# Coupon Based Incentive Systems and the Implications of Equilibrium Theory

Anargyros Garyfalos
Intelligent Systems Lab - BT Exact
British Telecommunications Plc
Ipswich IP5 3RE, UK
anargyros.garyfalos@bt.com

Kevin C. Almeroth
Department of Computer Science
University of California
Santa Barbara, CA, 93106-5110
almeroth@cs.ucsb.edu

## Abstract

*"Coupons" is an incentive scheme that gives users credit for forwarding information to other users over wireless, potentially ad hoc networks. Having previously performed an initial evaluation of the main characteristics, this paper first examines how this idea works in more complex, hybrid networks and then focuses on the effects of user behavior on system performance. By considering implications of game theory concepts, such as Evolutionary Stable Strategies, particular emphasis is given on how we can reasonably constrain behavior to a range of values, all of which result in good system performance. Results show that by developing and validating effective incentive systems, we can greatly improve the ability to efficiently disseminate information to users throughout the evolving Internet.*

## 1. Introduction

The Internet is moving from a wired-only infrastructure to a combined wired and wireless hybrid architecture. Operation at the fringes of the network is provided with much of the last mile being mobile and sometimes using ad hoc networking technology [3]. Connectivity to the Internet is therefore possible even when not in range of a wireless access point as data is relayed through other users who are themselves connected. However, the use of this ad hoc model in a commercial arena raises a number of issues since most nodes will not want to participate in such a scheme unless there is appropriate compensation. This issue has a significant impact on how existing Internet applications are ported to ad hoc networks and on how new applications should be designed.

The goal of this paper, therefore, is to investigate applications and services that are uniquely suited to hybrid environments. Even though existing applications are rarely designed to take advantage of the specific intricacies of such models, there has been little effort to adapt these applications. Our coupon scheme is specifically tailored to provide information dissemination in hybrid networks by incentivizing users to cooperate and exchange information. Cooperation is stimulated by adopting a basic pyramid scheme where users are awarded credits as they pass a received piece of information (or a *coupon*) to other people. Using a simple flooding mechanism, as one user forwards the coupon to another, a pyramid is built with the users residing at the top receiving more benefit than those at the bottom. The information exchanged is called a "coupon" because one application is the dissemination of a real coupon that can be used. When a coupon is used in the store, all users who participated in the forwarding of the coupon are given some kind of a credit.

This paper builds on our previous evaluation of coupons[4] by investigating the role of users. Having performed an initial assessment of the scheme's general characteristics, we found that each user's behavior is an important determinant of performance. The way nodes move, how often they broadcast a coupon, and whether they rebroadcast the coupon at all have a direct impact on whether effective information distribution is achieved and whether there is a heavy load of redundant transmissions. It is therefore essential to understand to what degree and under what circumstances node behavior affects performance.

The contribution of this paper is therefore twofold. First, we significantly extend our simulation capabilities by looking at a hybrid infrastructure where nodes are organized into and move within *clusters*. A cluster could be an urban area or even a small town thus giving us the opportunity to observe the spreading of coupons over a larger area. Second, we develop an understanding of how user behavior affects performance and how system operation and efficiency can be made to be robust even under widely varying, but still logical, user behavior. Our results show that we have developed a simple and elegant solution to the problems associated with network flooding. This is achieved through the implications of game theory equilibrium concepts such as *Evolutionary Stable Strategies* (ESS) [11]. Simply by selecting a reasonable behavior, users themselves can achieve the desired tradeoff between scalable data dissemination and network efficiency.

The remainder of this paper is organized as follows. Section 2 presents our coupon scheme in more detail and explains our motivation. Section 3 gives an overview of existing work and Section 4 offers a discussion of the metrics and parameters that we use to measure the effectiveness of our scheme. Section 5 presents a representative set of simulation results, while Section 6 investigates the implications of ESS. The paper is concluded in Section 7.

## 2. System Description and Motivation

The aim of our coupon scheme is to distribute information to as many users as possible and as efficiently as possible. Since we consider a hybrid network, consisting of a combination of wired and wireless/ad hoc nodes, there are two main challenges. First, the constantly changing network topology complicates the development of an efficient plan for wide-scale information distribution. Second, nodes need to be encouraged through some sort of incentive to relay the information of others.

