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MITIGATING THE TRAGEDY OF THE DIGITAL COMMONS: THE PROBLEM OF UNSOLICITED COMMERCIAL E-MAIL

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ABSTRACT

The growth of unsolicited commercial e-mail (UCE) imposes increasing costs on organizations and causes considerable aggravation on the part of e-mail recipients. A thriving anti-spam industry addresses some of the frustration. Regulation and various economic and technical means are in the works. All anti-spam measures aim at bringing down the flood of unwanted commercial e-mail.

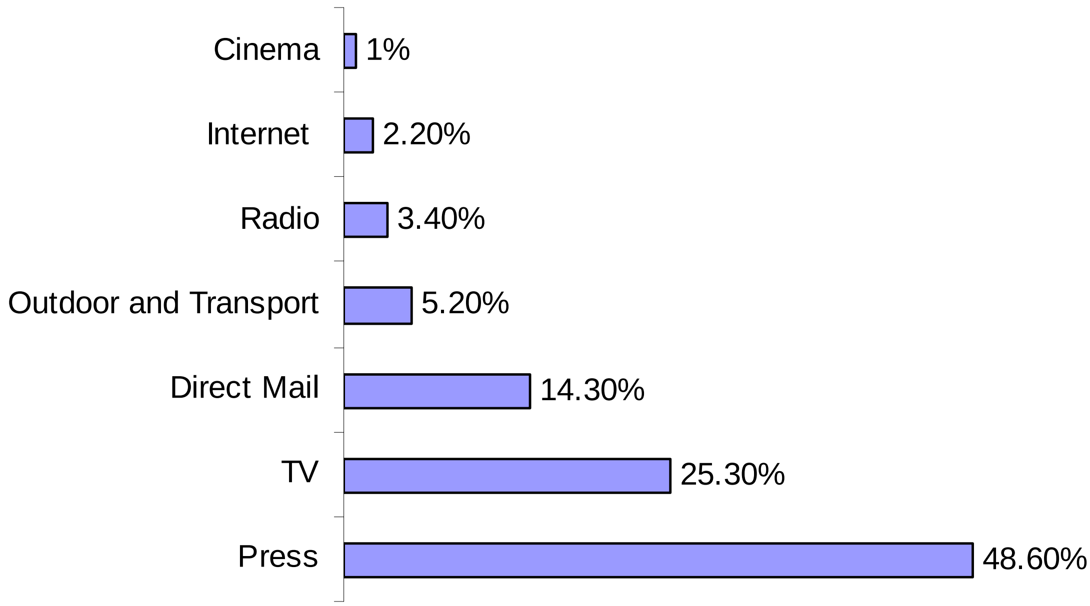
This paper contributes to the understanding of the UCE phenomenon by drawing on scholarly work in areas of marketing and resource ownership and use. Adapting the tragedy of the commons concept to e-mail, we identify a causal structure that drives the direct e-marketing industry. Computer simulations indicate that although filtering may be an effective method to curb UCE arriving at individual inboxes, it is likely to increase the aggregate volume, thereby boosting overall costs. We also examine other response mechanisms, including self-regulation, government regulation, and market mechanisms. We find that, of the various countermeasures, filtering appears to be the best currently available but that none are a satisfactory solution. The analysis advances understanding of the digital commons, the economics of UCE, and provides practical implications for the direct e-marketing industry.

Keywords: unwanted commercial email (UCE), SPAM, email marketing, markets for attention, information overload, tragedy of the commons, system dynamics, simulation

I. INTRODUCTION

Computer-mediated communication is one of the accepted channels in the mix of outlets that modern companies rely on to advertise and sell their products (Figure 1). Electronic mail (e-mail) advertising generated nearly a billion dollars in revenue in 2001 and is predicted to reach several billion dollars within a few years [Martin et al., 2003]. Reputable commercial establishments, such as J.C. Penney, Barnes and Noble, and Borders use e-mail for communicating with customers [Martin et al., 2003]. The marketing industry's search for an optimal portfolio of online and traditional advertising [Kover, 1999; Sheehan and Doherty, 2001] is expected eventually to evolve into integrated marketing communication programs [Brackett and Carr, 2001].

A cleverly designed direct marketing campaign contributes to overall sales [Chiang et al., 2003]. E-mail is more attractive than regular mail due to its lower distribution cost, wider reach, convenience, and faster responses [Mehta and Sivadas, 1995; Sheehan and McMillan, 1999; Martin et al., 2003]. The cost of sending e-mail is $5 to $7 per one thousand messages, while it is $500 to $700 for the same volume of regular mail – two orders of magnitude greater [Martin et al., 2003]. Moreover, digital marketing campaigns are easier to customize, which can produce better response rates than mail campaigns [Ansari and Mela, 2003]. Timing is also an issue. It takes, for example, 5 to 10 days to receive a response to e-mail surveys, versus 10 to 15 days to postal surveys [Sheehan and McMillan, 1999]. By including hyperlinks, e-mail allows a degree of interactivity not afforded by conventional direct mail campaigns [Martin et al., 2003].



Adapted from [DMIS, 2004]

Figure 1: Shares of Total Marketing Expenditure in 2003 by Channel: The UK Case.

DRAWBACKS OF DIRECT E-MARKETING

Despite the many benefits to senders of direct e-marketing campaigns, the impacts are pernicious on consumers, e-mail providers, and organizations. Many users are angry and frustrated because they must sift through mountains of unsolicited commercial e-mail (UCE) in their inboxes. E-mail administrators struggle to maintain high service quality in the face of increasing server loads, storage requirements, and security threats. Of the roughly 31 billion daily e-mails sent globally, about 12.4 billion (41 percent) are considered UCE [Spam Filter Review, 2005] – MSN alone blocks 2.4 billion per day [Unspam, 2005]. The average e-mail user receives 4.5 adult content e-mails per day, 16 percent of users change their e-mail address because of UCE saturation, and 4.5 seconds of corporate time is wasted per spam message [Halverson.Org, 2005]. With some users receiving hundreds of UCE messages per day [Halverson.Org, 2005], it is no wonder that frustration is growing. OECD (the Organization for Economic Co-operation and

Development) examined the costs of UCE, finding that in June 2004, the annual spam cost per employee exceeded $1900 and the annual lost productivity per employee equaled 3.1 percent [Anonymous, 2004]. Corporations are burdened by the financial and intangible costs of spam, and managers struggle to find solutions to UCE [Corbitt, 2004]. They fear that the situation is likely to become more grave in the future [Fallows, 2003].

