# Building the web infrastructure for providing rating services and subscription to them

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## Abstract

We simulate the process of possible interactions between a set of competitive services, web infrastructure agents (portals) that provide online rating for these services, and users of these services. We argue that to have a profitable business, these portals are forced to have subscribed services that are rated by the portals. We follow the "what-if" methodology, analysing strategies that a service may choose from to select the best portal for it to subscribe to, and strategies for a portal to accept the subscription such that its reputation loss, in terms of the integrity of its ratings, is minimised. The results of our simulation are that under natural conditions, if most of the services and rating portals in a given industry do not accept a subscription policy similar to the one indicated above, they will lose, respectively, their ratings and reputations, and, moreover the rating portals will have problems in making a profit. Our prediction is that the modern portal-rating based economy sector will eventually evolve into a subscription process similar to the one we suggest in this study, as an alternative to a business model based purely on advertising.

We propose a multiagent architecture which implements the developed strategies for services, portals and users.

**Keywords: web infrastructure for providing ratings, web portals, evolution of reputation, web advertisement models**

## Introduction

A web infrastructure (portals) for providing online rating of services, such as financial services, are becoming more popular nowadays. A rating portal providing comparisons between competitive services, has the potential of becoming a well established web enterprise. For some services the comparison is performed based on a set of measurable values such as performance and price, for example when the service involves computer hardware. In such an environment, services can make a rational decision whether they wish to advertise on the portal, based on the set of measurable values (compare with Tennenholtz 1999). However, for some services like banking, brokerage and other financial services, characterised by such parameters as customer support quality, it is impossible to establish an objective set of measurable values. In these cases the rating portals publish their scores for the competing businesses based on their own private estimation strategy. We believe that evolution of the interactions between the agents being rated and rating agents is an important social process which is worth examining thorough simulation.

In this study we simulate the plausible interaction between portals and services using a simplified model, and we analyse possible scenarios of how services can influence the portals' rating system. Our approach is based on a straightforward revenue model for rating portals, where they require the rated services to be paying to these portals in order to obtain a rating. Within this model we follow the dynamics of how the competing services may influence the portals to improve their respective ratings.

Over last couple of years, the role of paid advertisement placement at web portals has dramatically increased. Until recently, there were just one or two such advertisements per customer query displayed on keyword search portals. Nowadays, after Google's IPO, the business model of paid placement has become very popular, and the majority of search engines have designated areas for displaying advertisement slots on their search results web pages. This number of advertisement placements is expected to be growing even faster, and their order (from top to bottom) may be interpreted by users as a rating by a respective search portal. This is due to the fact that it is hard for end users to access the pricing policy for paid placements at keyword search portals (Sherman 2004). Therefore, possible mechanisms of providing such ratings and their evolution are worth exploring.

We conduct the *what-if* study suggesting a simple model with rational agents for services and portals as possible for a simulation of the subscription model. This model is implemented and analysed in detail in (Galitsky and Levene 2005). The resultant behaviour is verified and analysed with respect to the possibility of extracting patterns of rating subscription-based behaviour from real publicly available data. We conclude the paper with a discussion of how the predicted subscription process fits into the current advertising models; also the process itself is considered from the standpoint of conflict resolution in multi-agent systems.

## 1. An economic model

Portals are primarily characterised by their reputation. To express this quantitatively, we refer to the difference between the average rating of each service and the individual rating of each service on each portal. The higher the portal's reputation, the more potential customers it has and a higher the number of web surfers who would follow the portal's recommendation to select a particular (top-rated) service. Also, the higher the portal's reputation is, the higher is its appeal for the services to be rated by this portal, and, therefore, the potential revenue stream for the portal is higher. At the same time, when a portal accepts resources from the services it rates, its reputation may drop because its rating may become less objective. The dynamics of such a process is the subject of this study.

Each portal, while having its own rating system, aims to *maximise* its revenues on the one hand, and on the other hand aims to deviate as little as possible from the *average* portal rating. The justification for this is that often the public perceives the average (or typical) rating (or opinion) as the most trustworthy (Myung and Pitt 2003).

