Retailer Selection and Pricing Mechanisms in E-Business Context

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***Abstract*— The highly competitive communications markets of the future should encompass mechanisms for enabling users to find and associate with the most appropriate retailers, i.e., those offering at a certain time period adequate quality services in a cost efficient manner. This paper presents such mechanisms. In this context, key factor for retailers' success is the strategy adopted regarding service provision, since it forms a means of gaining new customers and enhancing existing customers' loyalty. Our starting point is the definition of a business case, through which the role of the best candidate-retailer selection problem is explained, while the alternative strategies a retailer may adopt under different circumstances in order to generate attractive offers are described. The identified components of the best candidate-retailer selection problem involve the evaluation of the quality of a retailer offer, which is concisely defined, mathematically formulated and solved. At the final sections results are provided and concluding remarks are made.**

Keywords- Retailer, Service Architecture, 0-1 Linear Programming, Pricing Policies, time limitations, resource availability.

I. INTRODUCTION

The ongoing liberalisation and deregulation of the telecommunication market will introduce new actors [1][2][3]. In principle, the main role of all players in such a competitive environment will be to constantly monitor the user demand, and in response to create, promote and provide the desired services and service features. The following are some key factors for success. First, the efficiency with which services will be developed. Second, the quality level, in relation with the corresponding cost, of new services. Third, the efficiency with which the services will be operated (controlled, maintained, administered, etc.).

The challenges outlined above have brought to the foreground several new important research areas. Some of them are the definition of new business models, the elaboration on e-business concepts [4][5], the specification of service architectures (SAs) [6][7], the development of advanced service creation environments (SCEs) [8] and service features (e.g. the personal mobility concept [7]), and the exploitation of advanced software technologies, (e.g. distributed object computing [9][10] and intelligent mobile agents [11][12]. The aim of this paper is, in accordance with the cost-effective QoS provision and the efficient service operation objectives, to propose enhancements to the sophistication of the functionality that can be offered by service architectures in open competitive communications environments.

Without being exhaustive five main different entities can be identified in a typical view of the competitive telecommunications world of the future, namely, user, retailer, (third party) service (or content) provider, broker and connectivity provider. The role of the (third party) service (content) provider is to develop and offer services (content). The role of the retailer is to provide the means through which the users will be enabled to access the services (content) of (third party) service (content) providers. Limited by techno-economic or administrative reasons each retailer offers services only inside a domain. Moreover, it can be envisaged that an arbitrary area will, in general, fall into the domain of several retailers (Fig. 1). The broker assists business level entities in finding other business entities. Finally, the role of a connectivity provider is to offer the network connections necessary for supporting the services.

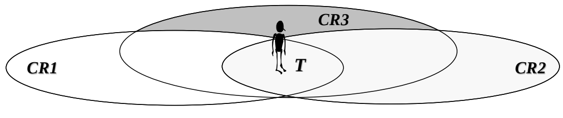

Figure1. A user is found in an area from which he/she wishes to access a given service through the most appropriate retailer. The area falls into the domain of various candidate retailers.

Highly competitive and open environments should encompass mechanisms that will enable users to obtain services through the most appropriate retailers, i.e., those offering, at a given period of time, adequate quality services in a cost efficient manner. In this paper the pertinent problem is called best candidate retailer selection. A general version of the problem can be described as follows. Given: (a) a user wishing to access a certain service, (b) user preferences, requirements and constraints regarding the features of the service, and (c) a set of candidate retailers and their offers (e.g., cost at which each service feature - quality level combination is provided), find the retailer that best matches a service quality and cost related criterion.

This framework constitutes predominant factor for retailers' success the strategies they adopt regarding service provision (e.g., service features offered with respect to the requested price). In this context, retailers should also be assisted in accounting for their interests, while possible limitations and constraints imposed by the environment should be considered (e.g., time deadlines, resources available). In this respect, retailers should be provided with a mechanism assisting them in the generation process of attractive offers in the context of each negotiation process considering different environmental conditions.