II. THE QUEST FOR EYEBALLS: ATTENTION AS A SCARCE RESOURCE

Over thirty years ago, Nobel laureate Herbert Simon [1971] observed that attention is a scarce resource in an information-rich society. In the parlance of modern theory, the attention of workers can be viewed as a strategic asset that determines the long-term success of an organization [Davenport and Beck, 2001]. When more information arrives than individuals can process, an information overload [Simon, 1971] occurs, and the likelihood of organizational failure increases.

> *"The design principle that attention is scarce and must be preserved is very different from a principle of "the more information the better."* Simon[1971, p. 44])

Examples of information overload are abundant. Perlow [1999], for example, describes a software company characterized by an environment in which employees were not able to dedicate adequate attention to their primary tasks. The company suffered from chronic project time overruns. Sometimes the results of information overload are tragic. Recent reports describe the FBI's inability to process hours of sensitive communication believed to be of high intelligence value [Lichtblau, 2004].

The attention squeeze and information overload are exacerbated by the onslaught of UCE, whether viewed from an individual, organizational, or macro level. At an individual level, spam is increasing at a great rate for some e-mail users[1]. At an organizational level, spam as a percentage of e-mail is substantial [Melville et al., 2004]. On an aggregate level, industry reports suggest a steady upward trend for UCE volume. Brightmail, for example, estimates that spam as a percentage of total e-mail grew by approximately a third from 49 percent in June 2003 to 65 percent in June 2004. More somber news is that spam is moving beyond e-mail to other platforms, including instant messaging (spim), blogs, and mobile text messaging. Given these trends and the limited time an individual can spend on dealing with e-mail, the e-mail recipient is bound to experience information overload.

We now extend the concept of attention as a limited resource to the concept of the digital commons (Section III) and to the review of several mitigation mechanisms (Section IV). We then construct a causal model of the UCE industry and use the model to analyze one popular abatement mechanism: filtering (Section V). The last section summarizes results and outlines extensions.

III. TRAGEDY OF THE DIGITAL COMMONS

Rapidly increasing spam volume is a result of decisions made by many self-interested agents involved in digital marketing. These participants vie for one common resource: the attention of e-mail recipients. A typical outcome for a situation in which many profit-seeking agents compete for the same scarce resource is resource overuse. The suboptimal outcome is often described as "the tragedy of the commons"[2] [Hardin, 1968]. A vivid example is overexploitation of fish stock in the ocean. In an online world in which many resources are still open to all:

> *Management of the digital commons is perhaps the most critical issue of market design that our society faces* [McFadden, 2001].

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[1] For examples see graphs at http://www.raingod.com/angus/Computing/Internet/Spam/Statistics/

[2] The term comes from the old English custom of providing a common lawn, called a commons, in the center of a village on which shepherds could graze their sheep.

THE PHYSICAL COMMONS

A common resource is typically identified as one with the following properties:

1. it is rival, that is, when it is used, less is available for others; and
2. it is nonexclusive, that is, no one can be barred from using it.

Individuals seek disproportionate private gains through the use of the resource but do not bear the full cost. The oceans, forests, grazing lands, the atmosphere, outer space, and highways are all susceptible to problems of the commons. History is replete with examples of resource degradation by rational, self-interested individuals such as grazing land for sheep, fish in oceans, and oil reserves.

THE DIGITAL COMMONS

The commons problem, however, is not limited to the physical world. Members of early Usenet discussion groups in the 1980s faced analogous circumstances: the groups were open to everyone and a small set of users could degrade the environment for all. In this context, the pollution sprang from various sources – excessive posting or posts that were off topic, offensive, or contained advertising – and lowered the value for all. The notion of virtual commons was thus applied to an online common resource whose misuse by the few degraded the value of the resource for the many [Kollock and Smith, 1996].

To formalize the application of commons logic to the Internet, two conditions are necessary [Regan, 2002].

1. The Web must be a place, just as the earth is a place. The Internet is commonly and consistently recognized as a place for conducting a wide array of economic and social activity. Everyday metaphors provide evidence in this regard, with terms such as “going online,” “size of the internet,” “internet storm,” “virtual community,” and “virus” illustrating the mapping of the physical to the virtual. The place metaphor is also a fundamental concept used in Internet law:

> *the cyberspace as place metaphor operates as one of the most compelling theories of how we have regulated cyberspace to date, and how we are likely to regulate it in the future* [Hunter, 2003, pp. 446].

2. An online commons must contain resources (analogous to fish stock in oceans) characterized by sharing, the lack of clearly defined private ownership, overuse, and negative externalities. A common resource is shared by many and private ownership is unclear or non-existent, just as no one owns the depths of the oceans and the fish stock in it. Many Internet resources involve sharing, including public discussion groups, peer-to-peer file sharing networks, and e-mail. No one can be barred from using these areas of cyberspace. The presence of overuse by rational individuals leads to pollution that affects all. In this context, e-mail is a common good [Regan, 2002].

Spam exhibits signs of a negative externality, which results in production that is higher than society desires. This assertion is evidenced by the bombardment of e-mail addresses with spam and the resulting financial and non-pecuniary costs borne by each of the millions of users, their respective e-mail administrators, and employers. Table 1 draws parallels between UCE and fish population, which is a canonical common resource suffering from the tragedy of the commons. As the online commons is not a biological system, we take care in drawing the analogy homomorphically, i.e., by “paying attention to the peculiarities of the digital environment as well” [Greco and Floridi, 2004].

Table 1. Comparison of a Physical and Online Commons

	Fisheries	UCE
Common Resource	Fish stock in oceans	Attention of e-mail users
Self-interested behavior	Fish as much as possible	Send as much UCE as possible
Technique	Fishing expeditions	Marketing campaigns
Tragedy	Over fishing	Information overload

IV. SOLUTIONS TO THE DIGITAL COMMONS TRAGEDY

Analysis of property rights, privacy, externalities, regulation, and incentives in the context of common resources such as forests and grazing lands

brings a wide variety of perspectives and research methodologies to bear on the problem. Here, we briefly review three broadly defined corrective approaches to the tragedy of the commons:

1. self-regulation through community norms;
2. government control and regulation; and
3. price and market mechanisms.