Evidently, services' ratings by portals is public information. A portal accepts an offer from the service which has a highest rank by the rest of portals, selecting among all services which offer a subscription payment.

Our model reproduces the real-life conflict between the services and portals: each service is determined to improve its ratings irrespectively of how it affects a portal's reputation, and vice versa, each portal wishes to achieve higher reputation and at the same time to increases its revenues. No evident compromise is possible.
We suggest a simple strategy, where the agents only take into account two parameters:

- Services select higher ranking of portals with higher reputation.
- Portals select services, which request a change in rating, that would minimise the damage to their reputation.

As our dataset for the initial conditions for our simulation we have chosen fifteen mutual funds as services and four well-known keyword search portals, which provide ratings for these services by ordering them within search results page. We have simulated all phases of the subscription process, including the initial phase, when the services initiate the subscription process to modify their initial rating, and the terminal phase, when the services run out of resources, and stop being selected by portals, or see no further benefit in participating in the process.

## 2. A formal model

We use a matrix *M* to express ratings, where *M(s,p)* denotes the rating of service *s* by portal *p*. Ratings of services are represented by integers from 1 to *ns*, where the ratings are presented in ascending order from the highest rated service (1) to the lowest one (*ns*). Each column of *M* contains integers 1,…,*ns* in a certain order such that each integer occurs only once, i.e. a portal cannot assign the same rating to two services.

The average rating for a service, *s*, over the set of portals, is given by:

$$r_{avg}(s) = \sum_{p} \frac{M(s,p)}{\# p}$$

where *#p* denotes the number of portals. Indeed, services intend to achieve better rating from portals with higher reputation, so the weighed *M(s,p)* comes into play (Section 3.6).

The reputation for a portal is calculated as the reciprocal of the deviation of the rating it gives to each service from the average rating of the service, and is given by

$$reput(p) = \frac{1}{\sum_{s} | M(s,p) - r_{avg}(s) |}$$

Portal reputations are greater than zero: the higher *reput(p)* the better the reputation is (i.e. the closer the totality of the given portal is to the average). If we assume that for a given portal its rating of every service is identical to the average rating, then the reputation of a portal approaches infinity. When choosing which portal to subscribe to, a service chooses the portal with the highest reputation while taking into account its possible increase in rating so that its rating will be as close to the highest rating (i.e. 1) as possible. More specifically, service, *s*, makes a subscription offer to portal, *p*, in such a way that

$$\frac{reput(p)}{M(s,p)}$$

is maximized.

Out of the totality of services which make a subscription offer to a given portal, the portal selects the one which would decrease its reputation the least. More specifically, portal *p* chooses to accept the subscription from the service *s* that minimizes

$$|\,M(s,p) - r_{avg}(s)\,|\,.$$

When portal, *p*, accepts the subscription offer from service, *s*, then *s* transfers *m* resource units to *p*, and *p* increases the ranking of *s* by one. So, if *s* was ranked at position *n* and *s'* was ranked at position *n*-1, their rankings are swapped. In the special case when *s* was already ranked at position 1, then the portal does not accept the offer from *s*.

The simulation that produced the results described in the next section was implemented in Matlab and is available from the first author on request.

## 3. Simulation

We formed the initial dataset of ratings from a selected set of fifteen mutual funds, rated by a set of four portals as a 4 by 15 matrix, where each column, representing a portal, contains numbers from 1 to 15 (without repetitions) denoting the ratings of the services by the portal.

For our simulations, we select four keyword-search companies as portals (Google, Altavista, Lycos and Hotbot) and obtained their ratings of the fifteen mutual funds as services abbreviated as ici, brill, vanguard, ameristock, mfs, bmo, rbcfund, ariel, oakmark, janus, portfolio21, scotia, prudential, ci, calvert.

