importance of collaboration of diverse stakeholders (see e.g. Miles et al., 2005; Shin, 2006). Moreover, the need to ensure the participation of many employees in the innovation processes of an organization has been also emphasized in the literature (Diehl and Stroebbe, 1987; Griffiths-Hemans and Grover, 2006). It has been shown that the use of cross-functional teams with diverse occupational and intellectual backgrounds increases the likelihood...
of combining knowledge in novel ways (Nonaka and Takeuchi, 1995). In such teams, the amount and variety of information available to members is increased, enabling the creation and consequent evaluation of different ideas from a number of different perspectives (Brown and Eisenhardt, 1995).

Adamides and Karacapilidis (2006) provide an overview of information technology tools for collaboration in the innovation process. They distinguish between tools that aim to facilitate and to increase the productivity of exchange of ideas through shared workspaces (Christensen et al., 2003; Sethi et al., 2003), systems for the controlled execution of routine sequences of work tasks associated to idea development projects (Bose, 2003) and group decision support systems that take into account explicitly the processes of idea creation, decision making, negotiation and argumentation. However, existing tools either aim to increase the productivity of communication among the actors involved without implementing a strategy for achieving shared understanding about the innovation process or rely on heavy use of modeling formalisms for representing and enacting collaboration routines and decision rationales that are time-consuming to implement and cumbersome for non-experienced users to take advantage of.

The global build-up of the world wide web has made possible that anyone with a computer and Internet access may explore, join, and contribute to any web community at any time. This new web computing paradigm is often attributed to the “Web 2.0 era” of services and applications that let users easily share opinions and resources (Lin, 2007). An exemplary form of this new trend is “collective intelligence”. According to Malone and Klein (2007) collective intelligence is the synergistic and cumulative channeling of the vast human and technical resources now available over the Internet, while Kapetanios (2008) defines collective intelligence as “human-computer systems in which machines enable the collection and harvesting of large amounts of human-generated knowledge, while enabling emergent knowledge, i.e., computation and inference over the collected information, leading to answers, discoveries, or other results that are not found in the human contributions”.

In this paper we focus on a typical example of collective intelligence, Internet-based information aggregation markets (IAMs). These are virtual stock markets whose purpose is to collect, aggregate and evaluate information (Spann and Skiera, 2003; Spann and Skiera, 2003; Chen and Plott, 2002). Participants trade on contracts that represent future events, and upon market closure an index, the price of these virtual stocks, incorporates the available information with respect to that event.

IAMs can be used in the innovation process for harnessing the collective intelligence of employees inside organizations. As reviewed in this paper however, although several tools exist for deploying IAMs, none of them corresponds to the particularities of the idea management process. First, they do not fully support user feedback, and in most cases user participation is limited to trading. Second, they are configured to aggregate information regarding well-defined future events. When IAMs are utilized for idea management, the underlying contracts are correlated to the potential of success of the ideas. This situation creates uncertainty since some ideas may never be realized and the future event may never happen. The third issue is the limited information they provide as output. Besides market price, analysis of other data such as transactions and user participation may reveal useful information.
These limitations urged us to develop a web-based software tool named IDeM, which is designed to facilitate the use of IAMs within companies in the idea management process. When designing it, we took into consideration that such a tool should allow the generation of new ideas and should be able to record feedback from the market participants. Furthermore it should be flexible enough in its configuration options to allow the formation of various usage scenarios, adapted to the needs of different companies. At the same time its code should be easily expandable, its GUI should be motivating, easy to understand and more game like, hiding all the complexity of traditional stock market applications.

The rest of the paper proceeds as follows. The following section reviews the most prominent collective intelligence methods and introduces the theory underpinning IAMs. In the next section we describe the architecture of our tool, we present the functionalities it supports and we outline the implementation technologies we used. Furthermore we report on a trial carried out to test IDeM. A review of related work is presented in the penultimate section. This paper concludes with a discussion of future research directions for enhancing our tool and for further studying its use empirically.