The aim of this paper is (primarily) to address the aforementioned problems from one of the possible theoretical perspectives and (secondarily) to show how the solutions can be incorporated in service architectures that run in the open competitive environment. It should be noted that the problems and the solution methods presented in this paper are relevant to the e-business context. Our reference service architecture bears resemblance with the one specified by the Telecommunications Information Networking Architecture Consortium (TINA-C) [13][14] and the PARLAY/OSA Framework [15]. However, the presented practices can be applied to other models as well.

The approach in this paper is the following. The starting point (section II) is the general description of the retailer selection concept, through the presentation of a relevant, overall business case. An outcome of the description of section II is the splitting of the (overall) retailer selection problem into two sub-problems, namely, that of evaluating the quality of a retailer offer encountered on the user's side and that of generating attractive offers addressed on the retailer's side. Section III presents a concise definition, mathematical formulation and solution to the problem of evaluating the quality of an offer. Section IV introduces the range of strategies a retailer may adopt in order to propose attractive offers to users and be more successful in the competitive, liberalised market. Section V provides a set of indicative results. Finally, section VI includes future plans and some concluding remarks.

II. General Presentation of the Retailer Selection Concept

This section starts from the description of the business case, through which the role (and importance) of the retailer selection concept can be understood. Sub-section II.A provides the description in terms of business level entities (i.e., users and retailers), while in sub-section II.B the description is refined by introducing the role of the computational level components.

A. *Description in terms of business entities*

Assume that a user, wishing to access a specific service, can be served by various candidate retailers (CRs), as depicted in Fig. 1. The choice of the most appropriate retailer requires the realisation of the three general phases depicted in Fig. 2.

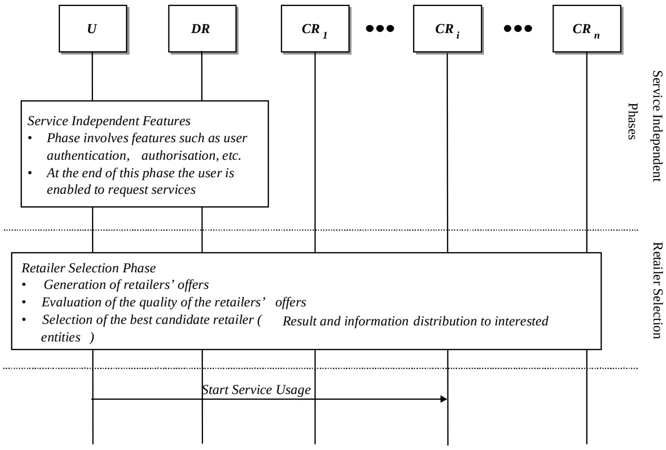

Figure 2. Interactions among the business level entities during the best, candidate retailer selection business case

The first general phase involves service independent features like user authentication, authorisation, etc. It involves the user and an entity that will be called default retailer (DR). In essence, at the end of this phase the user is enabled to request services. This phase will not be further addressed in this paper. Apart from its role in the first phase, the DR is seen as an entity that is specialised in the assistance of the user in the open competitive communication environment. The DR can accomplish this by providing, maintaining and hosting (essential parts of) the software that will conduct the retailer selection. In this respect, the DR is assumed to play a co-ordinating role in the second general phase, which is the core of the retailer selection. At this point the user has expressed the wish to access a given service. Involved in this phase will be the user, the DR and the candidate retailers. In general, the set of candidate retailers can be determined by means of a brokerage (a simple directory) service. Our approach is the most obvious one and engages all the possible candidate retailers in the negotiation process. Alternatively, learning from experience techniques can be exploited in order to confine the set of candidate retailers as is proposed in [16]. Moreover, there can be some retailers that choose not to make offers to users. In general, retailer selection may be founded on general and service specific user preferences and retailer policies. In the third phase of the business case the result of the selection is available, and hence an association between the user and the selected retailer can be established and the service usage can possibly start.