SELF-REGULATION

Even though societal norms sometimes prevent the tragedy of the commons from occurring (e.g., [Lessig, 2001, p. 22, note 9]), it is unlikely that such self-regulation will work in the case of spam. In theory, the Coase theorem (e.g. [Mankiw, 2001]) predicts that parties which are locked in a situation with negative externalities may negotiate their way out of the problem if property rights are clear and transaction costs are small. Inboxes, of course, have clearly defined property rights. Senders' identity, however, is misrepresented in about 70 percent of spam messages [Fallows, 2003: 13]. Moreover, locating the source of spam is not trivial. It took Earthlink a year and a team of 12 professionals to track only one spammer [Black, 2003]. Hence, the Coase theorem breaks down on this ground alone. Revamping the e-mail protocol to make it more difficult to hide one's identity [Fallows, 2003] may resolve the spammer identification problem. But even then, the transaction cost of reaching a settlement between millions of e-mail users and spammers is likely to be excessively high for self-regulation to work.

GOVERNMENT REGULATION

The second mechanism is government regulation. In the United States, for example, UCE led to anti-spam legislation, notably, the 2004 CAN-SPAM Act. Legislative activity is likely to increase [Fallows, 2003]. Given the cultural dimensions of spam, regulatory responses vary by country [Gratton, 2004]. The approach of the European Union is to ban spam outright, with steep fines for violators. In contrast, the U.S. allows spam, provided several constraints are met, including consistency between message subject and message content and indication in the subject line that the message is advertising. Regardless of the specific approach, enforceability remains an issue because the Internet is borderless and it is easy to locate e-mail servers in countries friendly to spam.

The debate about the effectiveness of the anti-spam laws is heated [Ray and Schmitt, 2003; Sipior et al., 2004]. Some even suggested that anti-spam laws will result in an increase in spam [Squillante, 2003]. The European Commission acknowledged in a recent report that spam cannot be stopped by regulation alone [Swartz, 2004b]. In the U.S., the CAN-SPAM Act does not appear to be working and the volume of spam is still growing [Swartz, 2004b]. One estimate claims that at most 3 percent of spam follows the CAN-SPAM rules [MX Logic, 2004]. Undoubtedly, recent lawsuits by major U.S.-based e-mail providers using the U.S. CAN-SPAM act will set important precedents.

MARKET MECHANISMS

Market mechanisms for controlling spam are still in the developing stages. One popular idea is the introduction of electronic stamps [Leyden, 2004]. Fixed e-postage is not unlike the Pigovian tax [Mankiw, 2001], a classical regulatory mechanism by which governments charge a fixed fee for each unit of pollution. Even though lab experiments [Kraut et al., 2002] and basic economic theory suggest that postage is likely to reduce UCE volume, the theory of the Pigovian tax suggests that the mechanism may miss the optimal spam production point. If the postage amount is not set correctly, then there might be either underproduction or overproduction of UCE. The U.S. government also attempted to address the problem of environment degradation by creating a market for tradable pollution permits [Mankiw, 2001]. This policy is often considered superior to a Pigovian tax. An idea similar to tradable pollution permits but for the realm of electronic marketing was proposed by Fahlman [2002].

Several other market mechanisms are under discussion such as attention bonds [Van Alstyne et al 2004]. However, because of their early-stage development, it is difficult to know which, if any, may achieve success.

V. DYNAMIC ANALYSIS OF FILTERING

Having outlined the digital commons problem and described several mitigation mechanisms, we now describe our simulation model that enables analysis of UCE dynamics and the assessment of the most popular UCE mitigation mechanism: filtering. The model was implemented using system dynamics as the modeling methodology. A comprehensive reference on system dynamics is Sterman [2000][3].

Conventional commons problems such as over fishing have been modeled as dynamic systems (e.g. FishBanks interactive computer simulation[4]). The system consists of at least two agents whose quests for private gain reinforce one another until curtailed by limits in the environment. In the case of fishing, each agent maximizes revenue or profit until the system is overrun and fish stocks become depleted. Our approach is to adapt this model to the case of the online commons, specifically, UCE. To the best of our knowledge, this approach to studying spam is unique and it allows leveraging what we already know about physical commons to the problems of online commons.

The UCE value chain includes four participants:

1. inbox owners	The inbox population is the set of feasible recipients of unwanted commercial e-mail.
2. harvesters	Harvesters are in the business of discovering inboxes and compiling them into lists of e-mail addresses, which they sell to UCE operators.
3. operators	UCE operators administer spam campaigns, which promote products from sponsors.
4. sponsors.	Sponsors support campaigns based on their success rate.

[3] A quick introduction to system dynamics by Craig Kirkwood can be found at http://www.public.asu.edu/~kirkwood/sysdyn/SDIntro/SDIntro.htm. Additional resources can also be found on the official website of the International System Dynamics Society: http://www.albany.edu/cpr/sds/.

[4] http://www.unh.edu/ipssr/Lab/FishBank.html

We now explain the dynamic processes relating these four value chain participants illustrated in Figure 2.

ADDRESS HARVESTING

To receive UCE, an inbox address must be discovered by a harvester. Inbox addresses can be collected in hundreds of ways [Brain, 2004]. One of them is via directory harvest attacks (DHA), in which automated programs query e-mail servers for the existence of millions of commonly designated usernames[5]. The Center for Democracy and Technology [2003] reports that harvesters are also effective at gathering e-mail addresses posted on the web[6]. Considering the many ways in which harvesters add e-mail addresses to their lists, it is reasonable to assume that it is only a matter of time before an e-mail account is discovered (Figure 2[7]). We model harvesting by including an average inbox discovery delay. Delays, including the discovery delay, are shown in Figure 2 as two short lines crossing an arrow.

ATTENTION AND INFORMATION OVERLOAD

The attention resource can be measured in terms of time [Simon, 1971]. A survey conducted by the American Management Association found that an employee typically spends about a quarter of her day on e-mail [Swartz, 2004b]. Employees possess a limited attention resource. The total demand for attention from regular and UCE e-mail is proportional to their respective volumes delivered to inboxes. Assuming that regular e-mail has a higher priority than spam, the time left for UCE is the difference between the attention resource and the attention devoted to regular e-mail (Figure 2). If the arriving volume of electronic messages is greater than what an individual is comfortable handling, then, using Herbert Simon's terminology, information overload occurs.

RESPONSE RATE

Advertisers know about the negative relationship between advertising volume that an individual is exposed to and the response rate to advertisements [Rudolph, 1947; Starch, 1966; Houston and Scott, 1984]. Houston and Scott [1984], for example, statistically showed a negative convex relationship between advertising readership and the number of pages in a journal. Recent research shows that the negative relationship holds equally well for electronic marketing. Martin et al. [2003] found that in the case of permission-based advertising for a company operating from Finland, the likelihood of visiting a link advertised within an e-mail decreased as volume of e-mail from the company increased. A survey by the Pew Internet & American Life Project [Rainie and Fallows, 2004] found a decline in the readership of UCE while the UCE volume increased.