The basic concept behind our coupon scheme is to distribute a given piece of information through an ad hoc network using a controlled broadcast. Nodes are encouraged to control the broadcast and to relay the coupon to other nodes using a specified incentive. The incentive we propose is based on an ordered list of unique IDs appended to the end of the message. The idea is that once the information/coupon is eventually used, users contained in the ordered list receive some sort of benefit. The benefit can be uniform for all users on the list or can be variable, e.g. the higher a user is on the list the more the value.

The key application scenario we envision is a true coupon where the information distributor is a store trying to advertise its products. A common mechanism for doing this is through discounts for merchandise. Normally users would have little incentive to relay this kind of information, but if they could attach their ID to the coupon and receive benefit if someone used the coupon with their ID in the list, it would create an incentive. Figure 1 shows a typical scenario with a store that is interested in advertising a coupon. The different clusters of houses may refer to adjacent urban areas or even small towns. The store will periodically broadcast the coupon and all nodes within the broadcast range will receive it. Some may decide to keep it and others to discard it. Some nodes may then also decide to re-broadcast it. Assuming user A is among those that keep the coupon and want to re-broadcast it, user A will start forwarding the coupon through periodic retransmissions. Then, as user A moves to the neighbor cluster, the coupon is forwarded to the local users who come into contact with A, such as user B. In the same manner user B may decide to forward the coupon to other users in the same cluster and possibly other users in other clusters depending on where user B moves. If a user chooses to use a coupon, points will be awarded to all users listed in the ID list. For example if user B goes to the store, user A could get a 10% discount for up to the value of what B spent.

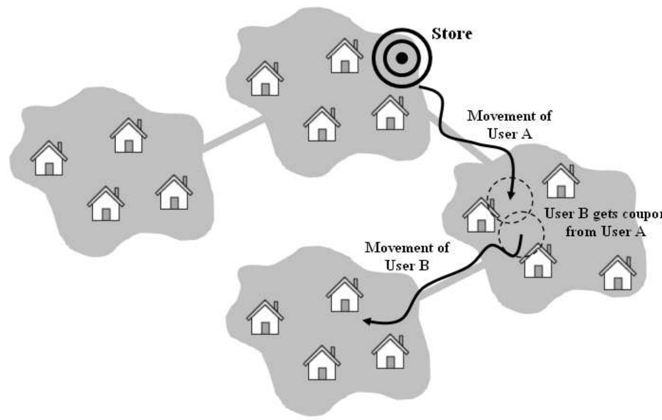


**Figure 1. Coupon operation.**

The motivation for developing our coupon scheme is that it solves the key problem of *efficient* wide-scale information dissemination. Although basic flooding schemes offer simplicity and high effectiveness in terms of spreading the information to a wide range of participants, there are three main concerns: incentives, security, and efficiency. First, there is little incentive for nodes in ad hoc networks to forward information. Second, security in ad hoc networks is still an open area of research[13, 14]. For our coupon scheme, we have developed a simple but effective security mechanism [4]. Third, in terms of efficiency, simple flooding is usually associated with the *broadcast storm* problem[8]. Broadcast storms cause three problems: a high rate of redundant messages, an increased probability of collisions, and increased congestion. This paper shows how our coupon scheme controls this problem by giving users an incentive to adopt a more reserved transmitting behavior.

## 3. Related Work

There are three dimensions behind the concept of coupons and therefore three related research areas. First is the notion of providing an incentive in order to stimulate user collaboration. Second is work related to the performance of epidemic protocols. And third is the literature describing the idea of coupons.

Providing incentives to users has recently attracted much attention both for ad-hoc and peer-to-peer networks [9, 13, 1, 7, 5]. While our coupon scheme should be regarded as complementary to this area, there are two main differences. First, coupons target more lightweight applications with a focus on minimizing complexity. Second, coupons have a vision to provide an incentive that not only enforces collaboration, but more importantly encourages nodes to not overload the network. This vision is also shared by Terminodes [2], where stimulation of collaborative packet forwarding in ad-hoc networks is achieved by using a virtual currency implemented in the form of a simple counter mechanism. Although our coupon scheme is different in the sense that it targets more lightweight applications, there is a common belief that given the appropriate motivation, technical boundaries of wide-scale operation can be overcome by the users themselves.