The core of the retailer selection process requires a method for evaluating the quality of the retailers' offers assisting users in selecting the best retailer for service provision. Additionally, a mechanism, which assists retailers in the process of generating attractive offers in a world of limited resources is desired in order to be successful in the competitive market of the future. In this perspective, in the section III, one possible version of the problem of evaluating the quality of a retailer's offer is addressed, while in section IV, a formal model of the retailer specific mechanism regarding generation of attractive offers is provided. In the current version of the problem, we limit our attention to price modification schemes in respect to the initial pricing structure adopted by retailers, taking into account critical environmental factors. Thus, a basic assumption adopted at this point is that candidate retailers are differentiated only on the basis of their pricing policy, on the grounds that all retailers may offer the specific service features requested by the user.

B. *Description in terms of Computational Level Concepts*

A computational level model of the business case is depicted in Fig. 3. Of interest to our study is the access session concept. In general, a session is defined as the temporary relationship among a group of objects that are assigned to collectively fulfil a task for a period of time. The access session is a service independent concept, which can be seen as the gateway to any specific service usage. It comprises activities that allow user authentication, user profile control (inspection), and service invocation.

The Framework Agent (FA) is the component that enables the initial access to a domain. The User Agent (UA) component represents the user beyond the terminal e.g., in the default retailer domain. Its role is to intercept and process user requests. The UA maintain user profile related information e.g. preferences, requirements and constraints regarding certain services, service subscriptions, etc. The User Application Agent (UAA) models the entity (user interface) with which the user is confronted in access session mode. The UA invokes the Service Factory (SF) for initiating a service.

The overall retailer selection task requires a computational component that will act on behalf of the user. Its role will be to capture the user preferences, requirements and constraints regarding the requested service, to deliver them in a suitable form to the appropriate retailer entity, to acquire and evaluate the corresponding retailer offers, and ultimately, to select the most appropriate retailer. As a second step, retailer selection requires an entity that will act on behalf of each candidate retailer. Its role would be to collect the user preferences, requirements and constraints and to make a corresponding offer, taking also into account the underlying connectivity providers and certain environmental criteria as well.

The following key extensions are made so as to cover the functionality that was identified above. First, the UA is extended, by being assigned with the role of selecting on behalf of the user the best retailer. Second, the Retailer Agent (RA) is introduced and assigned the role of promoting the services offered by a candidate retailer. In other words, the UA possesses the user preferences, requirements and constraints from a profile, interacts with the RAs of the candidate retailers so as to obtain their offers, and selects the most appropriate retailer for the provision of the desired service. The RA promotes the offers of a candidate retailer, interacts with UAs, and the underlying connectivity provider mechanisms. Consequently, the UA interacts with the RA of each candidate retailer , where denotes the overall set of candidate retailers. The aims of the UA - RA interactions are the following. First, to supply the RA with user preferences and constraints regarding the specific service. Second, to obtain the corresponding retailer offers. Third, to select the retailer that makes the best offer. The detailed description of these interactions is omitted for brevity.

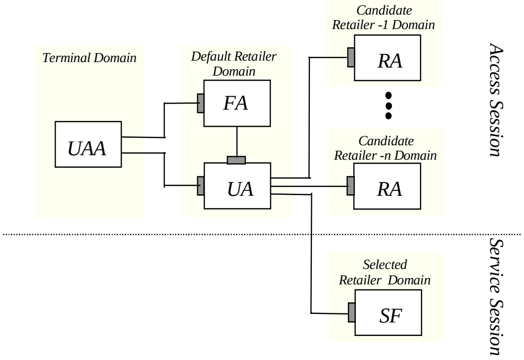

Figure 3. Computational model for the best candidate retailer selection business case

III. EVALUATING THE QUALITY OF A RETAILER OFFER

In general, the core of the selection process requires a method for evaluating the quality of each retailer offer. This paper (section III.A) includes a mathematical description of a general version of the problem. At a next step the problem version is formulated as a 0-1 linear programming problem [17][18], and a brief outline of computationally efficient solution algorithms is presented.