Anecdotal evidence from UCE operators [Hansell, 2003] also confirms the existence of a negative relationship between the amount of spam that a finite group receives and the response rate. This phenomenon is indicated by the loop in Figure 2 comprising *UCE* volume – attention required by UCE – information overload – response rate.

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[5] See http://www.postini.com/services/what_are_dhas.html

[6] An example of a clearly illegal harvesting technique is the AOL employee arrested for stealing the e-mail addresses of 92 million AOL users [Swartz, 2004a]. The employee sold the list to an operator of an online gambling business in Las Vegas for $100,000. That person in turn repackaged and resold the addresses to spammers for over a million dollars.

[7] Figure 2, is a schematic of our system dynamics model.

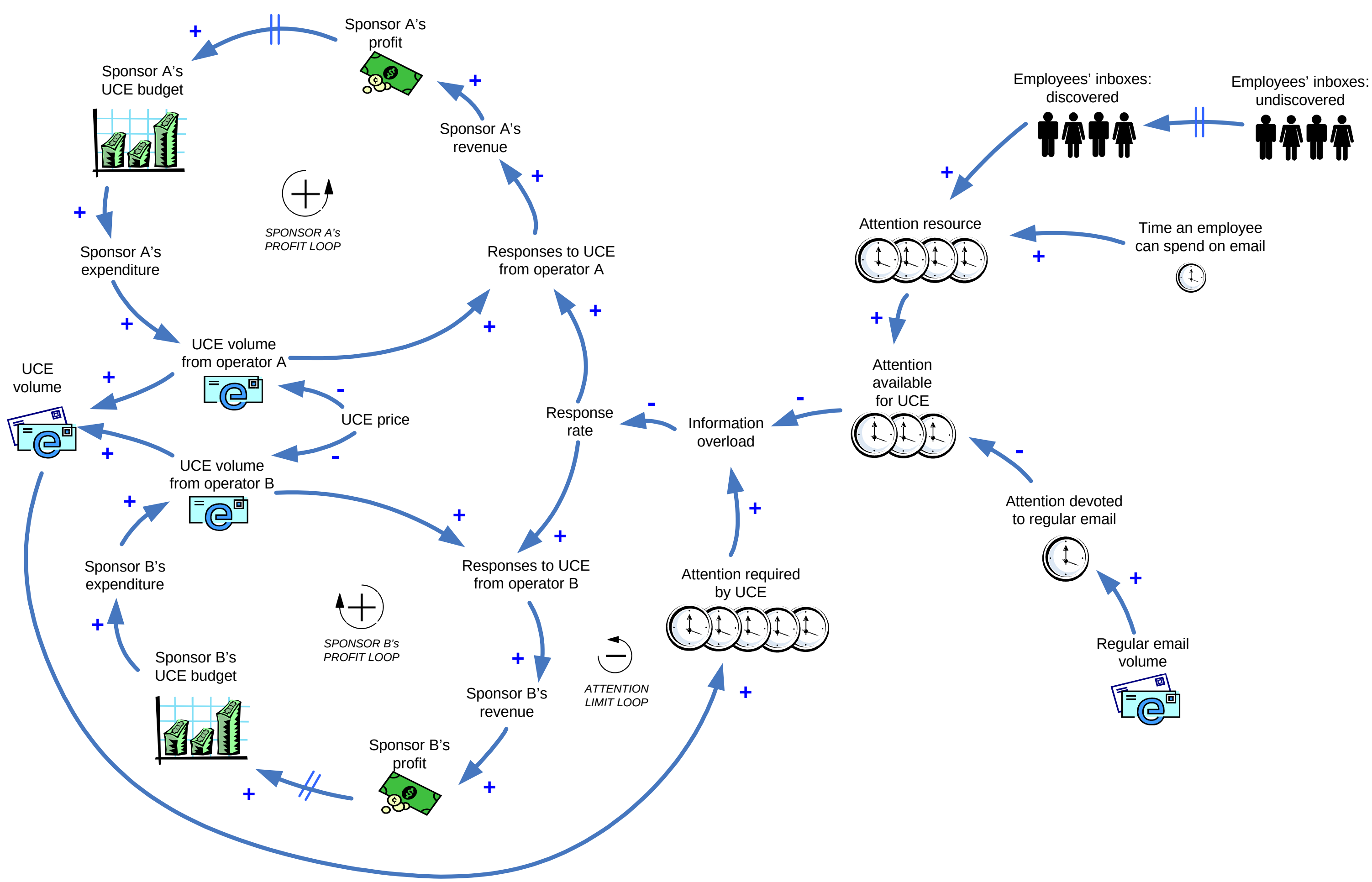


Figure 2: The Causal Structure of the UCE System

PROFITABILITY

For a given overall response rate, the total number of responses a company receives increases with its share in the e-mail volume (in Figure 2, this result is captured by positive links between UCE Volume from Operator and Responses to UCE from Operator). More responses imply more revenue (Figure 2). More revenue means more profit. Greater profit implies that with some delay (shown as two short lines crossing an arrow in Figure 2) more budget is allocated for UCE by a sponsor and thus expenditure on *UCE* volume increases. The UCE volume that a sponsor can buy for a given expenditure is inversely proportional to the UCE price that an operator charges for sending electronic messages.

It is clear from Figure 2 that UCE volume tends to increase while profits from UCE campaigns increase. This concept is captured by two positive Sponsor Profit Loops. Starting new campaigns is easy and quick thanks to specialized software packages [Lemke, 2003]. An example of such a tool is iBuilder from VerticalResponse[8]. Hence, campaigns involve low marginal cost, and therefore cost recovery is unimportant [Kraut et al., 2002]. A campaign requires an extremely low response rate to break even: 0.001 percent is often sufficient [Fallows, 2003: 26]. The causality acting through the response rate forms the Attention Limit Loop (Figure 2), which checks the exponential growth of spam.

RESULTS: BASE CASE

We conducted computer simulations for a fictitious organization with 10,000 inboxes. The organization could be, for example, a company with employees or an e-mail provider hosting e-mail accounts. We allow only a small portion of the accounts to be initially known to spammers. However, due to address harvesting (Section V), the number of discovered accounts increases over time . In the model, we assume that UCE budget is proportional to the profitability of UCE campaigns; that is, the more profitable the UCE, the greater budget will be allocated for e-marketing. Table 2 summarizes the assumptions of the model. Parameter values were suggested by published surveys and anecdotal evidence from experts.