To obtain the initial rating, we observed the order in which each of the above mutual funds appeared in the list of items delivered in response to query “mutual fund”. Only the occurrences (sequence) of the above funds were extracted from the search query results in each of the above search engines. In addition to the initial ratings, the following simulation parameters were used:

1) Initial resources set at 1000 units.
2) Subscription fee (per transaction) set at a flat rate of 50 units.

We assume that all services have the same initial resources; when they run out of resources they cannot subscribe for rating any more and become dormant. For the sake of uniformity of our simulation the services pay the same (50 units) for increasing their ratings. It is the same amount to change a rating from 13 to 12 as it is from 2 to 1; rating increases always start with the lowest number (which is the number of services being rated).

Naturally, the sum of the average ratings of the services is constant irrespectively of individual ratings. However, this is not the case for portals, whose reputations get worse in the course of subscription process.

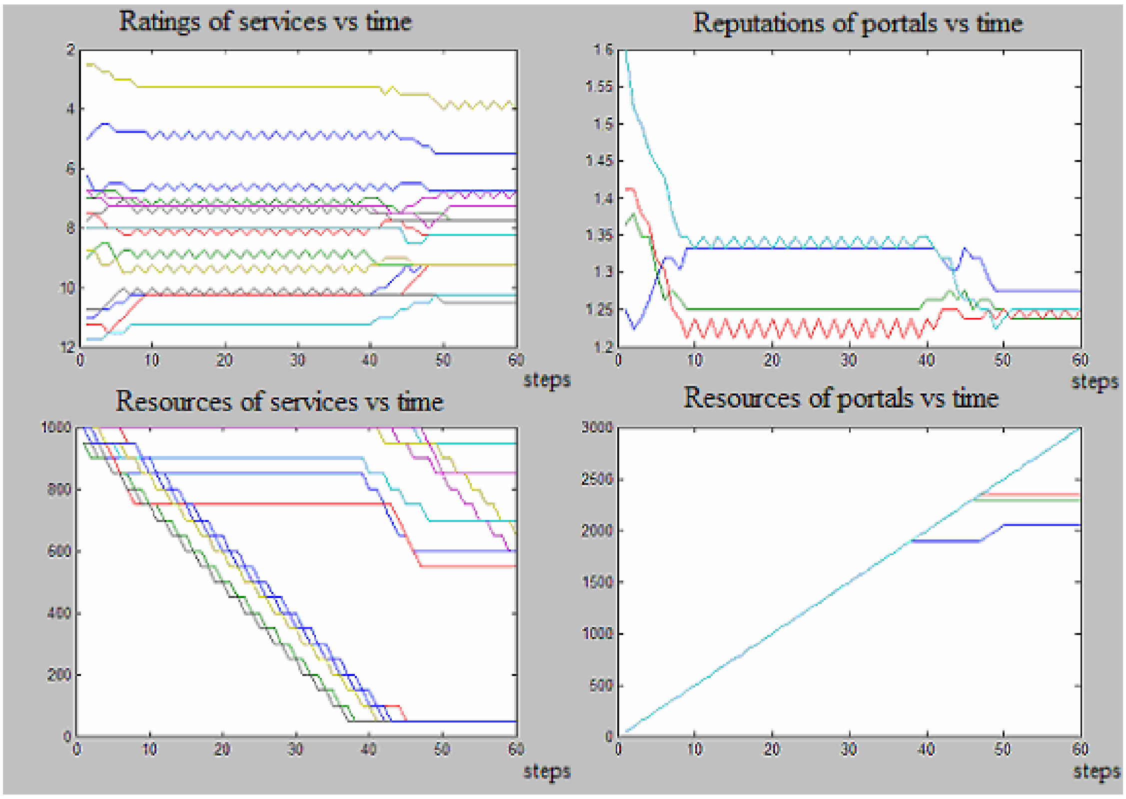

Figure 1: The evolution of ratings/reputations and resources of services and portals over time.

