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A Methodology for Comparing Service Policies Using a Trust Model

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The rapid growth of the Internet and associated technologies has created a new business environment. E-commerce can offer personalization, high quality customer service and improved supply chain management. The success of e-commerce strongly depends on building and maintaining *trusted* customer relationships. The retention of customers is extremely important to the longevity of an organization. Companies that do a better job of maintaining their customers generate superior financial results. The cost of acquiring a new customer is significant in most industries in terms of advertising, promotion, closing, and initial setup. E-consumer trust can reduce the perceived risk of an on-line transaction. This allows electronic consumers to consider a more manageable service providers based on their service behaviors. From the standpoint of a firm that is offering e-services online, increasing market-share depends heavily on the way it manages e-consumer trust. The present concern is to achieve competitive superiority for attracting and retaining the online customer community. Entrepreneurs are in need of a methodology to compare the performance of their policies that serve customers with widely differing risk attitudes. This thesis offers a methodology that permits comparison of service policies for managing a customer base and the available resources. This methodology relies on an experience based dynamic trust model**.**

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Keywords: multiagent systems; policies; E-commerce; Trust.

1. Introduction

The rapid growth of the Internet and associated technologies has created a new business environment. This has revolutionized online business transactions. Terms such as *digital economy*, *e-business,* and *e-commerce* are being used to characterize these developments (WTO, 2001). E-commerce is commerce which has been accelerated and enhanced by information technology. Enterprises are rapidly converting their conventional applications into web services. This expedites their internal as well as external operations. Services are applications, which run on distributed networks. The current trend is a transition to e-businesses. This enables service consumers as well as service providers to form new relationships. The growth in e-commerce has been enormous over the last few years. The present concern is to achieve competitive superiority for attracting and retaining the online customer community.

Riggins and Rhee defined e-commerce as “the sharing of business information, maintaining business relationships, and conducting business transactions by means of Internet-based technology” (Riggins & Rhee, 1998, p. 90). Alternately, it has been defined by Sullivan as “anything that enhances your relationships with an existing customer and increases the revenue you get from the customer” (Sullivan, 1998, p. 24). Customer relationships, their establishment and their maintenance form the central elements in both definitions. Consumer trust towards the service provider is the key construct to foster customer relationships.

Consumer trust is the major issue enabling e-commerce according to recent academic studies (Frederick, 2000; Gefen, 2000). E-commerce removes manual control systems and paper trails while increasing vulnerability in online transactions. Therefore, there is a significant need for greater cooperation and trust among participating organizations (Premkumar and Ramamurthy, 1995, Talwatte, 2000). From the standpoint of a firm that is offering e-services online, increasing market-share depends heavily on the way it manages e-consumer trust. Observing consumer service request behavior in online environments is an important factor for uncovering developments in electronic commerce. Since consumer concerns and perceived risks are particularly high in online purchasing the need for trust is considerably high in online purchases.

A consumer is besieged by a multitude of risks in electronic commerce such as financial, performance, social, psychological, and time/convenience loss (Murray, 1991). *Perceived Performance risk*, which focuses on quality of service has a significant influence on consumer attitudes and behavior. Therefore, higher levels of performance risk create greater uncertainty for consumers making a service request. Another factor influencing perceived risk is *lack of familiarity* with the service provider. Consumers perceive a service from a well known provider to have a low risk. However, the consumer perceived risk is well managed by shared history of interactions.

Since the intention of an e-business is to undertake business on the web, it will also need mechanisms that enable customers to access their services through the Internet. Web services (Cerami, 2002) are becoming a well-accepted way of putting e-business on the web as well as enabling users, either humans or other Web services, to use them. In the business world, web services represent the vehicle for distributed computing. Web services allow access to disparate computational resources. Broadly speaking, any object that can be invoked using Internet protocols qualifies as a web service. Alternately, web services are distributed services that are accessible via the web through Uniform Resource Locators (URLs). The World Wide Web Consortium (W3C), however, has a much narrower definition of web service. Web services (as per W3C) are described as distributed services that are identified by URL, while interfaces and binding can be defined, described, and discovered by XML artifacts, and that support direct XML message-based interactions with the other software applications via Internet based protocols .