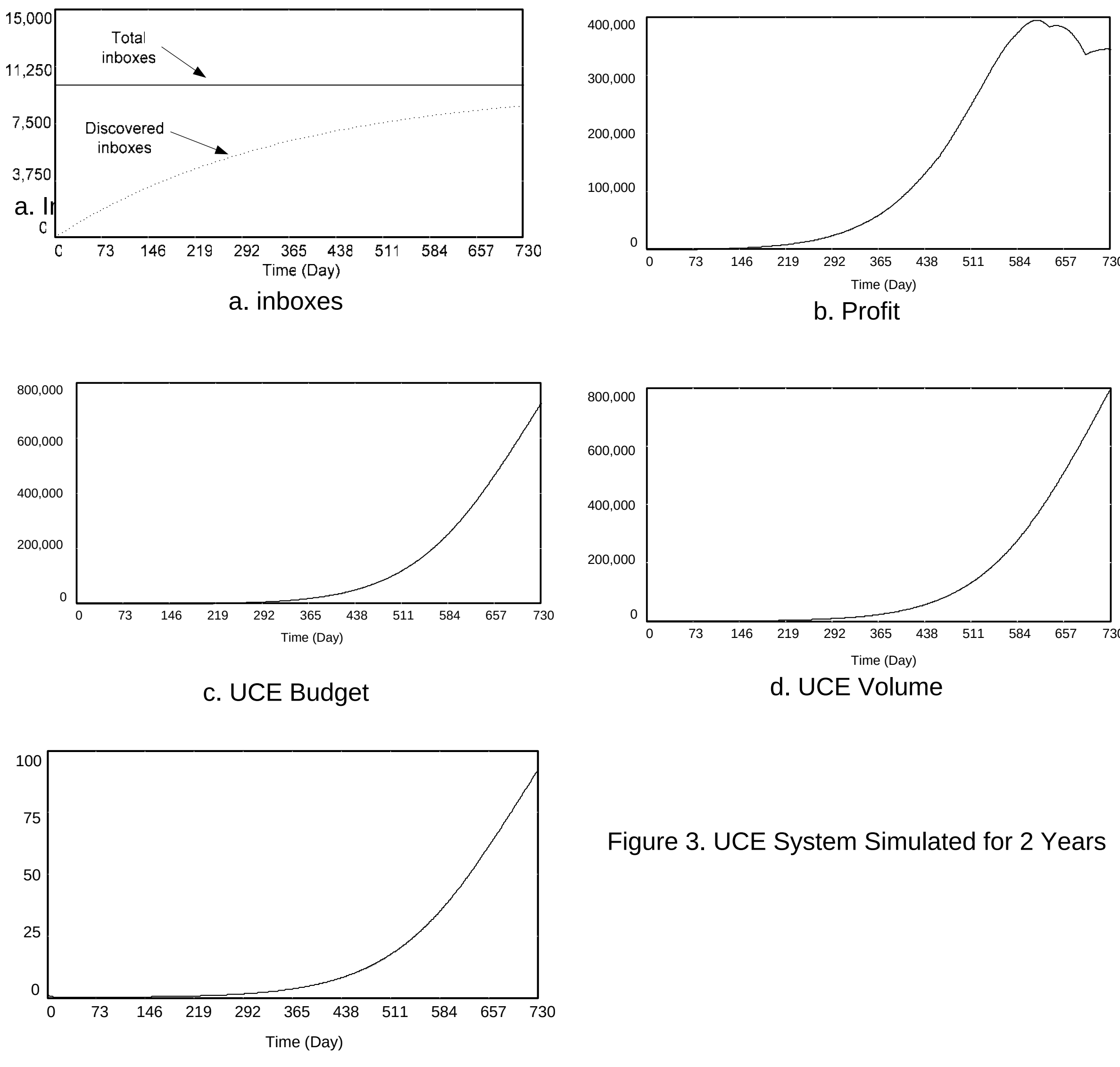
Table 2. Model Assumptions

Item	Implementation	**Source**
Organization size	10000 inboxes	Assumption
Initial population of discovered inboxes	10 Inboxes	Assumption
Time spent on e-mail by an employee	2 Hours/day	[Swartz, 2004b]
Average regular e-mail volume	20 Messages/day	Assumption
Base price of sending 1,000 UCE messages	$5 per 1000 messages	[Martin et al., 2003]
Response rate	A declining function of UCE volume	See Response Rate section above
E-mail marketing budget	Allocated proportionally to the past profit from the UCE campaign	Assumption

Figure 3 shows the base run for the simulated 2 years of life of our fictitious organization. Inbox discovery is proportional to the number of remaining undiscovered inboxes, and therefore the number of discovered inboxes grows monotonically and asymptotically toward the total inbox population (Figure 3a). Within two years, more than 80% of the inboxes are discovered. Positive profits accrued through spam campaigns (Figure 3b) encourage sponsors to allocate even more

[8] http://www.verticalresponse.com/

resources for electronic marketing (Figure 3c and Figure 2). Greater UCE budgets allow each sponsor to spend more on e-mail (sponsor's expenditure in Figure 2), which contributes to the growth of the UCE volume from operator A and B (Figure 2). Hence, global UCE volume grows as well (Figure 3d and Figure 2). The UCE volume that arrives to an individual inbox also grows exponentially (Figure 3e), which is consistent with real life examples (see Footnote 1).



a. inboxes

b. Profit

c. UCE Budget

d. UCE Volume

e. Average UCE Volume to a Discovered Inbox

Figure 3. UCE System Simulated for 2 Years

RESULTS: THE IMPACT OF SPAM FILTERING

When foreseeing an approaching information overload, Simon suggested filtering as a possible solution [Simon, 1971]. Filtering of unsolicited e-mail is capable of reducing demand for attention. Users report a lesser burden of spam at work than on their personal e-mail accounts because of active e-mail screening at work [Fallows, 2003]. The popularity of this solution feeds the growth of a new and active anti-spam software industry. The method, however, is flawed. Many inbox users fear that aggressive filtering may lead to some legitimate e-mail being discarded. The Pew Internet Project [Fallows, 2003: 29] found that about one third of the respondents feared their incoming e-mail might be blocked, and 13 percent were convinced that it happened to them. About a quarter of respondents feared that their outgoing e-mails might be filtered out by the intended recipient.