It takes first 10 steps to establish an equilibrium of ratings between the services, and an equilibrium of reputations between the portals (see Figure 1). Once the equilibrium is achieved, an oscillation pattern appears, which is caused by pairs of financial services that have their ratings swapped between position *i* and position *i*-1. As a result, the reputations of the portals are interchanged in a similar way, leading to an oscillating pattern between portals as well. The amplitude of oscillations for services is a quarter of unit (one out of four changes to the reputations of portals contributes to this amplitude). On the other hand, for the portals we observe oscillations with amplitudes which are higher than a single unit.

There is the critical point, at steps 38-45, when the interaction between the agents changes, at the time when eight of the services run out of resources. After that, the offers of the remaining services are always accepted, and the portal reputations are subject to further deterioration, as well as the ratings of these eight services that ran out of resources. However, the ratings of those services which have not run out of resources during these steps increase during steps 45-60. After that time, there is a smaller number of services capable of paying a subscription fee; 3 out of 4 of the portals are not offered a subscription and therefore do not increase their resources after this critical point. The competition for the subscription offers by services to be accepted by portals is still strong: all services wish to subscribe to the same portal, and the portal they all desire to subscribe to can only accept the subscription from a single service according to the rules of the game.

We outline the five zones we have detected within the evolution charts of interacting services and portals:

1) The *equilibrium establishing zone*;
2) The *oscillation zone*;
3) The *resources disappearance zone*;
4) The *limited resources equilibrium establishing zone*; and
5) The *stationary zone*.