A. *Formal Problem Statement*

Each UA acts on behalf of a user u, whose profile is known. User u wishes to use a given service s. A fundamental assumption at this point is that service s is composed of a set of distinct service features, which will be denoted as $SF(s)$. Furthermore, let us assume without loss of generality that these service features are offered (supported) by all candidate retailers. Among these service features, of interest to the user are those designated in the user profile and will be denoted as $SF(u,s)$ ($SF(u,s) \subseteq SF(s)$). Each service feature $i \in SF(s)$ has an associated set of possible quality levels, represented by the set $Q(i)$. A quality level can be seen as the specification of the (perhaps range of) values of quality parameters that are relevant to the service feature. The set of quality levels that are in line with the user profile is denoted by $Q(u,i)$ ($i \in SF(u,s)$). It holds that $Q(u,i) \subseteq Q(i)$. The user preferences and the retailer policies determine each of these quality level sets.

The anticipated user satisfaction level (measure) that results from the assignment of service feature-i at quality level-j is denoted as $b_{SQ}(i,j)$ ($i \in SF(u,s)$, $j \in Q(u,i)$). Some clarifications are necessary regarding these parameters. In practice, it is not necessary (or even expected) that the users will be the entities that explicitly configure these values (even though this can not be excluded in certain cases). A realistic assumption is that the DR, being in charge of assisting the user in the open competitive environment, has a solid interest in as accurately as possible reflecting the user views in these parameters. In this respect, the DR can be the entity that configures the values based on the service feature characteristics, the user preferences and requirements, and by co-operating with retailers and service providers for exploiting their experience. The method for determining the appropriate values can rely on experiments, user trials and the experience obtained during the service provision. The provision of examples on the determination of the $b_{SQ}(i, j)$ values for various services and user classes is a standalone feature left for a future version of this study. The associated price (tariff) that will be imposed on the user by retailer r for the assignment of service feature-i at quality level-j is denoted as $p_{SQ}(r,i,j)$ ($r \in R$, $i \in SF(u,s)$, $j \in Q(u,i)$).

The objective of our problem is to find a service configuration pattern, i.e., an assignment $A_{SQ}(r)$ of service features i ($i \in SF(u,s)$) to quality levels j ($j \in Q(u,i)$), that is optimal for retailer r. The assignment should maximise an objective function $f(r, A_{SQ}(r))$ that models the quality of the retailer r offer. Among the terms of this function there can be the overall anticipated user satisfaction level that results from the assignment, which is expressed by the function $b(A_{SQ}(r))$, and the price (tariff) at which retailer r will provide the assignment, which is expressed by the function $p(r, A_{SQ}(r))$. Of course, one of the two factors (anticipated user satisfaction or price of the assignment) can be omitted in certain variants of the general problem version considered in this paper.

The constraints of our problem are the following. First, each service feature-i ($i \in SF(u,s)$) should be assigned to only one quality level-j ($j \in Q(u,i)$). Second, a cost-related constraint can be imposed. As an example, a value $p_{\max}$ can be defined for representing the maximum price (tariff) that can be afforded by the user for the service usage. The $p_{\max}$ value can be seen as an expression of the user constraints. The corresponding mathematical description of the constraint is $p(r, A_{SQ}(r)) \le p_{\max}$. The third problem constraint refers to the anticipated user satisfaction level (measure), which should not be lower than a given value $B_{\min}$ (this may be seen as an expression of the user requirements). The corresponding mathematical description of the constraint is $b(A_{SQ}(r)) \ge B_{\min}$.

The overall problem can be formally stated as follows. *Problem 1: [Evaluation of the Quality of the Retailer-r Offer].* Given: (a) a user u who wants to use a service s, the profile of user-u, (b) the set of service features $SF(u,s)$ of service s that are of interest (relevant) to user u (this set is formed by the service specification, the user profile and the retailer capabilities), (c) the set of quality levels $Q(u,i)$ at which each service feature i ($i \in SF(u,s)$) can be offered, according to the service specification, the retailer capabilities and the preferences of user u, (d) the anticipated user satisfaction level $b_{SQ}(i, j)$ (expressing the user preferences), which derives from the assignment of service feature i ($i \in SF(u,s)$) to quality level j ($j \in Q(u,i)$), (e) the price $p_{SQ}(r,i,j)$ that retailer r associates with the assignment of service feature i ($i \in SF(u,s)$) to quality level j ($j \in Q(u,i)$), (f) the upper bound on the overall price (tariff) $p_{\max}$ that the user can afford for the service usage (this value is an expression of the user constraints), (g) the lower bound $B_{\min}$ on the anticipated user satisfaction level that has to be experienced during the service usage, find the best service configuration pattern, i.e., assignment of service features to quality levels $A_{SQ}(r)$, that optimises an objective function $f(r, A_{SQ}(r))$ that is related to the overall anticipated user satisfaction $b(A_{SQ}(r))$ and price $p(r, A_{SQ}(r))$ suggested by the assignment, under the constraints $p(r, A_{SQ}(r)) \le p_{\max}$, $b(A_{SQ}(r)) \ge B_{\min}$ and that each service feature is assigned to exactly one quality level.