**Collective intelligence with IAMs**

When referring to collective intelligence, an underlying information aggregation mechanism is implied. The mechanism elicits the collective intelligence by drawing out the pertinent information of each individual and by combining it in such a way as to make it useful (Watkins, 2007). In the Web 2.0 era, several mechanisms have emerged; the most prominent ones are content communities, collaborative tagging and folksonomies, social networks and IAMs also known as prediction markets (Yuan et al., 2008; Gartner, 2006).

Content communities refer to online communities created for publishing and sharing media contents like YouTube and del.icio.us. Collaborative tagging is the practice of allowing anyone – especially consumers – to freely attach keywords or tags to content which results to the collective categorization or indexing of the underlying content (Golder and Huberman, 2006). Social networks in the Web 2.0 context refer to online communities which begun with Friendster, and continued to more recent systems including MySpace and Facebook.

IAMs rest on the concept of bringing a group of participants together via the Internet and allowing to trade shares of virtual stocks (Spann and Skiera, 2003). The efficient markets’ hypothesis states that when a market reaches equilibrium, it reflects all available information about future events into market prices (Fama, 1970). The efficient market hypothesis requires that participants have rational expectations, that on average the population is correct (even if no single participant is) and whenever new relevant information appears, the participants update their expectations appropriately. An implication of the efficient market hypothesis is that share prices reflect their true expected value, therefore markets provide accurate forecasts of their underlying commodities and securities.

IAMs are designed and run for the primary purpose of mining and aggregating scattered among traders information and subsequently use of this information in market values in order to make predictions about specific future events (Berg and Rietz, 2003). Their fundamental difference to commonly defined markets is therefore their scope of use as they consist a forecasting tool, rather than a resource allocation.
mechanism (Berg and Rietz, 2003). A prediction market can also serve as a decision support system by providing information about the current situation or by evaluating effects of decisions over time (Hanson, 1999).

A Gartner report identifies IAMs as one of the emerging methods for business forecasting within corporations (Gartner, 2006). Although such a use of the method is at its very beginning and a lot of questions have still to be answered, it is characterized by its fairly easy deployment and high potential in providing significant value to the organizations by leveraging small contributions from a broad community of contributors and aggregating information about problems otherwise difficult to address. The notion of Enterprise 2.0 formulated by McAfee (2006) encourages the use of Web 2.0 applications including IAMs in corporate intranets as a means to increase productivity and information elicitation.

The use of IAMs in the context of idea management is fairly new. To our knowledge two large scale experiments have been conducted in this direction: one in General Electric (LaComb et al., 2006) and another in a large German business-to-business (B2B) company (Soukhoroukova et al., 2007). Both experiments involve the setup of an IAM where traders not only buy and sell idea-contracts, but they also propose new ideas that are being imported in the market. The reported results suggest that IAMs are a promising method for idea management. Moreover experiments using IAMs in the context of product concept selection have been conducted (Chan et al., 2002; Ondrus et al., 2007).

The IDeM idea management platform

In this section we present IDeM, a software system that incorporates features to render it a promising solution for the setup of IAMs for idea management. The system can be utilized in several scenarios related to idea management. The following three scenarios are representative of major innovation management processes (Figure 1):

1. **Idea generation.** The purpose of this scenario is the generation of new ideas. The game-like process of the IAMs impels users to propose their ideas, which are entered in the market. Trading occurs for all ideas, newly proposed and old. Participants are compensated not only according to their stock portfolio, but also for their idea contributions.
(2) **Idea enhancement.** The purpose of this scenario is to enhance the ideas in the market. Market participants can invest on an idea and then contribute to it by e.g. questioning some aspects of the idea, suggesting idea improvements or changes according to their personal view.

(3) **Idea evaluation.** The purpose of this scenario is the evaluation of new ideas. A market is setup with a number of new ideas and traders act as evaluators. They trade idea stocks in an effort to increase the value of their stock portfolio. Transactions are used to identify the most promising ideas. Additional explicit traders’ feedback, such as comments and ratings, can be requested as well.