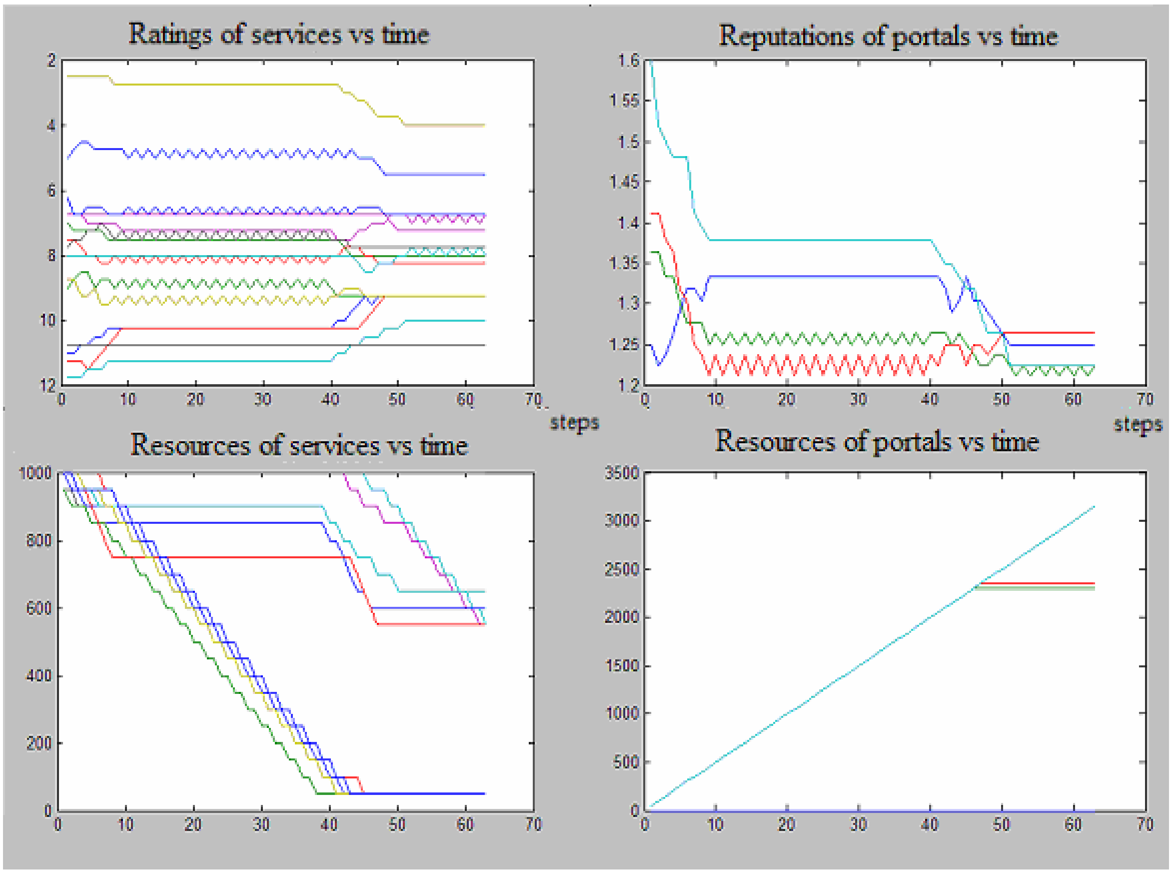


Figure 2: The evolution of ratings/reputations and resources of services and portals over time, where one portal with a low initial reputation is independent (i.e. it does not accept service subscription).

When a given portal does not accept subscription fees, its rating in the evolution curve in an environment where other portals accepts subscription fees is quite similar to the situation above, where every portal accepts subscription fees (Figure 2). The resource curve for this portal is a horizontal line on the bottom of the chart; the three remaining resources curves go together until step 48 when two of the portals stop gaining any further resources.

The resultant reputation of a portal is even lower when no subscription can be accepted, because the objective ratings it publishes will have a greater deviation from the average value. The latter is mostly affected by the portals that can accept subscriptions. The reputation dynamics closely follow the case when this portal can accept a subscription. Therefore, the overall subscription process is only weakly affected by a minority of portals which cannot accept subscription. The reputation of an independent portal which does not accept subscription drops because this portal becomes “less than average”, representing a true rating for services. Overall we observe the phenomenon that if the majority of portals accept subscriptions, their rating becomes “more average” and their reputation grows in comparison with an independent portal.

## 4 Results

In this study we have simulated the process of the interaction between the services which desire a higher rating on portals, whose revenue model is based on a subscription fee model where the flow of resources is from services to portals. We called this process the “subscription process”. We enumerate the common features of the behaviour of services and portals demonstrated under a wide variety of simulation settings, including their strategies and initial conditions:

- Participating in the subscription process, initially highly rated services run out of resources and drop their ratings while low rated services both increase their rank and keep resources. Overall ratings of services converge to a narrower range than initial.

- When each agent participates in the subscription process, the reputation of independent portals, which do not accept subscriptions, drops. Also, the ratings of the highly-rated services, which choose not to subscribe to portals in order to compensate for subscriptions of other services, drop in the course of the process.

- When just a small portion of lowest-rated services offer subscriptions to portals, it nevertheless strongly decreases the reputation of portals accepting these subscriptions and the ratings of other services.

Therefore, it seems that when a low proportion of interacting agents participate in the subscription process, it has a negative effect on the ratings of others, and thereby encourages these other services to compensate for their lost rating by joining the process. At the same time, it is quite unprofitable with respect to both ratings and resources to stop subscribing to portals. For services, it would be profitable to stop subscribing synchronously, knowing that other services would cooperate and also stop subscribing.

This is, however, impossible because the services do not have knowledge about each other in terms of participation in the subscription process.

We observe that for both services and portals, it is not a "winner takes all" situation: services which were initially rated as "best", drop their rating in the process of subscription. If the best rated services do not participate in subscription, their ratings fall even further. Therefore, special initiatives or proper timing of participation does not play a major role in the subscription process. Our predication based on the current model is that eventually all or majority of players in a market sector would have to join the subscription process, but one cannot expect major winners or losers. Instead, the subscription process is the machinery which brings the participants into an equilibrium state, providing a revenue stream for portals.

The paper suggests that portals should be following other portals very closely to observe and forecast their advertisement policy. Failing to do so would lead to loss of reputation even if a given portal tries to rate services as objectively as possible.