The simplicity of our scheme comes largely from the adoption of a simple, but controlled, flooding protocol. As a result, we need to examine the implications of the broadcasting problem. Related work in this is focused on *efficient flooding*; mechanisms that aim to control the number of unnecessary retransmissions by having each node make a decision on whether a message should be retransmitted or not. This decision can be based on a number of different heuristics, for example, a randomly chosen probability of retransmitting only when the number of received duplicate packets is below a certain threshold[8]. Although such schemes have been shown to perform more efficiently than simple flooding, they impose certain deployment requirements. In addition a heuristic works only if there is an incentive for users to participate, and equally importantly, if all users are aware of the type of heuristic and its value. The remainder of this paper shows that coupons not only avoid these concerns, as they assume uncoordinated deployment, but at the same time achieve similar levels of performance.

Finally, the idea of coupons has been mentioned in two places. Both iCLouds[6] and eNcentive[10] propose a similar coupon scheme with a coupon being an ID list where nodes append their unique signatures. The authors of both papers give good motivation for using coupons and they present a middleware architecture to enable this facility. However, although the basic concept is similar, the focus is not on the network aspects of disseminating coupons. This gap was initially filled by our previous work [4] which indicated that coupons can be an elegant solution to the problems associated with information dissemination in an ad hoc network. However these initial results did not look at hybrid networks, and did not try to achieve a balance between the time to receive a coupon and the network load.

## 4. Simulation Environment

The goal of our simulations is to evaluate specific metrics and examine how well our coupon scheme works under different circumstances. We are mainly interested in investigating the behavior of the system when nodes are organized into clusters; when nodes move at different speeds; and when varying user behavior profiles are used. Before explaining the results, we first describe our simulation environment.

We have performed our simulations using the GloMoSim simulator[12]. Our coupon scheme was implemented on top of a simple flooding protocol where nodes periodically broadcast a coupon to their surrounding neighbors. Initially the coupon is transmitted by a single stationary node that takes the role of the "store". Our simulation parameters are described below and summarized in Table 1:

**Number of nodes**: number of nodes in the network.

**Number of clusters**: the number of areas/clusters within which nodes can move.

**Cluster layout**: the way clusters are linked.

**Mobility model**: the way nodes move inside each cluster and the probability of moving to a neighboring cluster.

**Node speed**: nodes were modeled to be moving at pedestrian, standing, or vehicular speeds.

**Node degree**: we use node degree as an abstraction to represent node density. Since sparse ad hoc networks have significantly different characteristics than dense networks, we need to simulate both. Node degree is determined by a combination of three parameters: number of nodes, cluster size, and radio range.

**Coupon levels**: the maximum number of ID signatures each coupon can carry. We assume that a node will broadcast a received coupon only if there is at least one free slot in the ID list. Otherwise there is no incentive to re-distribute the information since there is no potential gain.

**Duration**: length of the simulation.

**Broadcasting delay**: the rate at which the participating nodes broadcast the coupon. This is measured as the number of seconds between each transmission.

**User behavior**: the way that users behave when receiving a coupon. Users might only cache the coupon for themselves or might also start re-broadcasting it with different patterns. Behavior depends on a number of factors, only some of which are quantitative. For example, behavior might depend on remaining battery power but might also depend on user "mood" or greediness. A description of the profiles and their affect on system performance are described in Section 6.

Based on this setup we performed our simulations according to the following two metrics:

**Application efficiency**: measured by both the percentage of nodes that get the coupon and the average time it takes for nodes to first receive the coupon.