The above general problem version is open to various solution methods. Its generality partly lies in the fact that the objective and the constraint functions are open to alternate implementations. The problem statement can be distinguished from the specific solution approach adopted in the next subsection.

B. *Optimal Formulation*

In this sub-section the problem above is formulated as a 0-1 linear programming problem. The experimentation and comparison with important alternate formulation approaches is a stand-alone issue for future study. In order to describe the assignment $A_{SQ}(r)$ of service features to quality levels, the decision variables $x_{SQ}(i, j)$ ($i \in SF(u,s)$, $j \in Q(u,i)$), which take the value 1(0) depending on whether the service feature-i is (is not) assigned to quality level-j, are introduced. The problem of obtaining the most appropriate assignment $A_{SQ}(r)$ may be obtained by reduction to the following optimisation problem.

Problem 1: [Evaluation of the Quality of the Retailer-r Offer].

Maximise:

$$f(r, A_{SQ}(r)) = \sum_{i \in SF(u,s)} \sum_{j \in Q(u,i)} \left[c_B \cdot b_{SQ}(i,j) - c_P \cdot p_{SQ}(r,i,j) \right] \cdot x_{SQ}(i,j) \quad (1)$$

subject to

$$\sum_{j \in Q(u,i)} x_{SQ}(i,j) = 1, \ \forall i \in SF(u,s) \quad (2)$$

$$b\left(A_{SQ}(r)\right) = \sum_{i \in SF(u,s)} \sum_{j \in Q(u,i)} b_{SQ}(i,j) \cdot x_{SQ}(i,j) \geq B_{\min} \quad (3)$$

$$p\left(r, A_{SQ}(r)\right) = \sum_{i \in SF(u,s)} \sum_{j \in Q(u,i)} p_{SQ}(r,i,j) \cdot x_{SQ}(i,j) \leq p_{\max} \quad (4)$$

$$A_{SQ}(r) = \left\{ x_{SQ}(i,j) \mid i \in SF(u,s),\ j \in Q(u,i) \right\} \quad (5)$$

Relation (1) expresses the objective of finding the best assignment of service features to quality levels that maximises the cost function, which is associated with the overall anticipated user satisfaction and the corresponding price. In other words, relation (1) expresses the quality of the retailer r offer (or equivalently, the objective function value that is scored by retailer r).

Weights c_B and c_P provide the relative value of the anticipated user satisfaction related part and the price related part. Constraints (2) guarantee that each service feature will be assigned to exactly one quality level. Constraint (3) guarantees that the level of user satisfaction will not be lower than a pre-defined value that is dictated by the user requirements. In the same manner, constraint (4) guarantees that total cost will not exceed a predefined value.

C. Computationally Efficient Solutions

In general, the solution of a linear problem can be a computationally intensive task. However, in case the size of the problem instance is not prohibitively large (as often encountered in this paper), a solution method can be to exhaustively search the solution space. The complexity of the search in this case is $\prod_{i \in SF(u,s)} |Q(u,i)|$, i.e., a function of the service features that are relevant to the user and the quality levels at which these service features may be offered.

In case the solution space is large the design of computationally efficient algorithms that can provide good (near-optimal) solutions in reasonable time is required. Classical methods in this respect are simulated annealing [19], taboo search [20], genetic algorithms [21], greedy algorithms [18], etc. Hybrid or user defined heuristic techniques may also be devised.