In this subsection we study the effect of filtering on UCE volume using the computer model introduced in Figure 2. We assume that the organization starts filtering e-mail in the third year. To address fears that legitimate e-mail may be discarded, the organization discards only UCE-suspects that it is most confident about. In other words, only some percentage of the UCE volume that arrives to the organization is delivered to recipients and the rest is filtered out. In reality, the portion of UCE messages which gets through the filter changes daily[9]. However, this model is concerned with the overall effect of filtering, rather than with daily variations in the positive identifications by a filtering algorithm. Therefore, the model assumes that every day the filter recognizes some fixed fraction of the incoming UCE volume as spam, which is consequently discarded.

Figure 4 shows a simulation that extends the run in Figure 3 for 5 more years (2555 days total). The figure compares the case when filtering is used to the case when no filtering is implemented. Under each scenario, during the seven-year period, harvesters discover all inboxes (Figure 4 a). Figures 4b through 4e show the case when the organization performs no active filtering with dotted lines. As in the base case simulation discussed earlier, driven by the two Sponsor Profit Loops (Figure 2), each operator continues to increase UCE that leads to the growth in global volume of unsolicited messages (Figure 4b), which in turn contributes to the increase in spam arriving to individual accounts (Figure 4c). Eventually, attention required by UCE outgrows attention available for UCE and information overload becomes more strongly felt (Figure 2)[10]. E-mail recipients, who are overwhelmed by increasing volumes of spam (Figure 4c), tend to delete most of it, thus driving the overall response rate down (Figure 2 and the 'no filtering' case in Figure 4d). The declining response rate leads to lower revenue and lower profit (use Figure 2 to trace the logic and Figure 4e for the resulting profit trajectory). With some delay, the declining rate leads to lower revenue and lower profit (use Figure 2 to trace the logic and Figure 4e for the resulting profit trajectory). With some delay, the declining financial performance of the electronic marketing campaigns affects the sponsors' UCE budgets (Figure 2). As a result, the UCE volume tapers off (later portions of Figure 4b).

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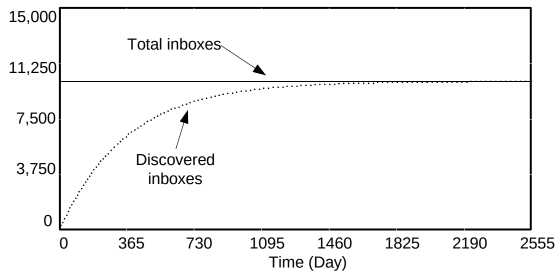
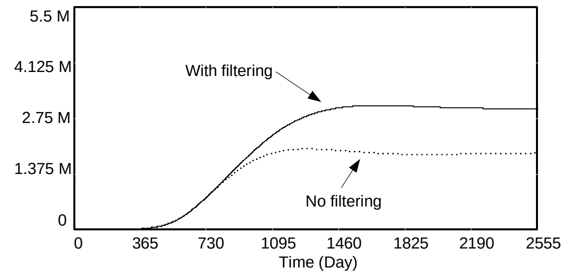
[9] For a detailed account of the filtering procedures followed by a typical medium-sized organization, see Melville et al. [2004].

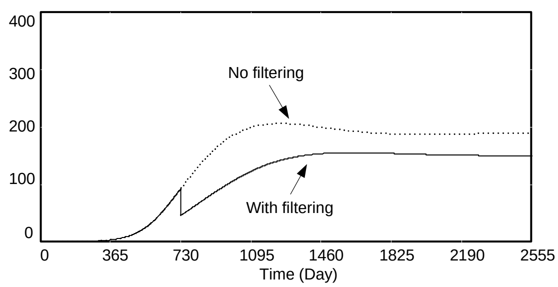
[10] According to the systems dynamics methodology (Footnote 3) dominant loops drive the dynamics of a system. Thus, positive Profit Loops drive the system initially, resulting in exponential growth of UCE volume. When the growth starts slowing down (as seen in Figure 4), it means that some balancing force becomes stronger in the system. In other words, the balancing loop Attention Limit gains force. Eventually, the Attention Limit loop becomes dominant and slows down the growth of UCE. Attention overload is the reason for the Attention Limit loop. Although Figure 2 does not show which loop is dominant at every moment, once loops are identified in Figure 2 we can draw conclusions, based on the system trajectories, which loops are influencing system's behavior.



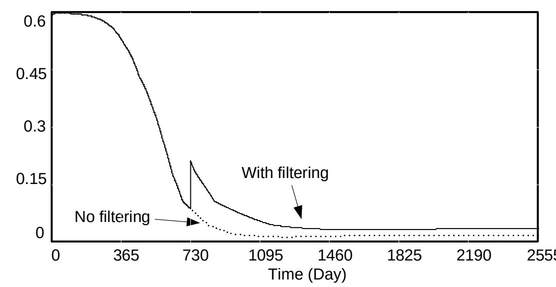
a.Inboxes



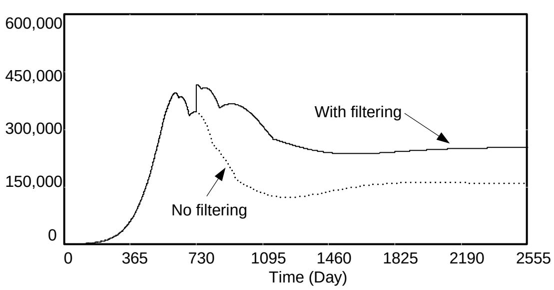
b.UCE Volume



c. Average UCE Volume to a Discovered Box



d. Response Rate



e. Sponsor's Profit

Figure 4. Organization Simulated for 7 Years With and Without Filtering Policy in Place

EFFECT OF FILTERING

The effect of filtering is clearly visible starting in year three. Filtering reduces the burden from UCE on an individual by lowering UCE volume arriving at an individual inbox (solid line in Figure 4c). Feeling less overwhelmed by incoming spam, we assume that readers tend to read a greater fraction of incoming messages, thus increasing the overall response rate (solid line in Figure 4d). Better response rates drive profitability upwards (solid line in Figure 4e), which in turn, as shown in Figure 2, encourages greater UCE budgets, thus allowing sponsors to spend more on e-mail marketing. Greater expenditure by each sponsor boosts overall UCE volume (filtered case in Figure 4b). Hence, while lowering the burden of spam on individuals (Figure 4c), filtering is likely to increase overall volume of UCE (Figure 4b).