**Network efficiency**: measured by both the total number of transmissions and the average number of times a node gets the same coupon.

| Parameter | Value Range | Nominal Value |
|---|---|---|
| Number of nodes | 400 | 400 |
| Number of clusters | 9 | 9 |
| Cluster layout | Ring, Chain, Mesh, Star | Mesh |
| Mobility model | RandomWaypoit | RandomWaypoint |
| Node speed | 70% Pedestrian (1 m/sec) 15% Standing (0 m/sec) 15% Vehicular (8 m/sec) | |
| Node Degree | 0.05…6 | 0.05…6 |
| Coupon levels | 5 | 5 |
| Duration | 7200 sec | 7200 sec |
| Broadcasting delay | 5 sec…40 sec | 40 sec |
| User behavior | Max User, Smart-Prob, Smart-Passive, Not-Interested | Max User, Smart-Prob |

**Table 1. Simulation parameters.**

The remainder of this paper presents our simulation results. Results are divided into two sections. The first is a representative set looking at general system behavior, and the second examines how to achieve desired performance tradeoffs based on the concept of Evolutionary Stable Strategies.

## 5. Representative Set of Results

This section gives a representative set of our simulation results through which we hope to achieve three goals. First, we want to understand the effect of nodes moving in and between clusters. For this reason we have used a range of cluster topologies (star, ring, chain and mesh). Second we want to analyze how the previous results are affected by varying the percentage of nodes that are actually willing to participate to the scheme. Finally we want to examine whether different transmission rates affect network costs and application efficiency.

Our first set of experiments show that the introduction of clusters brings little differentiation to the results presented in [4]. A high node degree implies faster coupon spreading but with the penalty of increased network load. The only difference with clusters is that it takes additional time for the coupon to transition across cluster boundaries. Because it then takes longer for nodes to first receive the coupon, fewer nodes are broadcasting the coupon and so there are fewer total broadcasts. As we regard these results to be intuitive, graphs are not included.

We then varied the percentage of nodes that were willing to retransmit the coupon. The goal is to test the ability of the system to spread the coupon even when not all nodes participate. Figure 2 shows the average time to first receive the coupon and Figure 3 shows the total number of transmissions. As the x-axis indicates the node degree, we measure the results for four different participation levels, ranging from 25% to 100%.

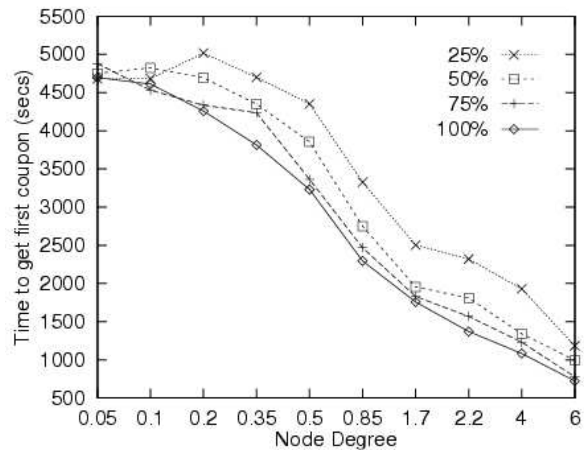


**Figure 2. Application efficiency under varying participation rates.**

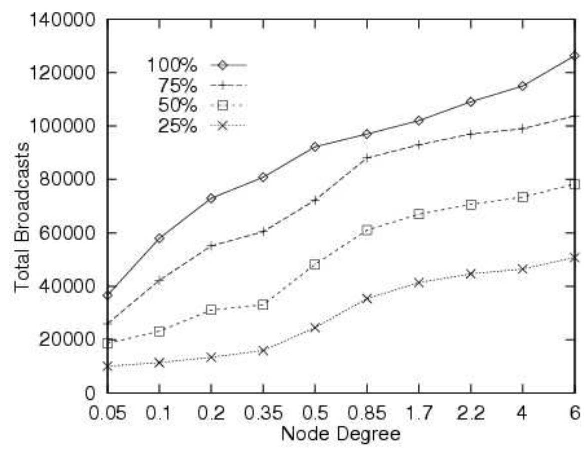


**Figure 3. Network load under varying participation rates.**

As expected, the results show that the participation rate affects the time to receive a coupon and the network load. There are two important observations that can be made. First, network costs are reduced to a greater degree than the increase in time to first receive the coupon. For example, when the node degree is 0.35, with only 25% of nodes participating, the coupon is distributed with a delay only 18% greater than if all nodes are participating. At the same time, total transmissions are reduced by more than 80%. This highlights the power of epidemic protocols since satisfactory information spreading can be achieved even with a small number of participating nodes. In fact, having all nodes participate typically means that all nodes get the coupon quickly but at very high overhead and a large number of redundant transmissions.