IV. Generating Attractive Offers in an Environment of Limited Resources

This section describes the mechanism that assists the RA in the generation process of new and more attractive offers, considering an environment with potential limitations. In essence, in this section the initial pricing structure produced in the context of a service request may be refined, constituting thus the candidate retailer more successful in the competitive market of the future. Retailers' range of acceptable prices for the requested service may be determined by market research results and service provisioning internal costs (taking also into account underlying connectivity providers), while learning from experience techniques [22] could as well be exploited.

Retailers can be provided with information on the agreements they fail to establish. This information can be exploited for determining whether there should be some modification on the retailer policies (e.g., price reduction, alteration of the set of quality levels offered, negotiation strategy modification [23][24][25]).

In the current version of this paper, candidate retailers may propose new price offers based on an estimation of potential limitations and constraints imposed by the environment. Our approach engages two critical environmental factors, namely, time limitation and resource availability (i.e., the number of clients being served by the retailer), which are considered to contribute significantly to the formation of the retailer's decision regarding the generation of an offer. Term 'strategy' denotes the varying importance of the two criteria to the retailer's decision. Retailers may readily adjust their strategies with respect to the ever-changing conditions, thus introducing an increased level of flexibility to our model. In this perspective, the sub-section IV.A describes the concepts underlying the determination of the RA's strategy, while subsection IV.B presents in a finer detail the Time-Related and Resource-Related families of functions modeling the effect of time limitations and resources availability to the agent's strategy, respectively.

A. Retailer Strategy Fundamentals

The RA, in the context of a specific negotiation process, may decide to propose a new offer (differentiated only with respect to the requested price) based on an estimation of the current environmental conditions. In our approach, this estimation comprises two factors. As already mentioned, the first factor considered is time deadlines and the second one is resource availability. The specific resource considered in this version of the problem engages the number of existing retailer's clients (currently being served by the RA) as well as an estimation of the number of potential future retailer's customers. This estimation is based on the number of users involved into a negotiation process with the RA and historical data gathered form previous experiences (i.e., number of agreements they failed to establish).

Time imposes a major constraint on the agent's behaviour. Although this is mainly true on the client's side, retailers may also face strict time deadlines. As an example we may consider a retailer that must have allocated the remaining service features, i.e., bandwidth, by the end of the day. Therefore, the Time-Related family of functions model the fact that the agent is likely to concede more rapidly (i.e., lower the price of the offered service) as the deadline approaches. The rate (shape of the curve) of concession is what differentiates functions is this set.

The Resource-Related family of functions model the pressure in reaching an agreement the number of clients (currently being served or even involved in a negotiation process) imposes upon the RA's behaviour. The lower the number of clients, the more urgent the need for an agreement to be reached. The functions in this set are similar to the time dependent functions except that they are dependent upon the quantity of resources available instead of the remaining time.

At this point it should be noted that the criteria presented above can be combined or one of them can be disregarded, without affecting the overall framework envisaged at this section. RA, for example, may use a weighted-linear combination of the Time-Related and Resource-Related families of functions, which in essence models their relative and even varying importance to the agent's decision. A more detailed experimentation with alternate (perhaps composite) criteria is left for a future version of this study.

B. Mathematical Description of the retailer strategy mechanisms

This subsection provides the formulas that realise the retailer strategy mechanism in the RA. The range of acceptable price values for retailer r regarding service s is denoted as $[\min_{price}(r,s), \max_{price}(r,s)]$. The upper limit $\max_{price}(r,s)$ is assumed to constitute the retailer's r initial pricing structure for service s, bearing the maximum profit, while the lower limit $\min_{price}(r,s)$ is in essence the retailer's r reservation value for service s below which loss may appear. Thus, the length of the interval, denoted as $c(r,s)$, characterise the concession margin of retailer r for service s and it may be defined by exploiting learning from experience techniques. Parameter $c(r,s)$ depends on each retailer's service provisioning cost and personal tactics. Therefore:

$$\max_{price}(r,s) = \min_{price}(r,s) + c(r,s)\,,\ \forall r \in R \qquad (6)$$

The retailer's r modified offer for service s, when considering environmental factor f, may be given by the following expression:

$$price(r,s,f) = \min_{price}(r,s) + (1 - l(r,f)) \cdot (\max_{price}(r,s) - \min_{price}(r,s)) \qquad (7)$$