VI. DISCUSSION

In this paper we addressed the growing problem of unsolicited commercial e-mail (UCE). Adopting the viewpoint that in an information-rich society attention is a limited resource [Simon, 1971] allowed us to describe the problem of spam in terms of a common resource. The common resource framework is well understood in economic literature and is helpful in explaining many phenomena that lead to the overexploitation of limited resources. The situation of overexploitation of a resource by self-interested agents is generally referred to as the tragedy of the commons. The framework was applied to other Internet-related problems (e.g.,[McFadden, 2001; Kollock and Smith, 1996; Regan, 2002; Hunter, 2003]). When applied to the virtual world, the phenomenon is dubbed the tragedy of the digital commons.

We reviewed several solutions to the spam problem: self-regulation, government regulation, market mechanisms, and filtering. We concluded that based on theoretical and empirical evidence self-regulation is unlikely to resolve the problem. Recent attempts at government regulation failed to lower the spam volume. In view of the commons theory and its applications to the cases when traditional resources are overused, market mechanisms appear to be quite promising; but they are still in their early development stages. Finally, we offered a simulation analysis of filtering, which is currently the most popular option to combat UCE.

Filtering was offered as a possible solution to information overload long before e-mail became popular [Simon, 1971]. Filtering, however, may impose costs that exceed the benefit [Cranor and Lamacchia, 1998]. The benefit is the reduction of spam volume arriving to an individual inbox. However, as our discussion in Section V showed, the use of filtering is likely to stimulate production of spam. Greater spam volume consumes more of an organizations' bandwidth and processing resources [Melville et al., 2004]. Furthermore, organizations and spam senders iteratively improve their filtering and electronic marketing tools, respectively, with no clear end to, or winner of, such an arms race. The continuous anti-spam effort is costly. Inbox owners bear the cost too because false positives during spam filtering lead to the deletion of desired e-mail. From a theoretical standpoint, this loss reduces consumer surplus [Loder et al., 2004]. Table 3 summarizes benefits and drawbacks of the filtering solution.

Table 3. Benefit and Drawbacks of the Filtering Solution

Benefit	
	Lower UCE volume to an inbox
Drawbacks	
	Greater global volume of UCE
	Emergence of the costly "anti-spam arms race"
	False-positives lower consumer surplus

The evidence and analysis in this paper indicate that currently available anti-spam options will not be effective in the long term at containing the spam pandemic. Hence, the search for more potent methods of abating the spam crisis and frustrating the unchecked onslaught of the electronic marketing industry must continue. In Section I, we pointed out that the direct marketing industry, which is legitimate, is affected by UCE. In Sidebar 1 we offer suggestions to the direct marketing industry on how to cope with UCE.

In our future work, we plan to apply the theoretical framework and the computer model developed in this paper to the in-depth analysis of government regulation and market mechanisms as solutions to the spam problem.

SIDEBAR 1. DIRECT MARKETING

To compete effectively with UCE for customer attention, the legitimate direct marketing industry will need to:

1. foster relationships with customers
2. be sensitive to the optimal emailing frequency
3. limit email to customers who consented to receiving such communication
4. target and customize email, so as to make email communication useful to the recipient
5. use email as only one dimension in a comprehensive marketing campaign
6. actively distinguish itself from UCE

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REFERENCES

EDITOR'S NOTE: The following reference list contains the address of World Wide Web pages. Readers who have the ability to access the Web directly from their computer or are reading the paper on the Web, can gain direct access to these references. Readers are warned, however, that

1. these links existed as of the date of publication but are not guaranteed to be working thereafter.
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Anonymous. (2004) "Squashing Spam", OECD Observer, 242, http://www.oecdobserver.org/ news/fullstory.php/aid/1244/Squashing_spam.html (current as of May 3, 2005).

Ansari, A. and C. F. Mela (2003) "E-Customization", *Journal of Marketing Research,* (40)2, pp. 131-146.

Black, J. (2003) "Before Spam Brings the Web to Its Knees", *Business Week Online,* June 10.

Brackett, L. K. and B. N. Carr (2001) "Cyberspace Advertising Vs. Other Media: Consumer Vs. Mature Student Audiences", *Journal of Advertising Research,* (41)5, pp. 23-32.

Brain, M. (2004) "How Spam Works", How Stuff Works, http://computer. Howstuffworks.com/ spam.htm (current as of May 3, 2005).

Chiang, W. Y. K., D. Chhajed, and J. D. Hess (2003) "Direct-Marketing, Indirect Profits: A Strategic Analysis of Dual-Channel Supply-Chain Design", *Management Science,* (49)1, pp. 1-20.

Corbitt, T. (2004) "Are You Suffering from Spam?" *Management Services,* (48)2, pp. 22-23.

Cranor, L. F. and B. A. Lamacchia (1998) "Spam!" *Communications of The ACM,* (41)8, pp. 74-83.

Davenport, T. H. and J. C. Beck (2001) *The Attention Economy: Understanding the New Currency of Business*, Boston, MA: Harvard Business School Press.

Fahlman, S. (2002) "Selling Interrupt Rights: A Way to Control Unwanted E-Mail and Telephone Calls", *IBM Systems Journal,* (41)4, pp. 759-766.

Fallows, D. (2003) *Spam: How It Is Hurting Email and Degrading Life on the Internet*, PEW INTERNET PROJECT.

Gratton, E. (2004) "Dealing with Unsolicited Commercial Emails: A Global Perspective", *Journal of Internet Law,* (7)12, pp. 3-13.

Greco, G. M. and L. Floridi (2004) "The Tragedy of the Digital Commons", *Ethics and Information Technology,* (6)2, pp. 73-81.

Halverson.Org. (2005), http://www.halverson.org/spam/ (current as of April 19, 2005).

Hansell, S. (2003) "An Unrepentant Spammer Vows to Carry on, within the Law", *The New York Times Online*, December 30.

Hardin, G. (1968) "The Tragedy of the Commons", *Science,* (162)3859, pp. 1243-1248.

Houston, F. S. and D. Scott (1984) "The Determinants of Advertising Page Exposure", *Journal of Advertising,* (13)2, pp. 27-34.

Hunter, D. (2003) "Cyberspace as Place and the Tragedy of the Digital Anticommons", *California Law Review,* (91)2, pp. 439-519.

Kollock, P. and M. Smith (1996) "Managing the Virtual Commons: Cooperation and Conflict in Computer Communities" in S. Herring (ed.) *Computer-Mediated Communication: Linguistic, Social, and Cross-Cultural Perspectives*, Amsterdam: John Benjamins, pp. 109-128.