A recurring issue in all electronic commerce research and one of the main impediments to growth of electronic commerce is the need for *quantification of customer trust* and *perceived consumer risk*. Designing appropriate e-commerce strategies and positioning of services in online environments is vital to maximizing sales. Therefore, the demand for best strategies and business models for online commerce is growing among many online firms. There is a need for a methodology for entrepreneurs to examine the relative performance of business policies for their service to operate on customers with different risk perception levels. This thesis focuses on such methodology that permits performance comparison of service policies operating on e-consumers. The objective of this methodology is to identify the policy options available to service providers, so that they can opt for the appropriate policy to retain or build their customer base. This methodology relies on a dynamic experience based trust model.

A multiagent system (MAS) is a network of software agents, evolved as an outcome of inability to solve complex problems by a single agent or restricted by the available resources. In multi-agent system, agents interact to solve problems that are beyond the individual capacities or knowledge of each problem solver and is achieved by the

distribution of computational resources across the network (Jennings and Woolridge, 1995) (Jennings, Sycara, and Woolridge, 1998). These agents carry out set of protocols of interaction so as to ensure that they can produce coherent computations despite changes in the underlying environment. Multiagent systems have a number of useful attributes, specifically that they offer decentralization of knowledge and computing power, help model complex components that behave adaptively, and potentially participate in complex interactions while maintaining coordination with other.

Multiagent systems are computational systems in which heterogeneous or homogenous collection of semi-autonomous agents work together to achieve some goals (Lesser, 1995). Due to the specific structural aspects in agent society, the agents were able to achieve their common goals. A multiagent system (MAS) is a composition of multiple self-directed agents exhibiting the following characteristics (Sycara, Decker, Pannu, Williamson and Zeng, 1996) (Sycara,1998):

- Without aid problem cannot be solved by an agent;
- No global system control;
- Information is distributed among the agents and;
- Asynchronous computation.

In business applications multiagent systems plays effective role as businesses deal with continuous input of vast and varying information, and maintenance of distributed databases over Intra and Internets (Chavez and Kasbah, 1996) (Carter, Ghorbani and Spencer, 2001). An agent is capable of representing various roles such as User Preference Agents, Information Broker Agents, Buyer Agents, and Seller Agents etc. Therefore agent technology is effectively used in online bidding, auctions, and search engines. Agent modeling in e-commerce is mainly based on the social awareness of an agent. Trust and negotiation are forms important part of social agents. Agents need to cooperate and organize their activities to achieve their individual goals as well as collective goals (Rahman and Hexmoor, 2004) (Beavers and Hexmoor, 2003).

ACORN (Agent-based Community Oriented Routing Network) is a distributed multi-agent architecture for the search, distribution and management of information in networks (Marsh, Ghorbani and Bhavsar, 2003). It is used in various applications such as search engines, B2B (business to business) and B2C (business to consumer) applications (Marsh and Masrour, 1997). In ACORN, each agent represents different piece of information, which includes where it is originated, owner and information about its community. Agents can learn and gather or alter the information it carries with it dynamically as it moves around the network as they are considered autonomous and socially aware.

Tim Berners-Lee, the inventor of World Wide Web, proposed Semantic Web. The idea of the Semantic Web is to identify more Web-based data and their interrelationships so that searches can be more effective by enabling more flexible and robust business processes. Web services are central to this vision. Agents further advance the vision, because they provide greater flexibility in how services are used and created. The Semantic Web will make the Web more accessible to agents by making use of semantic constructs, such as ontologies, so that agents can have understanding capabilities.

Agent architectures are very closely related to service-oriented architectures in many of their features. Agents advertise their functionalities with the help of yellow-page and white-page directories, so that the other agents can search and locate these agents to request their functionalities. However, agents extend Web services in several important ways.

Unlike agents, a service is only aware of itself, but it is not aware of its customers. On the other hand, agents are often self-aware at a higher level. Through interactions with other agents they learn and gain awareness of their capabilities. In order to take advantages of new capabilities in its environment, a web service should have this awareness so that it can customize and provide better service according to client requirements.

The rapid development of commerce on the World Wide Web has been accompanied by the creation of new business models and customer relationships involving the use of e-services. E-services are much like software agents in that they are characterized by autonomy, perception, and intelligence. Throughout the world of commerce, agents play an integral role, such as real estate agent, travel agent, or insurance agent. In the traditional world of business agents are viewed as individual with specialized knowledge and contacts who perform a service on behalf of a client. The agent delivers better service, the more it knows about client's preferences and objectives. A method in which e-commerce can evolve to incorporate more sophisticated business services is through the use of intelligent agents. Intelligent agents are defined as persistent, active, software components that perceive reason, act and communicate (Singh, 1994).