## 5. Bringing the customer agent in the loop

In accordance to our model above the reputation of portals did not depend on the actual quality of products and services (true rating). This assumption is adequate for products and services which are hard to perform a competitive analysis about, or where such analysis takes a long time (compare with the duration of the subscription process). If this assumption is incorrect then one needs to simulate how customers perceive the deviation of portals' rating from true rating and how it affects the income flow to the services being rated.

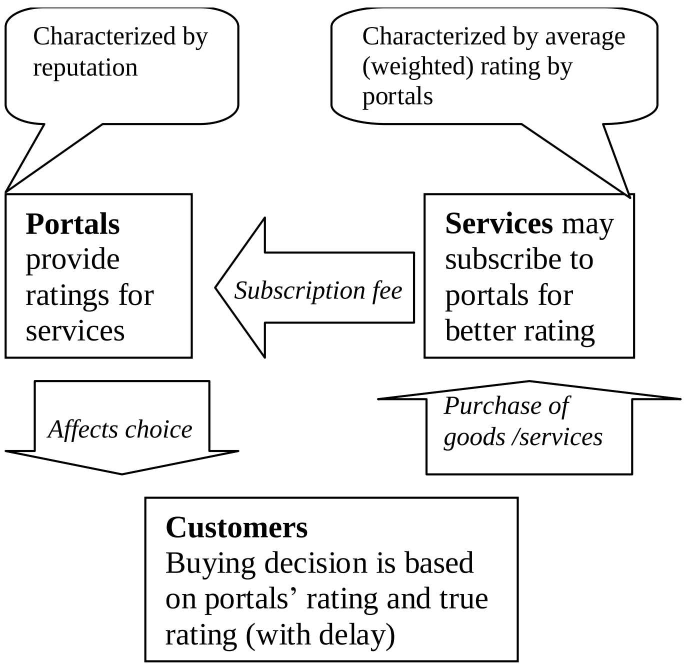

Figure 3: the interaction three agents involved in the online rating infrastructure. Block arrows show the flow of resources from customers to services, and then from services to portals. The loop is closed by the link between portals and customers: how the portals' rating affects the distribution of customers' resources among services.

Customers purchase a service proportionally to the ratings of this service by each portal and to the reputation of this portals, summed up for all portals. These are the purchases made based on portal ratings of this service:

$$resourceFromPortal(s) = advert\_portion * \sum_{p} (reput(p) * M(s, p)),$$

where *resourceFromPortal(s)* is the influx of resources to service *s*. The coefficient *advert_portion* is chosen so that the total influx of resources for services is equal to the total spending on subscription.

Other customers' purchase is based on the true rating

$resourceWithoutPortal(s) = advert\_portion * M_0(s, p).$

We hypothesise that initially customers trust the portals, but then observing the deviation from true rating, follow it in their choice of service.

$$resource(s) = advert\_portion * (resourceFromPortal(s) * \omega(t) \ + resourceWithoutPortal(s) \ * (1 - \omega(t)))$$

where $\omega(t)$ is the coefficient for the lost of trust for portals dependent on time (step) t.

## Multiagent implementation

Our prediction is that the modern portal-rating based economy sector will eventually evolve into a subscription process similar to the one we suggest in this study, as an alternative to a business model based purely on advertising. Services will need to deploy the procedure of the search of best portals to subscribe to on a regular basis. Portals will need to select the most appropriate subscription offers. Finally, users will need to make their buying decision in an uncertain environment of ratings altered by subscription. Since a large amount of data has to be processed by each involved agent, a respective software infrastructure is proposed (Figure 4).