To support the aforementioned scenarios, IDeM provides functionalities for three roles: the market administrator, the trader and the decision maker. The administrator is responsible for setting up new markets, managing existing markets, selecting the original set of ideas included in a market and inviting traders. Traders are employees who participate in the idea evaluation or contribute ideas and/or idea enhancements in the corresponding scenarios. Decision makers are responsible for making decisions about new products and services based on the available information and the market outcome.

**Architecture**

The logical architecture of our system is presented in Figure 2. We followed a three-tier architecture that allowed us to use different tools to develop our system and furthermore rendered it easily expandable with new features.

**Market engine**

This component comprises the core of IDeM. It is responsible for executing buy and sell transactions that traders place. Currently the continuous double auction (CDA) and the CDA with market maker (CDAwMM) trading algorithms are implemented.

![Figure 2. IDeM's architecture](image-url)
In the case of CDA, the system stores active orders in a table called the “book of orders”. When a trader places an order for a particular idea-contract, the system validates the order and performs an order matching with the information stored in the book of orders. If a match does occur the correct number of shares are bought or sold and the data are updated in the database. The active orders are scanned based on their price and timestamp. Depending on the type of transaction (buy/sell) the highest or the lowest opposite offers are prioritized. In case two entries have the same price, the first entered is preferred. The system accepts limit and market buy orders. The former are placed in the form: “Buy (or Sell) xx shares at yy price”. The system will match these bid (or ask) offers at the exact yy price or lower (respectively higher) when and if opposite offers are available.

When CDAwMM is in effect the book of orders is integrated with a market maker (MM). The system takes over this role and is always ready to accept buy and sell orders at a certain price acting as an “always there” buyer and seller. A price function inspired from the Zocalo open source tool (http://sourceforge.net/projects/zocalo) is utilized to simulate real life supply and demand conditions. The function follows a logarithmic rule that increases the MM’s price when many are buying (high demand) and decreases it when many are selling. A control parameter can adjust the market’s depth, which means that traders can buy more shares from the MM without causing massive price fluctuations. The original algorithm utilized a span of prices between 0 and 1 so we scaled it from 0 to 100 in order to make trading more intuitive. Moreover we configured the system so that one market contains many makers, one for each idea-contract since in the Zocalo implementation each contract constitutes a separate market and therefore only one market maker was provided for each market.

When processing a new order, the system compares the best existing offer in the book of orders to the MM’s. If the MM’s price is no better than the book order, a trade with the book order is executed, otherwise the MM’s price is preferred. The imminent consequence of the MM is the increased liquidity of the market place.

Depending on the market configuration, the CDA or the CDAwMM trading mechanisms may handle the transaction.

Market and GUI configuration
This component handles the system settings. A new market can be setup by using a guided three-step process during which the system asks for a number of configuration options. A high degree of flexibility has been added and the market administrator can configure a number of parameters: closing date, operating hours, ideas to be assigned to the market, users to be invited. The trading mechanism, the initial endowment of money and contracts to users can be selected as well. Furthermore the system is designed for gathering input and feedback from the participants therefore two specific features that support this need can be selected:

(1) whether to allow submission of new ideas from traders and if these ideas will be automatically entered in the market or the administrator should review them and add them manually; and

(2) whether traders will be able to provide feedback with respect to existing ideas.

Available types of feedback are comments and rating based on a five-point Likert scale for aspects of the idea the administrator considers important.
Moreover this component contains the market closing function that marks the market as inactive and calculates the final portfolio of participants. The final value of the contracts for the calculation of the participants’ portfolios can be determined in two ways: either using their final price or manually setting it. In the latter case the average of the opinions of an expert committee can be used to determine the value. In general the clearing mechanism in our markets is an issue of high importance. IAMs need a well-defined future event in order to provide best results. However, such a well-defined future event is not applicable in IAMs for ideas since not all ideas will be realized. If the final price of the stocks is used in the payoff function, participants may trade on contracts with a high price and not based on their beliefs and the information they hold.