Find and *Retrieve* agents are the most common type of intelligent agents used particularly in Business-to-consumer (B2C) e-commerce. These agents are mobile and travel across the network in search of information requested on behalf of their consumer. Buyer agents and shopping bots are the examples of Find and Retrieve agents. They are very efficient at searching commodity products on the Web. The contribution of agents to e-commerce lies in their ability to add value to the process through improved consumer-provider mediation. They enhance information access, reduce transaction cost, and increase transaction speed. Many of the intelligent agents presently in use possess qualities of semi-autonomy, some are adaptive without sociability. To be truly beneficial within the e-commerce paradigm, these characteristics need to be further developed and exploited within the context of emerging business models.

Trust is important in the adoption of new technologies including the Web and e-commerce (Fukuyama, 1995) (Gefen, 2000). In general, trust is a vital aspect of commerce. This is due to the inherent uncertainty created by many commerce interactions depend on a service request (Fukuyama, 1995) (Luhmann, 1979) (Williamson, 1985). This uncertainty in service request may result in possibility of encountering opportunistic behavior by service providers not revealing all the appropriate risks (Williamson, 1985). The same scenario applies to e-commerce where electronic consumers need to depend upon often unknown service providers who may resort to opportunistic behavior (Frederick, 2000) (Gefen, 2000).

E-commerce strongly depends on building and maintaining trusted relationships. Winning consumer confidence plays important role in the success of any online business strategy. E-consumer trust can reduce the perceived risk of an on-line transaction. This allows electronic consumers to consider a more manageable service provider's based on their service behaviors. The e-consumer cannot be certain that the service provider will not engage in abusing the service requests, due to this reason, trust and the building of trust is an essential element of e-commerce (Frederick, 2000) (Gefen, 2000).

Service providers and e-customers are connected through series of business interactions. A customer seeks out a particular service-provider who can provide required service. Each time that customer repeatedly needs the same service, she habitually returns to the same provider. If the customer is not satisfied with the service provided and knows

of a competing provider, she may change providers in an attempt to get superior service. The provider in turns needs customers for its business and is motivated to deliver superior service in an attempt to gain new customers and to retain old ones. This is the essence of coherence connection between customer and service provider. When a customer and service provider initially interact, they anticipate future interactions, and their behavior reflects their anticipation. Thus, both parties are motivated to be courteous and polite and to confine their actions to role-appropriate behavior.

The provider-customer dyad evolves a shared history of interactions over time that both parties can rely upon their future interactions. The shared history of interactions that characterizes their mutual trust, allows both parties to accumulate information about each other. Much of the information they accumulate aids their subsequent transactions.

Frequent Service-Oriented interactions permit enduring and predictable expectations between provider and customer. A customer engaging in interactions with a service-provider gains trust and positive expectations from the provider. Individual customers who are satisfied with the service do contribute substantially to the service- provider's business. These consumers introduce new customers to the provider. This increases the provider's dependence on the customer.

From the customer perspective there exist inverse relationship between trust and perceived risk of an interaction with service provider. A business with a trusted service provider has a low perceived risk of abuse. In contrast, there is a high risk associated with distrusted providers. The trust values associated with e-customer represent the view of individual customers, subjectively based on their experience. They are not directly comparable across customers. Trust values of consumers are associated with a measure of confidence towards service-providers. A customer confidence improves with the increased interactions service provider. With out prior experience, trust takes an initial value according to customer's disposition. Customers might be predominantly *risk seeking* or *risk averse*. Risk seeking customers assign a high initial trust value to service providers i.e., implying low perceived risk, risk averse customers assign low trust values. This disposition affects how trust is updated on subsequent interactions (Marsh, 1994).

Typically trust among service-providers and e-customers improves with gradual interactions (Slovic, 1997). Fulfilling the customer request successfully by the service provider is stated as *honoring trust* and the opposite is *abusing trust.* Single interaction is not sufficient to establish trust because provider may employ *abusing trust* for a short lived incentive. This leads to a non-cooperative equilibrium state. The emergence of *honoring trust* could result in multiple successful interactions. Typically this behavior evolves when a service provider perceives the benefits from future interactions with customer. In repeated interactions among consumer and service provider, the customer adjusts expectations towards provider based on its past interactions. Customarily, in the onset of interactions, consumer begins with prior beliefs about the trustworthiness of the service provider. With the increased frequency of interactions, beliefs are adjusted. After a episode of positive interactions, the consumer's trust in service provider will gradually increase. A low estimate of trustworthiness of the provider will result from multiple unsuccessful interactions in which *abusing trust* is employed. This behavior leads the consumer no longer wishes to interact with service provider. In this case the customer stop interacting with service provider.