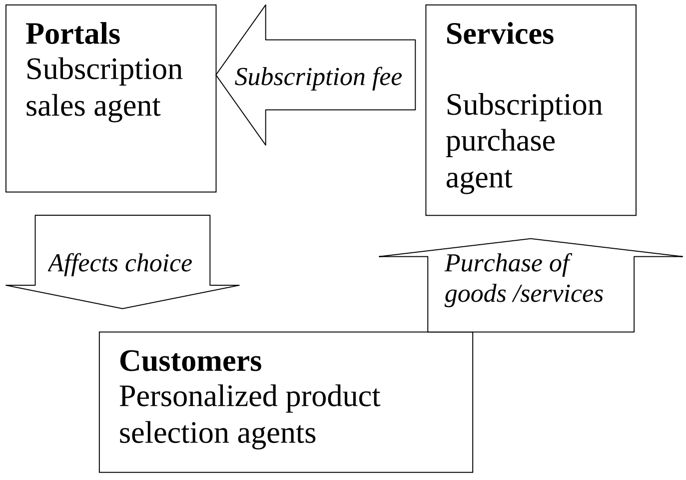


Figure 4 Multiagent architecture

## Discussion and Related Work

This study highlights the role of the concept of *distributed mental attitudes* for simulating the processes in a society. The concept of distributed knowledge have been thoroughly explored in artificial intelligence literature and applied to a variety of multiagent model (see e.g. Fagin et al 1996). At the same time the notion of *distributed intentions* has not been extensively applied to the simulation of economical or social processes (Galitsky 2002, Galitsky 2005). In this study we may define distributed intentions as the intention of the majority of community members to participate in a process such that other members are forced to participate as well even if they do not have direct explicit intentions of doing so. In other words, collective intention of a multiagent community to perform an action is where a majority of its (typical) members explicitly intend so and the rest of (atypical) members believe the following. If they do not commit that action then, believing that other agents will commit it, the atypical agents will find their desired state (a long-term goal) further away.

The notion of distributed intention is worth applying to the setting of *multiagent conflict*. In terms of a multiagent conflict, the subscription process can be considered as a negotiation to achieve a state where the intentions of services becomes consistent with the intentions of portals. Note that the conflict of intentions between the services cannot be resolved. Without a subscription process there is no explicit conflict of intentions between the portals, but as only portals are competing for subscribing services, the conflict arises.

We used numerical simulation to represent the subscription process in this study, however the essence of our approach to obtain the behavioural phenomenology should be referred as *logical* instead. The simulation is concerned with the conflict resolution strategy, which is formed by participating agents in the online mode. Subscription process is a new form of economic behaviour

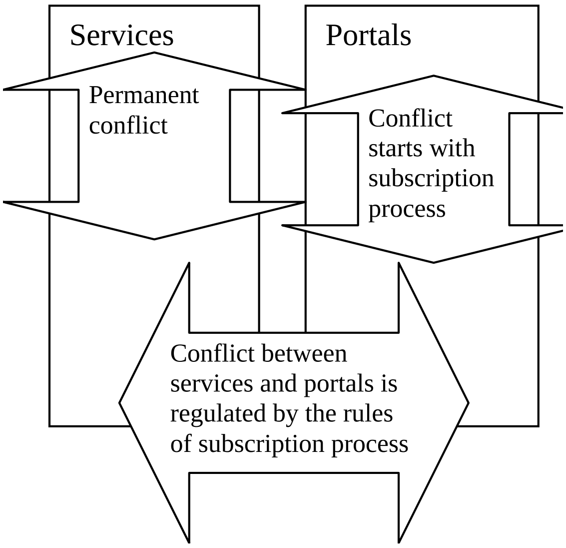

Figure 4: The outline of conflicts between the parties involved in subscription process.

Coalition formation is a desirable behavior in a multiagent system, when a group of agents can perform a task more efficiently than any single agent can. Computational and communications complexity of traditional approaches to coalition formation, e.g., through negotiation, make them impractical for large systems. (Decker, Sycara and Williamson 1996) propose an alternative, physics-motivated mechanism for coalition formation that treats agents as randomly moving, locally interacting entities.