Having selected a market closing function, the total portfolio value results from the sum of the user’s play money and the value of the stocks in her/his ownership.

**Market data interface**

This component exposes market data as web services, so that other corporate applications may easily access them for further processing. The exposed data include the current ranking and portfolio value of traders and the current ranking of idea-contracts. Furthermore statistical data based on the information stored in IDeM’s database are computed by this component. A set of this data is accessible by traders. These are the high and low price, the price of the last transaction and the price fluctuation in time and the transactions’ volume fluctuation in time. Market administrators have access to additional data, which are volume traded/participant/time, average idea scores and ranking of ideas. Ranking is calculated based on the idea-contracts’ volume weighted average price (VWAP) (Lim and Coggins, 2005) value, given from the following formula:

\[
\text{VWAP}_i = \frac{\sum_{t=1}^{T_i} P_{t,i} Q_{t,i}}{\sum_{t=1}^{T_i} Q_{t,i}}
\]

where \(P_{t,i}\) and \(Q_{t,i}\) denote the price at which each trade occurred and the number of shares traded for stock \(i\) respectively.

VWAP can be calculated using a user-defined subset of the trading actions e.g. the last 60 percent of them. Using this approach, the preferences of traders are more accurately reflected since not only the price, but also the volume of a trade conveys information about them.

**Market data handler**

This component is responsible for retrieving and storing data to the underlying RDBMS. According to the role of a user the corresponding information can be read, written or deleted.
Market data repository
This component persists market data, such as data about ideas and transactions performed. An important aspect for the system utilization is how ideas are described. IDeM provides a configurable set of attributes that can be used to describe ideas. The basic are “Title” and “Abstract”. These attributes allow traders to get a quick overview of ideas. Further attributes include “Type”, “Application Context” which describe applicable industries (e.g. healthcare, utilities, etc) or department (e.g. marketing, logistics) or market (e.g. CRM, ERP, etc.) or operation (e.g. IT audit or production planning), “Technical Specifications”, a description of the “Problem Space”, potential “Relations” to other ideas, “Additional Information” and the current “Status” of the idea. In order to provide equal chances to ideas competing in the market, the amount of information entered for each attribute must be in the same level. In this way traders can readily compare ideas.

Security module and user access rights
This component controls user access (authentication function) and the pages that users have access to (authorization function). The market administrator can setup user groups. This function allows several markets to run in parallel. Each market has its own group of users.

Trial overview and system walkthrough
In order to test the perceived usefulness and IDeM’s ability to support collaborative idea management, we implemented a trial. The trial involved 31 postgraduate students enrolled in a course on group decision support systems. During the course, subjects were introduced to the concepts and tools of group decision making. They were then asked to assume that they are employees of a venture capital firm and that they are about to collaboratively decide on an investment on one out of various alternative web 2.0 technologies and applications. Our subjects were not familiar with the concept of IAMs although most had a basic knowledge of how stock exchanges operate. We conducted an introductory session for two hours where the main concepts of IAMs and the functionalities of the software were explained. Since we expected low liquidity of the market, we chose the CDAwMM trading algorithm. To alleviate possible evaluation apprehension effects, participant contribution was anonymous. The market was open continuously for three weeks and each trader was initially allocated 10,000 imaginary monetary units.

In addition to trading, subjects were also allowed to introduce new ideas from other sources (e.g. from Internet searches). The introduction of new ideas in the market was controlled by two appointed judges. The latter selected the most relevant to the problem space of the trial. The ideas that passed this test were introduced in the market as new ones. The starting trading price of all new ideas was set at 50 imaginary monetary units and the traders’ portfolios were updated with 50 shares of each one.

In the following we provide a short system walk-through aiming to demonstrate how IDeM supports the three generic scenarios outlined in the previous section, while the evaluation results of the trial are reported in the next section.