Our second observation is related to the time to receive a coupon. Given the kinds of applications we discuss, near instantaneous delivery is not needed as a coupon lifetime should be valid for several hours or even days. Our results show that at worst, even with low participation and only a few widely scattered nodes, the average time to receive the coupon is about 1.5 minutes. In fact, it might be reasonable to have even longer delays and even fewer network transmissions.

In the final set of experiments we observed the overall behavior when different transmission rates were used. Until now we had performed our tests under the assumption that nodes would transmit a coupon with a rate of once every 10 seconds. By varying the pause interval from 5 to 40 seconds, our results demonstrated once more the flexibility of coupons. Even when the nodes transmit once every 40 seconds, the effect on the spreading delay is minimal. However, there is a significant effect on the total number of broadcasts as a considerable saving of up to 70% can be achieved. Again, graphs for these results are not shown.

The last point is of particular importance since it exposes a key problem with epidemic networks: there is little control over how quickly the coupon spreads and how many network resources are used. If all nodes choose to participate and broadcast the coupon frequently, a large network load will be created, most of which will be useless. On the other hand, certain levels of participation and broadcast frequency have to be maintained in order to ensure efficient information spreading. The problem of finding the desired tradeoff is solved with our coupons scheme by taking advantage of user behavior. Users are rational and configure their broadcasting rate based on their best interest. Even assuming an environment where each user can choose his or her own behavior, equilibrium theory shows that the collective behavior will effectively result in the proper balance between time to spread a coupon and network load. In the next section we show how this balance can be achieved.

## 6. Implications of Equilibrium Theory

In the previous section we saw that a key metric to the performance of our coupon scheme is how often users transmit. As the frequency of transmissions leads to a tradeoff between distribution speed and resource consumption, the ultimate goal would be to find a balance between the two. This section investigates a mechanism to achieve this balance by considering game theory concepts.

The desired tradeoff could be enforced through a number of high-overhead solutions (e.g. histories of coupons broadcast), but we believe that we would lose the simplicity and elegance of the basic coupon idea. Therefore, we argue that a performance balance can be achieved simply by leveraging the innate behavior of the users themselves. Users will come to learn that it is in their best interest to act in a certain way. It is through this collective behavior and the implications of the Evolutionary Stable Strategies (ESS)[11] that a desired tradeoff is reached and maintained.

In order to demonstrate how these concepts apply to coupons, we must first identify a set of user profiles and evaluate their impact on the system. We then refer to the concept of ESS and how it can be applied.

### 6.1. User Profiles In Coupons

The previous section indicated that it is desirable that nodes control their behavior by broadcasting periodically. We would now like to extend our investigation by considering a more dynamic set of profiles. As behavior depends on a number of factors, only some of which are quantitative, we have considered a combination of the concern for the battery power remaining and the user "mood" or greediness. The profiles we used are described below:

**Max User**. This role corresponds to a user who either has no reservations concerning his power consumption or simply behaves as aggressively as possible. In simulation terms, once a node gets a coupon, it broadcasts it on a frequent time interval (if there is at least one free level in the ID list).

**Smart-Prob**. A "Smart" user has a more controlled behavior. "Smart-Prob" is one example and is implemented with a probability function to decide whether a coupon is broadcast or not. This works by taking into consideration the number of free levels in the coupon and the time elapsed since the coupon was first broadcast by the original source. These two metrics attempt to capture the essence of the user's incentive to redistribute the coupon (more free levels imply higher incentive) and the concern for battery consumption.