Kover, A. J. (1999) "Another Unsolved Problem", *Journal of Advertising Research,* (39)3, pp. 5.

Kraut, R. E., et al. (2002) "Markets for Attention: Will Postage for E-Mail Help?" *Yale ICF Working Paper No. 02-28*

Lemke, T. (2003) "How Spammers Exploit the News: Current Events Trigger Onslaught of E-Mail Ads", *The Washington Times*, October 14, p. A01.

Lessig, L. (2001) *The Future of Ideas: The Fate of the Commons in a Connected World*, New York: Random House.

Leyden, J. (2004) "We'll Kill Spam in Two Years – Gates", The Register, January 26, http://www.theregister.co.uk/2004/01/26/well_kill_spam_in_two/ (current as of May 3, 2005).

Lichtblau, E. (2004) "F.B.I. Said to Lag on Translating Terror Tapes", *The New York Times Online*, September 28.

Loder, T., M. Van Alstyne, and R. Wash (2004) "Information Asymmetry and Thwarting Spam", *MIT Working Paper*, pp. 1-11.

Mankiw, N. G. (2001) *Principles of Microeconomics*, Mason, Ohio: Thomson.

Martin, B. A. S., et al. (2003) "Email Advertising: Exploratory Insights from Finland", *Journal of Advertising Research,* (43)3, pp. 293-300.

McFadden, D. (2001) "The Tragedy of the Commons", *Forbes ASAP,* September 10, p. 61-62.

Mehta, R. and E. Sivadas (1995) "Comparing Response Rates and Response Content in Mail Versus Electronic Mail Surveys", *Journal of the Market Research Society,* (37)4, pp. 429-439.

Melville, N., R. Plice, and O. V. Pavlov (2004) "Spam Flow: An Exploratory Empirical Case Study", *mimeo*

MX Logic. (2004) "MX Logic News Release: MX Logic Reports 16 Percent of Spammers Adopt Sender Policy Framework (SPF) Email Authentication Scheme", http://www.mxlogic.com/news_events/09_08_04.html (current as of Sept. 16, 2004).

Perlow, L. A. (1999) "The Time Famine: Toward a Sociology of Work Time", *Administrative Science Quarterly,* (44)1, pp. 57-81.

Rainie, L. and D. Fallows (2004) *The Impact of Can-Spam Legislation*, Pew Internet Project.

Ray, C. and J. Schmitt (2003) "Stopping Spam: Federal and International Initiatives", *Journal of Internet Law,* (7)5, pp. 4-13.

Regan, P. (2002) "Privacy as Common Good in the Digital World", *Information, Communication and Society,* (5)3, pp. 382-405.

Rudolph, H. J. (1947) *Attention and Interest Factors in Advertising*, New York, NY: Funk & Wagnalls Company.

Sheehan, K. B. and C. Doherty (2001) "Re-Weaving the Web: Integrating Print and Online Communications", *Journal of Interactive Marketing,* (15)2, pp. 47-59.

Sheehan, K. B. and S. J. McMillan (1999) "Response Variation in E-Mail Surveys: An Exploration", *Journal of Advertising Research,* (39)4, pp. 45-55.

Simon, H. (1971) "Designing Organizations for an Information-Rich World" in M. Greenberger (ed.) *Computers, Communications, and the Public Interest*, Baltimore, MD: The Johns Hopkins Press, pp. 38-52.

Sipior, J., B. Ward, and P. G. Bonner (2004) "Should Spam Be on the Menu", *Communications of The ACM,* (47)6, pp. 59-63.

Spam Filter Review. (2005) "Spam Statistics 2004", http://spam-filter-review.toptenreviews.com/spam-statistics.html (current as of April 19, 2005).

Squillante, N. J. (2003) "The Can-Spam Act of 2003: Real Reform or Political Pork?" *MarketingProfs.com*.

Starch, D. (1966) *Measuring Advertising Readership and Results*, New York: McGraw-Hill.

Sterman, J. D. (2000) *Business Dynamics*, Boston, MA: McGraw-Hill.

Swartz, N. (2004a) "AOL Employee Charged for Stealing Screen Names", *Information Management Journal,* (38)5, pp. 16.

Swartz, N. (2004b) “The Worldwide War on Spam Continues”, *Information Management Journal,* (38)2, pp. 16.

Unspam. (2005), http://www.unspam.com/fight_spam/information/spamstats.html (current as of April 15, 2005).

Warren, K. (2002) *Competitive Strategy Dynamics*, New York, NY: John Wiley & Sons, Inc.

APPENDIX I. MODEL EQUATIONS

This appendix presents the model equations. Note that the described Profitability is for sponsor A and operator A. Equations for the profit loop formed by sponsor B and operator B are identical and differ from A only in terms of subscripts.

Address Harvesting	
Average time to discovery	t_d
Undiscovered inboxes	I_u
Discovered inboxes	$(d/dt)I_d = I_u / t_d$
Total inboxes	$I = I_u + I_d$
Fraction of inboxes discovered	$i = I_d / I$
Attention and Information Overload	
Time an employee can spend on email	T
Attention resource of an organization	$A = T \cdot I$
Discovered attention resource	$A_d = i \cdot A$
Time it takes to read an email	e
Regular email volume to discovered inboxes	E_r
Attention devoted to regular mail	$A_r = e \cdot E_r$
Attention available for UCE	$A_{UCE} = A_d - A_r$
UCE volume	$E_{UCE} = E_A + E_B$
Attention required by UCE	$D = e \cdot E_{UCE}$
Information overload	$O = D / A_{UCE}$
Response Rate	
Maximum response rate	$r_{\max}$
Response rate	$r = r_{\max} \cdot f(O)$
$f(O)$	$0 \le f(O) \le 1 \qquad f'(O) < 0$
Profitability	
Sponsor A’s profit	$\pi = M_A - C_A$
Budget duration	τ
Average daily profit	$(d/dt)\bar{\pi} = (\pi - \bar{\pi})/\tau$
Sponsor A’s expenditure	$C_A = B_A / \tau$
Price of UCE	p
UCE volume from operator A	$E_A = C_A / p$
Responses to UCE from operator A	$R_A = r \cdot E_A$
Average revenue per sale	m
Sponsor A’s revenue	$M_A = m \cdot R_A$
Marketing fraction	a
Adjustment of spam budget	$B_+ = a \cdot \bar{\pi}$
Sponsor A’s UCE budget	$(d/dt)B_A = B_+ - C_A$

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