Function $l(r,f)$ is dependent on the specific factor f considered, that is time t, or total number of clients (existing and potential) of retailer r, $|N_r|$. A wide range of functions may be defined simply by introducing different specifications of the $l(r,f)$ function. However, all functions should satisfy the following constraint:

$$0 \le l(r,f) \le 1 \qquad (8)$$

In case the factor f considered is time t, function $l(r,f)$ should be incremental, while the following constraints should also be satisfied:

$$l(r,t_{\min}) = 0 \qquad (9)$$

$$l(r,t_{\max}) = 1 \qquad (10)$$

Constraints (9) and (10) designate that the retailer r will suggest the initial offer $\max_{price}(r,s)$ bearing the maximum profit at the beginning of a negotiation process, progressively lower the requested price and offer the reservation value $\min_{price}(r,s)$, when the deadline is reached. In case the factor f is the number of clients of retailer r, $|N_r|$, function $l(r,f)$ should decrement, while constraints (9) and (10) are modified in the following way:

$$l(r,|N_r|_{\min}) = 1 \qquad (11)$$

$$l(r,|N_r|_{\max}) = 0 \qquad (12)$$

Constraints (11) and (12) designate that the retailer r will suggest the reservation value $\min_{price}(r,s)$ when the number of his clients is low and tend to give the maximum requested price $\max_{price}(r,s)$, when the number of his clients is big, in which case retailer r cares less about reaching an agreement with a specific user.

a) Formulation for the Time-Related Family of Functions

As already mentioned, a wide range of functions may be simply defined by altering the specification of the $l(r,t)$ function. We restrict our attention to two families of functions that satisfy the constraints presented in the previous section: *exponential* and *polynomial*. Other functions could be defined as well.

$$l(r,t) = e^{-a \cdot \left(1 - \frac{t}{t_{\max}}\right)^{\vartheta}}\,,\ 0 \le t \le t_{\max}\,,\ a > 1 \qquad (13)$$

$$l(r,t) = \left(\frac{t}{t_{\max}}\right)^{1/\vartheta}\,,\ 0 \le t \le t_{\max} \qquad (14)$$

Expressions (13) and (14) provide a formal model of the exponential and polynomial families of functions, respectively. These families of functions represent an infinite number of different retailer policies, one for each value of ϑ. Parameter ϑ has been included in order to highlight the different patterns of retailer's r behaviour with respect to the adopted rate of concession. For example, retailer r may adopt *Boulware policy* [26], according to which offers almost the same price ($\max_{price}(r,s)$), until the time deadline is reached, whereupon concedes to the reservation value ($\min_{price}(r,s)$). Otherwise, retailer r may exploit the *Conceder policy* [27], according to which proposes the reservation value $\min_{price}(r,s)$ in quite a short period time. Parameter a for experimentation reasons is taken equal to 3 and is introduced in order for the constraint (9) to be satisfied.

2) Formulation for the Resource-Related Family of Functions

Resource-Related family may be modelled in a similar manner to the *Time-Related* family but now function $l(r,|N_r|)$ depends solely on the number of retailer's r clients. The retailer r is expected to become progressively more reconciliatory (lower the price of the requested price), in case the number of users is getting smaller. Reservation value $\min_{price}$ will be proposed, if the number of potential users approaches nil. Expression (15) provides a formal model of function $l(r,|N_r|)$.

$$l(r,|N_r|) = e^{-|N_r|} \quad (15)$$

where $|N_r|$ represents the total number of retailer's r customers (existing and potential), at the time the negotiation process is instantiated.

It is noted that time may also be considered as a potential resource available to agents. Thus, we could model function $l(r,t)$ as a Resource-Related family of functions as follows:

$$l(r,t) = e^{-(t_{\max}-t)} \quad (16)$$

V. Results

The results of this section aim at discussing on the efficiency of the overall retailer selection scheme and on the designation of the retailer strategy mechanisms that could be adopted for the generation of new, more attractive price offers to the users in the context of a specific service request. The efficiency of the overall retailer selection scheme will be measured with respect to a random retailer selection scheme.