2. Methodology

We offer a methodology to compare various service policies intended for an online service with an underlying trust model. The main objective of this methodology is to explore and to understand underlying scheme for attraction and retention of a diverse consumer community. A few simple service policies are exemplified and are compared using our experience-based model of trust.

In an experience-based trust model, a group of customer agents with different risk attitudes are initialized with random trust values. The trust value of a consumer agent is a real number in the interval 0.0 and 1.0. The values approaching 0.0 represent complete distrust and those approaching 1.0 represent complete blind trust. The consumer agents interact with services when the threshold trust value of a customer is less than or equal to the perceived trust value of a service agent. Initially the threshold trust value for each service is initialized to 0.5. Respectively, the threshold decreases or increases with service honoring or abusing the customer request. The abuse or honor of a customer request by the service is either prescribed or proscribed by the underlying service policy. For example, if the policy of a particular service is *First Come First Serve* (FCFS) then the service will honor all the requests of the customers until the resources are depleted. Once the service is out of resources it will start abusing any further requests from any customer. If a service abuses the customer request in a sequence for several times, then its threshold crosses its perceived trust towards that service. This results in service rejection by the customer, until trust levels are re-established.

The customer-service described is finitely repeated and the performance of each service policy is observed. The performance of a policy is a measure of customer retention. The relative performance of each policy is discussed within the context of scarcity of resources. This paper introduces a multiagent system and trust-based service policy comparison methodology. The trust-based approach towards service comparison is simulated and the results from the simulations are analyzed and subsequent discussions and conclusions are presented.

The trust model in this paper is largely inspired by Gambetta's theoretical work and follows the abstract results obtained from (Braynov, 2005). We assume the trust value of an agent to be a real number in the interval between 0.0 and 1.0. The numbers merely represent comparative values, and have no strong semantic meaning by themselves. 0.0 represents complete distrust, and 1.0 represents complete blind trust. There is an inverse relationship between trust and perceived risk of an interaction. Cooperating with a trusted agent has a low perceived risk of failure, while there is a high risk associated with distrusted agents. Trust values represent the view of an individual agent, subjectively based on its experience, and are not directly comparable across agents.

Agent trust values are associated with a measure of confidence. With improvement in an agent's experience, its confidence increases. With no prior experience, the initial trust value of an agent is based on its disposition to be *risk seeking* or *risk averse*. Risk seeking agents ascribe a high initial trust value to others, implying they experience low perceived risk in general. On the other hand, risk averse agents ascribe low trust values.

It is assumed that the roles of consumer and service provider in our model are synonymous to trustor and trustee in the Braynov model (see Section 2.6.3). Customer group with different risk attitudes interact with different services. The risk attitude of a customer is determined by the L and G values that are initially assigned. The G value represents the customer's perception of gain when a service request is honored by the service. Similarly, the L value represents the customer's perception of loss when its

service request is abused by the service. Initially, L and G values are assigned randomly to all the customer agents and L/ (L+G) represents the trust threshold of a customer. A customer is a risk seeker if its trust threshold is less than or equal to 0.5 and is risk averse when its trust threshold is greater than 0.5. The trust threshold of a customer is the risk attitude towards its operating environment rather than to any specific service. Therefore, the trust threshold of a customer is a global parameter that varies with every service interaction. The variation of the threshold strictly depends on the service behavior. If a service honors the customer request, then its threshold tends to decrease implying that the customer tend to be more risk seeking than previously and vice versa.

Every customer will have a preconceived trust estimate of a service with which it wants to interact. This trust estimate is termed as *perceived trustworthiness* of a service. A customer estimates this trust value based on her previous experience with the service. From Braynov's model discussed in Section 2.6.3, when a service honors 'h' times out of 'n' interactions with a customer, then the perceived trustworthiness of the service is estimated as (h+1)/(n+2). Initially, when a customer interacts with a new service with no prior experience, the number of honors and interactions are null. Therefore the default perceived trustworthiness towards any new service is 0.5.