Before presenting the walkthrough from the trader’s perspective, let us see which are the steps required by the administrator to set up the market environment. The market administrator logs in and sets up a new market and assigns traders. As shown
In Figure 3, he/she selects the configuration options i.e. trading mechanism, whether idea submissions by traders are allowed and the type of feedback traders can provide besides their market transactions. In our trial we selected the continuous double auction with market maker to be the trading mechanism and activated the option of adding new ideas. Furthermore we allowed the submission of comments to the ideas. The market was initially populated with six ideas (the Yahoo Answers – answers.yahoo.com, the LinkedIn – www.linkedin.com, the Feeds2 – www.feeds2.com, the MyFilmz – myfilmz.net, the Ta-Da Lists – www.tadalist.com and the ToEat.com – www.toeat.com) acting as an initial seed so that our subjects could understand the kind of ideas relevant to the problem space.

From this step onwards traders log in and place their orders. Assume that a trader enters the system and selects the “MyFilmz” idea. The trading screen appears which displays various information as depicted in Figure 4. The high, low and last trade prices are presented in section (1) of the screen. Graphs are used for the volume and price history (see section (2)). Furthermore the trader can view the best four orders of the market book and enter her/his offers in section (3). In section (4) the description of the idea stock is given. Once having reviewed the available information our trader can buy stocks of the idea if s/he believes will be successful or sell stocks of the idea if s/he believes it will fail.

New idea submission was allowed in our trial; hence a link to a relevant form was activated (screen 1 of Figure 5). We chose to limit the mandatory information for a new idea in order to ease the submission so the mandatory information included a title, an abstract and a category that was selected from a predefined list. In screen 2 of Figure 5 a trader has entered a new idea and is ready to submit it.

Since the feedback option was activated, a hyperlink was provided leading traders to the feedback page through which they could submit comments. Traders occasionally accessed their portfolio where a list of the idea-contracts they own is
presented as depicted in screen 1 of Figure 6. Traders can view their pending buy/sell offers and have the possibility to cancel them.

During market operation the administrator monitors the course of the market, views newly proposed ideas and adds those that are considered adequate in the market. Upon market closure, he/she accesses a ranked list of the ideas in the market based on the VWAP as shown in screen 2 of Figure 6. Further, he/she can view any comments on ideas provided by traders.
Trial results

An expert committee consisting of five professionals evaluated all the idea contracts of our trial on a scale of 1 to 100 upon market closure. The mean price of the above valuations was the final value of the contracts and that price was used in the payoff function that produced the final portfolio value of each trader. The payoff function took into consideration the ideas that traders proposed. Those who proposed new ideas received a bonus of ten extra shares of their ideas. The trader with the highest portfolio received a prize. A total of 1,572 trading actions were recorded in the three weeks time frame and a total of 34 ideas were proposed. A total of 26 were judged as adequate and were inserted in the market as new but not all of them were traded.

We evaluated our trial in terms of the ability of IAMs as a method to support the generation of new ideas and their evaluation at the same time, and the ability of IDeM as a software to support the same tasks. The evaluation was performed with the use of questionnaires given to participants and the expert committee. A total of 15 questions were addressed to our traders and five questions to our experts.

The participants’ questionnaire gathered information regarding previous involvement of the subjects in innovation processes, their assessment of the IAM methodology, the usability of our system and how the characteristics of our trial (e.g. anonymity) affected their behavior. As depicted in Figure 7, participants found the game fairly interesting (65 percent) on a five-point Likert scale while most of them (68 percent) would be willing to take part in a similar game in the future. With respect to the perceived usefulness of IAMs in the business environment 80 percent of the participants agreed or highly agreed that IAMs are useful. It is also important to mention that participation was found to be not time consuming.

Regarding IDeM, the process of trading was found to be quite understandable (37 percent agreed) and transitions between the various screens easy enough (80 percent provided positive feedback). Moreover the new idea submission procedure was considered easy to follow (74.1 percent).

The same experts who valuated the idea contracts were asked to review all the proposed ideas and assess whether their quality and number was adequate. In addition they evaluated the market outcome (ranked list of ideas) and provided feedback regarding the perceived usefulness of the method. The proposed ideas were found quite interesting (80 percent agreed) and yielded a positive answer when asked of the
method’s usefulness (80 percent), on the five-point scale. Furthermore a positive answer was provided when questioned about the possibility of using IAMs in their business.