**Smart-Passive**. Another variation of the "Smart" profile is for a node to broadcast in a *passive* fashion. A "Smart-Passive" node distributes a coupon only if it has not recently heard the coupon being transmitted by a neighbor. The motive for this model is to preserve resources and only distribute a coupon when not directly competing with others. We have implemented this profile by recording when the coupon was last received. A broadcast takes place only after not hearing the same coupon broadcast in the last 30 seconds.

**Not Interested**. This role corresponds to a user who is not interested in participating in the scheme at all. In simulation terms this implies that a received coupon is never retransmitted.

By considering each of these profiles, we run experiments to test their impact on the system. Figures 4 and 5 show a representative set of results. Simulations use a mesh cluster topology with an intra-cluster node degree of 2.2. All nodes in each simulation use the same behavior profile. The x-axis indicates the transmission delay for the nodes. For example, a value of 10 implies that "Max User" nodes broadcast steadily every 10 seconds. "Smart-Prob" do the same unless a broadcast is skipped because of the probability function, and "Smart-Passive" nodes broadcast every 10 seconds unless they recorded having received the coupon in the last 30 seconds. As before, Figure 4 shows the time to receive the coupon and Figure 5 the number of total broadcasts.

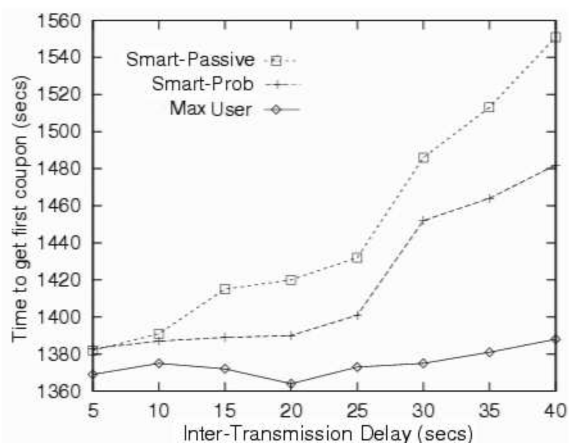


**Figure 4. Application efficiency with various user profiles.**

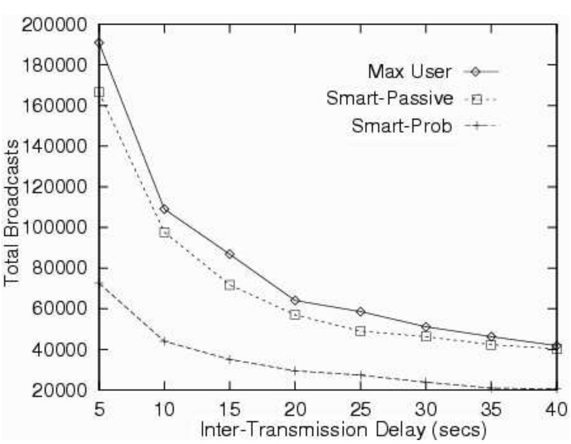


**Figure 5. Network load with various user profiles.**

Overall we notice that each profile gives different results. For example "Smart-Prob" has a clear savings advantage in terms of total number of broadcasts. However, we also notice that unlike "Max User" nodes, which hardly suffer any application performance penalty, the time to receive a coupon for the "smart" profiles is more dependent on the transmission rate. For transmission rates beyond 30 seconds the delay in receiving the coupon rapidly increases. Different profiles have different impact in achieving the desired tradeoff between the time to spread the coupon and the network load.

One issue in establishing what the desired tradeoff should be is the varying requirements of the application. For example, a "Smart-Prob" profile with a broadcast delay of 20 seconds should be used when the freshness of the coupon is relatively important. A delay of 40 seconds and beyond would be preferable when the primary concern is the reduction of network load. We assume a more general scenario where the ideal results would be given if all users would adopt a "Smart-Prob" profile with a delay of approximately 20 seconds. The challenge now is to see whether the majority of users could be encouraged to adopt this profile as opposed to the "Max-User".