A customer interacts and places a request with a service when its trust threshold falls below the perceived trustworthiness of a service. A service is governed by a service policy, a scheme to manage the available resources and the customer requests. Therefore, a service's ability to satisfy the customer request is strictly dependent on the underlying service policy. A service satisfying or honoring a customer request results in an increase of its perceived trustworthiness for that customer and also lowers the trust threshold of a customer. This behavior motivates the customer to interact with the service in the future. On the contrary, if a service does not satisfy or abuses the customer request, then the perceived trustworthiness of the service decreases for that customer and increases the trust threshold of that customer. If a service does not satisfy the customer request for several times in a series, then the trustworthiness of a service declines gradually and eventually falls below the trust threshold of the customer. This situation leads to service rejection by the customer implying that the customer is not willing to interact with the service in the future.

When a customer rejects a service, it is not necessarily the case that the service is rejected forever. There is a possibility that the customer will initiate interaction with the service in the future when its threshold changes after a certain period of time. Since the customer trust threshold represents its risk attitude towards the environment, it fluctuates with each service behavior and is not completely tied to a single service. It may decline due to some service but at the same time, it can improve due to some other service.

The customer service interactions are repeated for a predefined times and the relative performances of each service is observed. In a particular business scenario, the success of a service in managing customers strongly depends on the underlying service policy. Fig 1 gives the general idea of the Trust-based service model. From the Fig 1 service handles the customer requests by consuming available resources. The policy keeps track of resources and acts as a decision support system to service in handling customer requests. Related terminology and mathematical formulations of service model are further discussed in Terminology section.

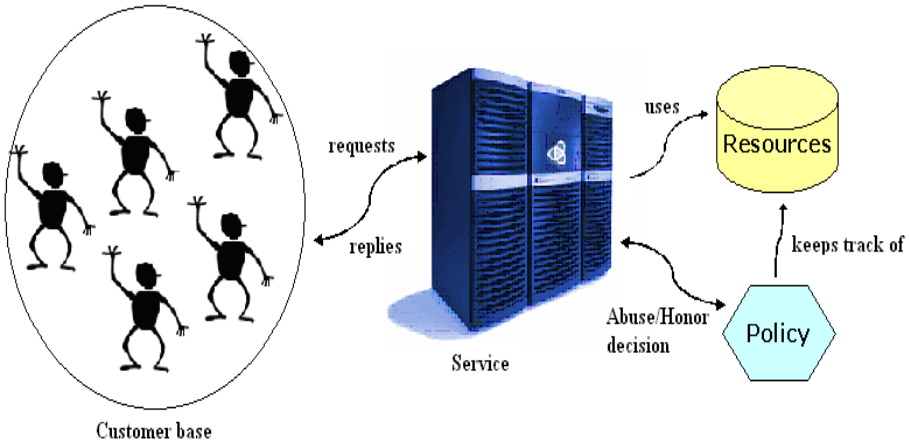

Fig. 1. Trust-based service model architecture

An *opportunity* is the event associated with interfacing an agent with a service. In simulation we will call opportunity *interchangeably* with *Cycle*. In a cycle all the customers will have chance to interact with all available services.

$$|\text{Opportunities}| = \text{Total number of customer agents} * \text{Total number of services}$$

Resource scarcity provides the measure of the maximum available resources per cycle. It is equal for every service and constant throughout our simulation.

$$\text{Maximum available resources} = \text{Total estimated customer's requests} * (1 - \%\ \text{Resource scarcity})$$

Service health is a parameter which quantifies performance of a service. The performance of a service closely depends on the nature of the underlying policy governing the service. After every cycle, every service is allotted available resources according to its health. A service with superior health is allotted relatively higher resources.
Service health is measured by the ratio of number of successful customer interactions with a service over the sum of successful interactions and rejections of a service by in that cycle.

$$\text{Service Health} = \frac{\text{(Successful interactions with customers per cycle)}}{\text{(Successful interactions + Rejections by customer per cycle)}}$$

$$\text{Resources allocated for a service per cycle} = \text{Service health} * \text{Maximum available resources}$$

A Training phase is an initial series of interactions during which services are given adequate resources without regard to *service health*. Although policies are enforced, resources are abundant.

Generally, our methodology aids in comparing various service policies, which govern available resources to retain the customers. Initially, resources available for a service are less than or equal to the customer requests. Resources are renewed after every opportunity in the simulation. The basis for allocation of resources after every cycle is *service health.*

Rejection Count is defined as the total number of rejections a service receives per cycle. A rejection is when a customer refuses to interact with a service. A customer will reject a service when the perceived trustworthiness of that service is smaller than the customer's trust threshold.