Related work
There are three categories of software applications implementing IAMs:

1. those that are being sold as complete solutions;
2. those that are offered as online services; and
3. open source software.

Representatives of the first category are Hollywood Stock eXchange (www.hsx.com), InTrade (www.intrade.com) and ConsensusPoint (www.consensuspoint.com). They offer their software to companies in order to run internal IAMs. In the second category we have Inklingmarkets (www.inklingmarkets.com). Users may create an account and build their markets through a web-based configuration panel. Regarding open source software, to our knowledge four tools are available:

1. Zocalo (http://sourceforge.net/projects/zocalo);
2. Freemarket (http://www.freemarket-project.org);
3. Jmarkets (http://jmarkets.ssel.caltech.edu); and

All of the open source tools are web based and their purpose is to provide a platform for experimenting with IAMs. Except for Zocalo, the other software tools implement the continuous double auction mechanism. These tools are optimized for predicting future events with a well-specified outcome, while user involvement besides trading is limited. We note that IdeaFutures and Freemarket offer the possibility for traders to propose new contracts which are “judged” by the administrator who can introduce them in the market later on.

IDeM’s difference to the above tools is threefold. First, it supports user feedback by allowing new idea-contracts submission, rating of the idea-contracts already in the
system and commenting. Second, it confronts the uncertainty of the underlying event by offering an expert based valuation of the contracts. Third, it ranks ideas based on the volume weighted average price, which aggregates traders’ preferences better than the market price as it takes into consideration number of transactions, and therefore ideas attractiveness, as well. Table I presents a comparative analysis of the aforementioned tools including our proposed system, IDeM.

Conclusions
We have presented IDeM, a software system that aids decision makers in the idea management process to collect, enhance and evaluate ideas by involving a broad range of participants, aggregating their opinions through the mechanism of IAMs. Specifically, IDeM:

- supports user feedback in terms of new idea-contracts submission, rating of the idea-contracts already in the system and commenting;
- confronts the uncertainty of the underlying event by offering the option to enter an expert based valuation of the contracts; and
- ranks ideas based on the VWAP of the idea-contracts, a measure that takes into account both price and transaction volume of ideas.

Although the use of IAMs in the idea management process is new, existing research including our own inaugural trial shows encouraging results but points out several issues that need to be further researched.

First, we confronted the issue of the large number of ideas. At the market’s closing point, 31 ideas were available. In a realistic corporate environment this number can be significantly higher. It is important for traders to be able to navigate among them in an efficient way, such that it lets them identify those that best match their interests. To this direction, support for automatically categorizing and clustering of similar ideas as well visualization and personalization techniques can help users quickly comprehend the available ideas.

Another issue worthy of research is the role of the facilitator in the idea generation scenarios. In our trial we used a “dictatorial” method for introducing new ideas to the market i.e. appointed judges decided which ideas were to be entered. However, this process may be democratized by allowing participants themselves to decide on which ideas should be inserted in the market. This would mean to hold initial public offerings (IPOs) and decide based on trader’s interest during them. Another solution could be to allow total anarchy in the system and publish every proposed idea in the market without any filtering. In this variant the market itself rejects low quality ideas through the ranking mechanism. An enhancement to this anarchist scenario is to use wiki-like markets in which new ideas are freely modified or extended by their investors. Towards the testing and evaluation of the above issues we have planned a series of experiments among which one, testing IAMs for the evaluation of new ideas, will take place in a large multi-national IT services company.

In conclusion our first results are very encouraging showing that the use of IAMs is a promising method able to reduce time and cost since it can combine idea generation and evaluation at the same time. It is for further study to fully understand their potential.
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Notes: \(^{a}\) An index contract is used to forecast the mean value of a random variable (Wolfers and Zitzewitz, 2004); \(^{b}\) a winner-takes-all security predicts the probability that an event will occur (Wolfers and Zitzewitz, 2004)
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