### 6.2. Coupons and Evolutionary Stable Strategies

Even if we assume that the ideal situation would be to have a system consisting of only "Smart-Prob" nodes, we should anticipate a certain degree of variation. The issue however is to evaluate whether the case of having the majority of nodes being "Max-User" can be avoided as such a scenario would make the system prohibitively inefficient. This section shows that although a certain number of "Max-User" nodes should be expected, the majority of users will come to learn that it is in their best interest to adopt a more controlled profile. In simple terms, assuming that the desired performance tradeoff can be reached through a balance of "Max-User" and "Smart-Prob" nodes, the characteristics of the application itself can make the users unconsciously choose to behave in a way that will collectively lead to the desired result.

From an abstract level, we believe this is aligned with the theory of ESS [11]. Introduced by John Maynard Smith, ESS depends on the idea of invasion, where a population of strategy-X players is visited by a strategy-Y player. The new player is said to invade if, following strategy Y, he scores better than the average strategy-X player. Assuming players are able to choose and switch strategies, this would induce the indigenous population to start switching to strategy Y. In many cases there are diminishing returns for the later adopters, and what follows is an equilibrium ratio of strategy-X players to strategy-Y players. By considering user profiles as different strategies, we can then use the properties of ESS as a guide in investigating how the system-wide performance balance can be reached.

As a first step in our examination, we must first expand on the participation incentive by understanding the concept of profit. Due to the nature of coupons, profit can be measured as the number of *points* a user earns during the simulation period. Nodes are assigned points by looking at the ID list of the coupon each node carries at the end of each simulation run. We award points to each node whose ID is found in the list. A higher position in the list means more points.

Based on that notion of profit, we have performed our experiments by first assuming that all nodes follow the ideal behavior, i.e. "Smart-Prob" with a 20 second transmission delay. After measuring the awarded points, we run the same experiments with 10% and then with 20% of the nodes being "Max User". At the end, we compared the awarded points of the nodes that had changed their behavior in order to see if they received considerably more points using the "Max User" profile. The aim was to measure the difference in points when some users behaved more aggressively from one simulation to the next.

Overall the results indicated that the "Max Users" earned minimal advantage while some nodes were in fact penalized for changing their behavior. On average we found that nodes gained a marginal benefit when they behaved as "Max Users". Considering the extra energy spent due to frequent broadcasts, we believe the incentive is too low to make a rational agent deviate from the "Smart-Prob" behavior. However, it is still the case that there is a fair degree of randomness in the system: it is very difficult to control the earned points since what matters most is when a node receives a coupon, how rapidly it moves, and where it moves to.

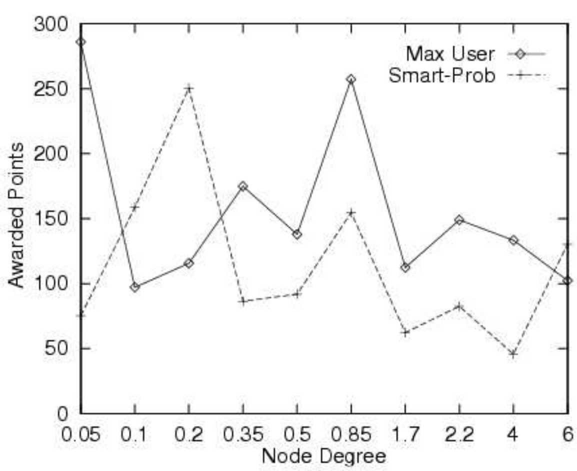


**Figure 6. Awarded points for all nodes.**

In order to examine whether a balanced collective behavior is still feasible under a more dynamic and expansive set of parameters, we run a set of experiments with two important differences. First, although we kept the transmission delay for "Smart-Prob" as 20 seconds, we reduced the transmission delay for the "Max User" from 20 to one second. In other words, the "Max-Users" became much more aggressive than in the previous experiments. Second, we tested against the complete range of intra-cluster node degree in order to get a more complete view of the system. The metric was once again the number of awarded points.