Customer retention percentage provides the measure of total number of customers retained for a service after every cycle.

$$\left.\begin{array}{l}\text{Customer retention} \\ \text{percentage}\end{array}\right\} = (\text{Total customer interactions per cycle}) * 100 / (\text{Total Customers per cycle})$$

The high level algorithm for simulation of service model discussed earlier is shown in Fig 2.

1. Initialize all customer agents risk attitudes randomly.
2. Assign the resource scarcity for services.
3. Assign the service policies for each service.
4. Perform training phase for customer-service interaction.
5. Initiate the normal customer service interaction process.
6. Assign resources to each according to their performance.
7. Compute the performance of each service.
8. Repeat steps 5 to 7 for predefined time period.
9. Note the overall performance of each service

Fig. 2. High level algorithm for simulation

Four hypothetical service policies are introduced for the purpose of simulation. These service policies are broadly classified into Resource-centric Policies and Customer-centric Policies. They are further discussed in the following sections.

2.1 Resource-centric Policies

These policies do not differentiate among customers based on any of their attributes, but rather focus strictly upon resource management. For example FCFS, Random and 50% honor policies are resource-centric. The following sections contain the detailed descriptions of these policies.

When all customer requests for the service are honored on a *First Come First Serve* basis (shown in Fig 3), preference is arbitrarily given to those customers who interact earliest with the service. Once resources are depleted, any further service requests will be abused. Hence this policy is resource-centric and does not differentiate customers by any specific criteria. FCFS is the default behavior of all the other policies when their behavior might otherwise be undefined.

```
If (resources > 0)
  Honor the customer request
else
  Abuse the customer request.
```

Fig. 3. Pseudo-code for FCFS policy

In Random policy (Fig 4), all customer service requests are honored or abused randomly until the available resources are exhausted. Once resources are depleted, any further service requests will necessarily be abused.

```
If (resources > 0)
  Randomly honor or abuse the customer request
Else
  Abuse Customer request
```

Fig. 4. Pseudo-code for Random policy

At any given time, with 50% honor policy (Fig 5), it satisfies only 50% of customer requests upon availability of resources. Any further requests on depletion of resources will be abused. Basically this policy focuses on the future needs of the service by preserving some resources on every cycle.

```
If (resources > 0)
  Honor customer request 50%
else
  Abuse customer request
```

Fig. 5. Pseudo-code for 50% honor policy

2.2 Customer-centric Policies

Customer-centric policies focus on a service's history of interactions with specific customers. Preference is given to those customers who best satisfy the criteria of a particular policy. Preferred customers are more likely to be honored, whereas less preferred customers conversely will more likely be abused. *old customer preference Policy* (Fig 6) and *New Customer Preference Policy* (Fig 7) are customer-centric. *Old Customer Preference* policy gives more preference to those customers with the longest standing patronage. Basically, the strategy of this policy is to retain old customers by giving more preference to them. Initially, customers with a larger number of service requests during the training cycles are considered as customers with long standing history. Other customers with fewer service requests are treated accordingly with one of the *resource-centric* policies.

```
If(resources >0)
      If (customer request with long standing history)
           Honor the request
     else
           Honor the request with resource centric policy
else
   Abuse customer request
```

Fig. 6. Pseudo-code for Old Customer Preference Policy

New Customer Preference Policy gives more preference to the new customers in contrast to customers with long standing patronage. The main strategy of this policy is to attract new customers by giving more focus to them. Initially, customers with fewer service requests during the training cycles are given more preference. Other customers with long standing history are treated accordingly with one the resource-centric policies.

```
If(resources >0)
      If (New customer request)
           Honor the request
     else
           Honor the request with resource centric policy
else
   Abuse customer request
```

Fig. 7. Pseudo-code for New Customer Preference Policy

3. Conclusion

The methodology provided in this paper can be used by entrepreneurs to gauge the relative performance of different policies managing their business customers. Observing the results from our implemented experiments indicate that customer-centric policies are more successful when compared to resource-centric policies in retaining a customer base with 30% or less resource scarcity. At high levels of resource scarcity (like 90%), customer-centric policies are less effective when compared to resource-centric policies. This work is limited to direct experience among electronic customers and services. Several training sessions were conducted to adjust the initial beliefs of the customers with the services. Initial beliefs about the services can be acquired, if the *reputation* of each service is available. Incorporating the notion of service *reputation* would be an interesting addition to the current model. With this addition, all the customers have the opportunity to communicate among themselves about the service attributes. This leads to a hybrid trust model incorporating both experience-based trust as well as reputation based trust.

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