This section assumes the existence of an area that falls into the domains of R=10 candidate retailers. Users access the area in order to initiate a service usage. In the context of our experiments, it is assumed that users request a videoconference service. A simple and well-known service has been chosen in order to explain the proposed scheme. Nevertheless any other service could have been chosen instead. The videoconference service comprises two service features, namely audio and video. In the context of our study, four quality levels have been considered for these service features.

Regarding the different users that access the area, it is assumed that k=10 user classes exist. In the definition of these user classes we have also assumed that all users in these classes are interested for both service features. However, each user class is interested in different quality levels of these service features.

Concerning the implementation issues of our experiment, the whole TINA access session has been implemented in Java [28] in the context of [3]. The OrbixWeb CORBA compliant platform [29] was used for the inter-component communication. Moreover, the UA and the RA have been implemented as intelligent, mobile agents based on the use of the Voyager platform [30].

As previously mentioned, the first objective of our experiment is to provide indicative evidence of the overall retailer selection scheme, with respect to a random retailer selection scheme. The simulated annealing technique has been adopted for acquiring a solution to the problem of evaluating the quality of a retailer's offer. In general, from the results obtained it is observed that the best candidate retailer-selection scheme exhibits a better performance with respect to the random retailer selection scheme, which on the average is in the order of 20%. This decrease is due to the selection of the most suitable retailer taking into account the user preferences and the retailer policies.

The second objective of our experiment is to highlight the proposed retailer strategy mechanisms that assist retailers in the process of generation of new, more attractive offers to users, after considering potential environmental constraints and limitations. Fig.4 gives for comparison reasons the different patterns of the retailer's R_2 behaviour with respect to the adopted rate of concession when the time-limitations criterion is considered. An exponential, polynomial and a resource related function has been adopted for the calculation of parameter $l(r,t)$. Thus, for consecutive time instances, under the assumption that time instance $t_{\max}$ =20 constitutes retailer R_2 deadline and the initial pricing structure yields $\max_{price}$ =5, the updated offers are described. The retailer's offers based on the resource related model lie in between the offers created by adopting the exponential and polynomial model. Thus, we could say that this modeling leads to a less Boulware behaviour than when adopting the exponential related family of functions, but a more Boulware behaviour compared to polynomial related family of functions.

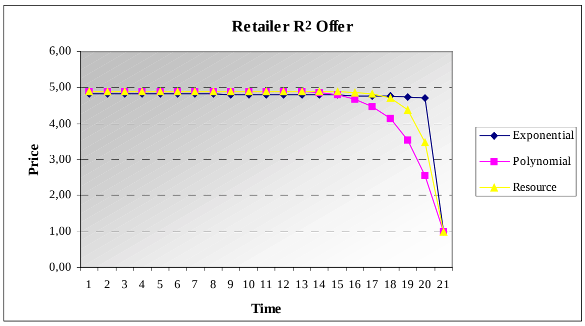

Figure 4. Different patterns of retailer R_2 behaviour when time limitations and resource availability criteria are considered.

VI. Conclusions

The highly competitive communications markets of the future should encompass mechanisms for enabling users to find and associate with the most appropriate retailers, i.e., those offering adequate quality services in a cost efficient manner. Additionally, retailers should be assisted in the process of generation of attractive offers to users. This paper presented such mechanisms. Our starting point was the definition of a business case, through which the role of the best candidate-retailer selection problem was explained. In the sequel, the problem of evaluating the quality of a retailer's offer was concisely defined, mathematically formulated and solved. In the sequel, the problem of generating attractive offers in an environment of limited resources was analysed. Specifically, the range of strategies a retailer may adopt under different circumstances in order to propose attractive offers to users was presented and mathematically formulated. At the final sections the paper results are provided and concluding remarks are made.

Directions for future work include, but are not limited to the following. First, the realisation of further wide scale trials, so as to experiment with the applicability of the framework presented herewith. Second, the experimentation with alternate approaches for evaluating the quality of the retailers' offers and the retailer strategies regarding the generation of new attractive offers. Third, the experimentation with approaches that combine the time limitation and the resource availability criteria.

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