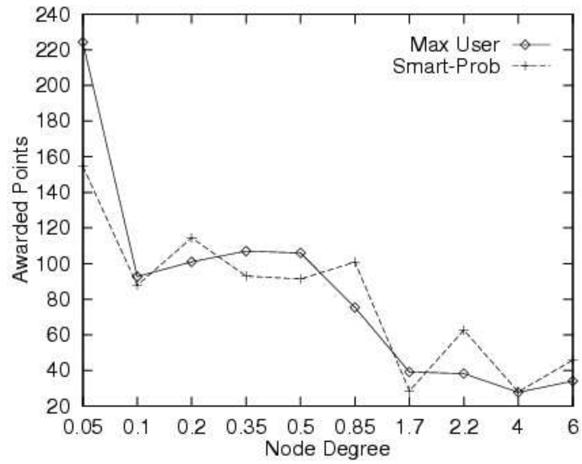


**Figure 7. Awarded points for nodes who received the coupon after 360 seconds.**

Overall, although the initial interpretation of the results indicated a clear advantage for this new group of "Max Users", a more careful examination revealed the high resiliency of the system. Figure 6 shows that apart from exceptional cases, "Max User" nodes have a clear advantage. However, this is misleading due to a very important point: the nodes that get the coupon early do much better that those who get it later. Considering this, we excluded the nodes that received the coupon within the first 360 seconds and created Figure 7. This graph shows that users who do not receive the coupon within the first 360 seconds, have essentially the same potential profit in terms of awarded points regardless of whether they behave as "Max Users" or "Smart-Prob". Given the increased transmission cost associated with the "Max User" profile, rational users have a strong incentive to adopt the "Smart-Prob" pattern. This result continues to exist even when we increase the "Smart-Prob" transmission delay from 20 seconds to 40 seconds. Therefore, aside from the few users who receive the coupon first and could then earn more points, the majority of nodes have an interest in adopting a more reserved profile.

If we define the desired performance of the system as a tradeoff between the time to first receive a coupon and the network load, then using ESS we can anticipate an equilibrium ratio between "greedy" (i.e. Max-User) and "reserved" nodes (i.e. Smart-Prob). In other words, the system is in balance since only a small subset of nodes may act greedily (the ones that get the coupon within a certain time period) while for the rest it is in their best interest not to do so. One final point is that as ESS is only stable with respect to randomly and occasionally occurring invading strategies, it would be interesting to measure whether coupon efficiency would be stable with respect to a large number of coordinated aggressive users. However, this is left for future work.

## 7. Conclusions

The goal of this paper has been to investigate applications and services that are uniquely suited to hybrid infrastructure models that may or may not include ad hoc wireless nodes. Coupons is a scheme that expands on the basic idea of wide-scale information dissemination by investigating incentives for cooperation. Cooperation is stimulated by adopting a basic pyramid scheme where users are awarded credits as they pass a received piece of information (a *coupon*) to other people.

Although the basic concept of a coupon has been previously mentioned, that work only contemplated the idea and did not simulate its network performance. The contribution of this paper is therefore twofold. First, we have evaluated the effectiveness and efficiency of our coupon scheme by performing a number of simulations using an expansive set of parameters. Secondly, using equilibrium concepts from game theory, we have elaborated on the issue of reaching a performance tradeoff through the behavior of the participating nodes.

With regard to evaluating effectiveness and efficiency, the basic behavior of coupons, independent of the factors of user behavior, is roughly analogous to that of any normal epidemic network. That is, coupons is effective at widely distributing information, but has the disadvantage of high network costs and repetitive distribution of information. However, we have found several ways to significantly reduce the inefficiencies. First, by considering more realistic hybrid infrastructures, we can expect more constrained distribution. Second, satisfactory information spreading can be achieved with even a minority of forwarding nodes, who may each be broadcasting at different transmission rates.

With regard to reaching a performance tradeoff, based on the implications of Evolutionary Stable Strategy there can be a ratio of user behavior profiles that can bring the system into balance. Although a certain subset may have the incentive to adopt a more greedy profile, the majority of users are shown not to derive any significant advantage when they try to take advantage of the cooperative nature of the system.

Coupons is a simple and powerful mechanism specifically tailored to commercial applications for the demands of the current world. It can be a simple and elegant solution to the problems associated with network flooding on a hybrid of infrastructure and ad hoc wireless systems. By deploying a simple scheme that creates a true incentive for users to participate, we can create a desirable compromise between scalable data dissemination and network efficiency.

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