It is worth considering subscription process by a group of services as their coalition formation with rating portals. Coalition formation methods allow agents to join together and are thus necessary in cases where tasks can only be performed cooperatively by groups (Zacharia et al 1999, Lerman and Shehory 2000, Klusch and Gerber 2002) . This is the case in the Request For Proposal (RFP) domain, which is a general case for what we call here the subscription proposal. A requester business agent issues an RFP - a complex task comprised of sub-tasks - and several request processing agents need to join together to address this RFP. (Shehory and Kraus 1998) have developed a protocol that enables agents to negotiate and form coalitions, and provide them with simple heuristics for choosing coalition partners. The protocol and the heuristics allow the agents to form coalitions under the time constraints and incomplete information. The authors claim that the overall payoff of agents using suggested heuristics is very close to an experimentally measured optimal value, in accordance to their extensive experimental evaluation.

We have presented the process of competitive services *officially* subscribing to a rating mechanism on portals. In reality, this process may not have such a formal arrangement and occur in way where different participating agents lack information about the subscription arrangements of others. We have obtained the sequence of zones in our simulation process: transition from the initial zone to the final zone is expected to be associated with some *legalisation* process, when explicit rules of subscription offer/acceptance are formed and every agent becomes knowledgeable of these rules. The services subscription model should become transparent to the customers, and we suppose that some legislation will control the practice of this process and enforce the disclosure of its details. Currently, the Federal Trade Commission in the USA recommends search engines having paid-placement advertising results to clearly separate these from results obtained from the search engine ranking algorithm (FTC 2004, www.ftc.gov/bcp/conline/pubs/buspubs/dotcom/).

We expect the portals to find the ways to legalize the subscription practice. Since the technology and business development goes ahead of the respective legislation, we believe portals will try to be appealing to both services (advertisers) and the end users. In a more realistic model, we assume that portals will have a more accurate way to reflect a “real“ quality of service.

This work follows along the lines of the study of an economy of web links, where the potential monetary values of web links has been explored and a link exchange process has been simulated (Galitsky and Levene 2004). Clearly, assuming that the majority of links are established as a result of such exchange is unrealistic, however, it sheds some light on how web links might be established in a future economy should the process of link exchange become prevalent. Analogously, in the current study, we overstate the role of the interaction between a service and a rating portal in order to judge how the former may affect the latter in the course of a competition for a better rating.

The results of our simulation study can be considered as creation of a novel advertising model that is suitable for online portals. Subscription process is a way of increasing demand by bringing the product to the attention of consumers. Advertising can be either informative or persuasive advertising. The effectiveness of advertising can be measured by the advertising elasticity of demand, which measures the percentage increase in demand divided by the percentage increase in advertising spending. In terms of advertisement, rating can be considered as a persuasive advertising means .

It is known that keyword search portals do not always make it clear how the ratings are provided. It has been shown show how both Google and Altavista systematically relocate the time stamp of Web documents in their databases from the more distant past into the present and the very recent past and delete documents (Wouters et al 2004). Therefore, the quality of information is decreased. The search engines continuously reconstruct competing presents that also extend to their perspectives on the past. This may potentially have major consequences for the end users of search engine.

## Conclusions

In this study we suggested a possible process of how the natural intentions of services to sacrifice their resources in order to gain a better rating may be formulated, and the formulation of the intentions of portals to, possibly, sacrifice their reputation in order to gain resources from services, may compliment each other. We observed that the collective intentions of the above agents find the matching strategy, not the individual intentions of participating agents, some of which may deviate from the majority of agents. In particular, initially highly rated services do not intend to enlist to the subscription process, but they have to accept the rules of the game once the other services have enrolled.

Since it is possible to observe real-world rating data and its evolution, one can extract the patterns of the subscription process, including the stationary zones and the transition zones. Such behaviour as oscillations in ratings , for example, will indicate that there is a strong competition between services for a particular portal. Such patterns can be revealed even analysing the search engine ranking resulting from keyword queries, which is the subject of our future studies.

Returning to the real-life problems, we cannot reject the possibility that the rating portals would form their business model in accordance to what we suggest in this paper. The question remains, if not the suggested business model, what else should the rating portals do nowadays to have a stable revenue stream? Probably, in the current web economy, there is no plausible business model for providing true ratings.

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